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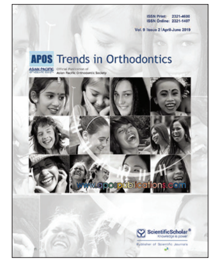

Original Article

Evaluation of facial soft-tissue values and craniofacial morphology in obese adolescent patients with different skeletal classes

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ABSTRACT

Objectives: The purpose of this study was to evaluate the facial soft tissue and craniofacial morphological structures in adolescent obese individuals with different skeletal patterns.

Materials and Methods: The study was carried out on 292 adolescents examined under three groups based on their body mass indexes (BMIs) as obese, healthy, and overweight. The subjects were also categorized based on skeletal classes as Class I, Class II, and Class III.

Results: The glabella, nasion, labiale inferius, labiomentale, and pogonion values of the female patients were significantly higher in obese group. In the obese and overweight groups, effective midfacial and mandibular length, anterior and posterior facial heights, and SN values of the females were higher than males. In the obese group, the mean effective midfacial and mandibular length (Co-A and Co-Gn), anterior and posterior facial heights (S-Go and N-Me), and anterior cranial base (SN) values were significantly higher than other groups.

Conclusion: Soft-tissue thicknesses increase as BMI value increases. Craniofacial morphology reveals significant differences between BMI groups.

Keywords: Facial soft tissue, Obese, Body mass index, Craniofacial morphology

INTRODUCTION

In recent years, there has been a rapid increase in the prevalence of obesity in children and adolescents worldwide.[1] The childhood obesity epidemic has turned into a serious public health problem worldwide in several countries, and it is the greatest public health problem of the 21st century. Recent studies have shown that approximately 20% of school-aged children in Europe are overweight or obese, while 5% are obese. In North America, these numbers are, respectively, 30% and 15%. This shows that 155 million or one in every 10 children at school ages of 5–17 years are overweight or obese.[2] It is accepted that the etiology of obesity in childhood is multifactorial, and it is in an interaction with genetic and environmental factors such as lifestyle habits and social environments.[3] Overweight and obesity in childhood have a significant effect on both physical and psychological health.[4]

Neeley and Gonzales reported that bone density and size increased in children with increased body mass index (BMI), and there were also changes in the bone metabolism and tooth movements. They also stated that there are increased skeletal growth and differences between growth and development in obese children.[5] Yasa *et al*.[6] found that the mandibular index and panoramic mandibular index measurements of obese and overweight individuals to be higher than those in normally weighted individuals. Obese children show a faster linear growth than non-obese children. Childhood obesity may lead to a relative increase in body height.[7]

Craniofacial growth is dependent on the interactions among genes, hormones, nutrition, and epigenetic factors.[8] Disruption of any of these mechanisms may lead to abnormal growth. It was reported that some facial structure measurements decreased in children whose somatic growth decreased due to various reasons.[9,10] Patients with growth hormone (GH) deficiency have a short posterior cranial base and a long posterior face height.[10,11] In these patients, both the maxilla and mandible are small and have retrolocalization.[9-11] It was also reported that the mandibular plane angle is higher than normal in patients with GH deficiency.[11]

Facial soft-tissue thicknesses (FSTTs) are affected by sex, age, ethnic origin, and nutritional status. BMI is one of the main factors of interpersonal differences in soft-tissue thicknesses.[12] Various imaging methods have been reported for the measurement of facial soft-tissue thickness in living beings. These are the lateral cephalometric radiography, computerized tomography (CT), ultrasonography, and magnetic resonance imaging (MRI) methods. CT, CBCT, MRI, and ultrasonography provide a better accuracy in examining FSTT; however, while being expensive, time-consuming, requiring technique-sensitive procedures or having more radiation dose, they are also not suitable for easy usage. X-ray imaging appears to be an easy, less time-consuming, and more inexpensive technique.[13] In the study by Visser *et al*., it was reported that the radiation dose can be adjusted and is lower in comparison to the conventional method in digital cephalometry.[14]

The purpose of this study was to assess the facial soft tissue and craniofacial morphological structures in adolescent obese individuals with different skeletal patterns.

MATERIALS AND METHODS

The study was approved by the Local Ethics Committee İstanbul Aydın University (No: 2020/263). Written consent forms were taken from all parents and children. As a result of the power analysis conducted using the G*Power software, then the effect size for glabella measurement was taken as 0.647, and DF was taken as 1, the minimum sample size for power: 0.80 and alpha error probability = 0.05 was calculated as $n = 159$ individuals.

The study was carried out on a total of 292 adolescents who visited the Faculty of Dentistry at İstanbul Aydın University University for treatment. The gender distribution was 135 (46.2%) females and 157 (53.8%) males and the mean age was 15.65 ± 1.16 years. The individuals were examined under three groups based on their BMIs as obese (95 subjects, 32.5%), healthy (104 subjects, 35.6%), and overweight (93 subjects, 31.8%). In addition, all subjects were categorized based on their facial skeletal patterns as Class I (103, 35.3%), Class II (95, 32.5%), and Class III (94, 32.2%). The exclusion criteria were a history of orthodontic treatment, craniofacial anomaly, congenital syndrome, history of facial trauma, and poor quality radiographs.

Lateral cephalometric radiographs were obtained using a cephalometric imaging device (Planmeca 2011-05 Proline Pan/Ceph X-Ray unit, Planmeca, Helsinki, Finland) in natural head position, and the lips were passive. Lateral cephalometric reference points and lines were used to measure and evaluate the craniofacial parameters [Figures 1 and 2]. Soft-tissue linear measurements and other cranial skeletal measurements on the radiographs were performed using a cephalometry software (Facad, trial version, Linkoping, Sweden).

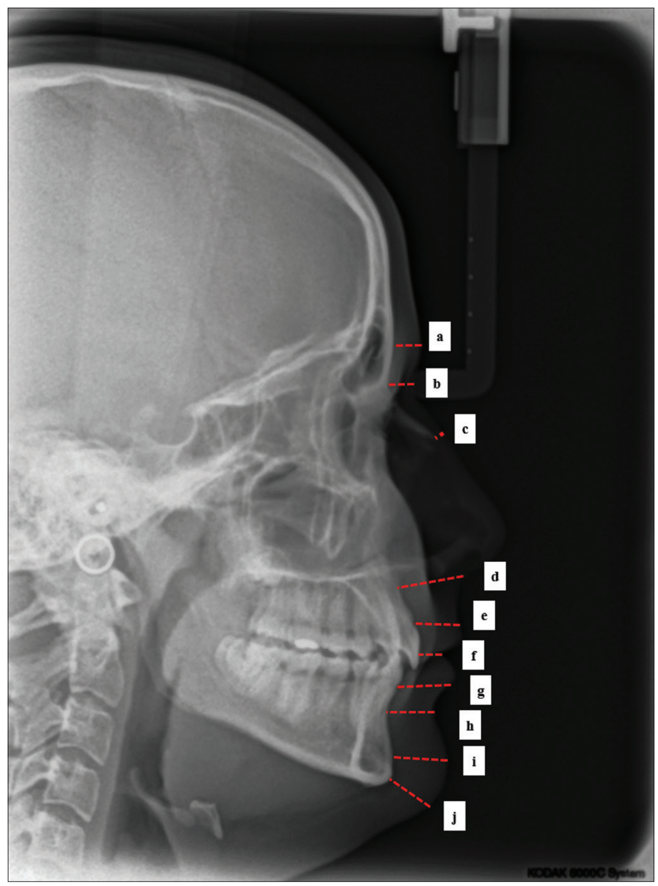

Figure 1: Lateral cephalometric facial soft-tissue thickness measurements: (a) Glabella, (b) nasion, (c) rhinion, (d) subnasale, (e) labiale superius, (f) stomion, (g) labiale inferius, (h) labiomentale, (i) pogonion, (j) gnathion.

During the patients' first visit to the clinic, chronological age was calculated. The body weight was measured using a mechanical weighing scale with a sensitivity of 0.1 kg, and the height was measured using a wall-mounted stadiometer with a sensitivity of 1 mm. BMI was calculated by dividing body weight (kg) by height squared (m^2). Using the BMI score parameters, age- and sex-specific BMI percentile values were calculated using the BMI percentile formula of the Centers for Disease Control and Prevention. A BMI score of <5% was defined as underweight, 5–84% was defined as normal weight, 85–94% was defined as overweight, and scores higher than 95% were defined as obese.[15] A total of 150 patients were randomly selected and reevaluated 4 weeks later.

Statistical analyses

In the analysis of the results that were obtained in the study, the IBM SPSS Statistics 22 (IBM SPSS, Turkey) software was utilized. The suitability of the parameters for normal distribution was assessed by Shapiro–Wilk test. In the analysis, in addition to descriptive statistical methods (mean, standard deviation, and frequency), one-way ANOVA was used for intergroup comparisons of the normally distributed quantitative data, and Tukey's HDS test and Tamhane's T2 test were used to determine the group causing the difference. In the comparison of the normally distributed parameters between two groups, Student's *t*-test was used. The qualitative data were compared using Chi-squared test. Cohen's kappa statistics were performed to evaluate intraobserver reliability. The statistical significance level was set at $P < 0.05$.

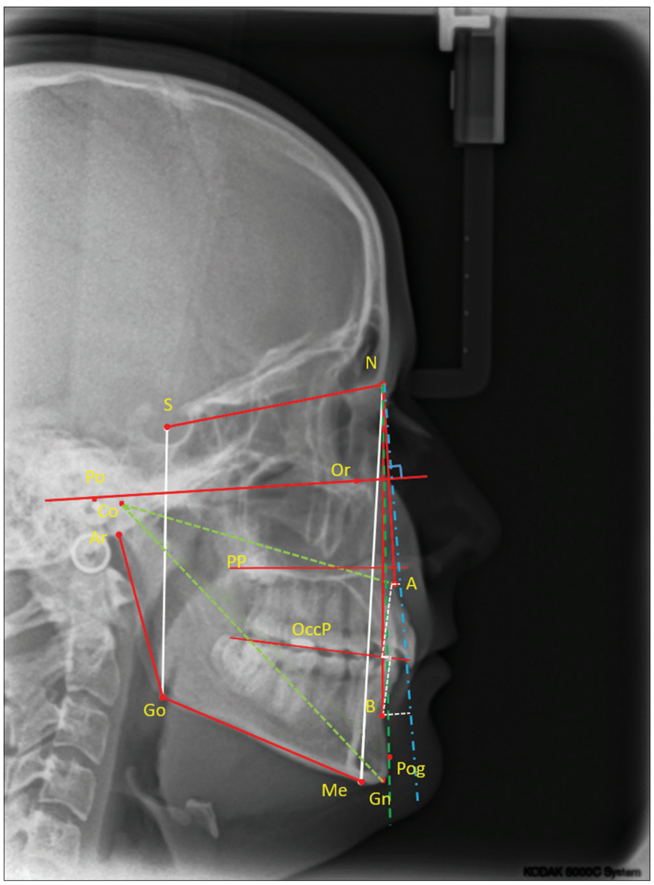

Figure 2: Lateral cephalometric facial hard tissue measurements: (S) Sella, (N) nasion, (Or) orbitale, (Po) porion, (Co) condylion, (A) subspinale, (B) supramentale, (Ar) articulare, (Go) gonion, (Me) menton, (Gn) gnathion, (Pog) pogonion, (SN) anterior cranial base, (Po-Or) Frankfort horizontal plane, (PP) palatal plane, (OccP) occlusal plane, (Go-Me) mandibular plane, (Co-Gn) effective mandibular length, (Co-A) effective midfacial length, (S-Go) posterior facial height, (N-Me) anterior facial height.

RESULTS

The intraclass correlation coefficients for the soft-tissue linear and cranial skeletal measurements were >0.990, and the intraobserver statistic was 0.935, confirming the measurement reliability. The study was conducted with a total of 292 adolescent individuals at ages varying between 14 to 18 including 135 (46.2%) female and 157 (53.8%) male patients. The mean age was 15.65 ± 1.16 years. There was no statistically significant difference among the groups in terms of their sex distribution ratios and mean ages ($P > 0.05$) [Table 1]. The individuals were also examined under three groups as 95 obese (32.5%), 104 healthy (35.6%), and 93 overweight (31.8%). The patients were also categorized based on their skeletal classes as 103 (35.3%) in Class I, 95 (32.5%) in Class II, and 94 (32.2%) in Class III.

In study, when the effects of BMI on soft-tissue thicknesses were examined, there was a statistically significant difference among the groups in terms of the mean glabella, nasion, rhinion, subnasale, labiale superius, stomion, labiale inferius, labiomentale, pogonion, and gnathion values ($P < 0.05$). These values of the healthy group were significantly lower than those of the obese and overweight groups ($P < 0.05$). The mean glabella, labiale inferius, pogonion, and gnathion values of the overweight group were significantly lower than those of the obese group ($P < 0.05$) [Table 2].

Table 1: Evaluation of age and gender between BMI groups.

	Gender		Age
	Female	Male	
	n (%)	*n* (%)	Mean±SD
Obese group	45 (47.4)	50 (52.6)	15.75±1.19
Healthy group	46 (44.2)	58 (55.8)	15.62±1.26
Overweight group	44 (47.3)	49 (52.7)	15.58±1.04
P	0.878[1]		0.585[2]

P^1: P value from Ki-Kare test, P^2: *P* value from one-way ANOVA test, *P<0.05, SD: Standard deviation, BMI: Body mass index

Table 2: Evaluation of facial soft-tissue measurements between BMI groups.

Parameter (mm)	Obese group	Healthy group	Overweight group	*P*	*Post-hoc*		
	Mean±SD	Mean±SD	Mean±SD		O-H	O-OW	H-OW
Glabella	6.82±1	5.11±0.78	6.26±1.01	0.000*	0.000*	0.000*	0.000*
Nasion	6.5±1.5	5.63±0.97	6.91±1.2	0.000*	0.000*	0.118	0.000*
Rhinion	2.99±0.69	2.61±0.52	2.88±0.63	0.000*	0.000*	0.569	0.004*
Subnasale	16.13±1.81	13.64±2.08	15.87±1.85	0.000*	0.000*	0.703	0.000*
Labiale superius	14.26±2.18	12.05±1.65	14±1.91	0.000*	0.000*	0.762	0.000*
Stomion	6.3±2.04	4.54±1.48	6.06±1.53	0.000*	0.000*	0.737	0.000*
Labiale inferius	14.18±1.42	12.33±1.49	13.59±1.5	0.000*	0.000*	0.017*	0.000*
Labiomentale	13.11±1.71	10.66±1.5	12.55±2.01	0.000*	0.000*	0.110	0.000*
Pogonion	15.14±2.17	11.38±1.29	13.89±1.55	0.000*	0.000*	0.000*	0.000*
Gnathion	10.86±2.42	7.49±1.54	9.61±1.77	0.000*	0.000*	0.000*	0.000*

P: *P* value from one-way ANOVA test, **P*<0.05, Tukey's HDS test and Tamhane's T2 test for *post hoc* comparison, H-OW: Comparison between healthy and overweight groups, H-O: Comparison between healthy and obese groups, OW-O: Comparison between overweight and obese groups, SD: Standard deviation, BMI: Body mass index

In the effect of skeletal characteristics on the relationship between BMI and FSTT, the mean labiale superius and labiale inferius values in Class I group in the obese group were significantly higher than those in Class III group ($P < 0.05$). The pogonion and gnathion mean values of Class III were significantly lower than those of Classes I and II groups ($P < 0.05$). In healthy group, the mean glabella, rhinion, subnasale, labiale superius, stomion, and gnathion values of Class II were significantly lower than those of Classes I and III ($P < 0.05$). The nasion and labiomentale mean values of Class I were significantly higher than those of Class III ($P < 0.05$). The pogonion mean value of Class I was significantly higher than those of Classes II and III ($P < 0.05$). The mean stomion and gnathion values decreased from Class III to Class II ($P < 0.05$). In the overweight group, the subnasale mean value of Class I was significantly higher than those of Classes II and III ($P < 0.05$). The mean stomion and gnathion values of Class II were significantly lower than those of Classes I and III ($P < 0.05$). The mean labiale inferius value of Class I was significantly higher than that in Class III ($P < 0.05$), while the mean labiomentale value was significantly lower than that in Class II ($P < 0.05$) [Table 3].

Considering the sexes, in the obese group, the labiomentale values of the female patients were significantly higher than those of the male patients, while gnathion values were significantly lower ($P < 0.05$). In the healthy group, the glabella, nasion, labiale inferius, labiomentale, and pogonion values of the female patients were significantly higher than those of the male patients ($P < 0.05$). In the overweight group, the glabella, nasion, labiale superius, rhinion, labiomentale, pogonion, and gnathion values of the female patients were significantly higher than those of the male patients ($P < 0.05$) [Table 4].

In terms of skeletal parameters, there was no significant difference among the groups in terms of the SNA, SNB, ANB, Wits, SNPog, and PP/SN values ($P > 0.05$). The mean NPerp-A and NPerp-Pog values of the healthy group were significantly lower than those of the obese and overweight groups ($P < 0.05$). In the obese group, the mean Co-A, Co-Gn, S-Go, N-Me, SN, SN-GoMe, and PP/GoMe values were significantly higher than those of the healthy and overweight groups ($P < 0.05$) [Table 5].

Considering the changes in the hard tissue measurements based on the sexes in different BMI groups, while SNA and Wits values of the female patients in the healthy group were higher than those of the male patients, while SN-GoMe and PP/SN values were significantly lower ($P < 0.05$). In the obese group, Co-A, Co-Gn, S-Go, N-Me, and SN values of the female individuals were higher than those of the males, while their SN-GoMe and PP/SN values were significantly lower than those of the male patients ($P < 0.05$). In the overweight group, the SNA, Wits, Co-A, Co-Gn, S-Go, N-Me, and SN values in the female individuals and the PP/SN value in the male individuals were significantly higher ($P < 0.05$) [Table 6].

DISCUSSION

Various mechanisms play a role in the growth and development of craniofacial structures. Genetic and hormonal factors may lead to alterations in the skeletal development of the adolescent population.[16] In obese patients, the bones and soft tissues of the craniofacial complex grow differently, and the differences between obese and normally weighted individuals have been the focus of attention for several studies.[17]

Considering the effects of BMI on soft-tissue thicknesses in our study, it may be seen that all soft-tissue thicknesses in the obese and overweight individuals were higher than those in the healthy individuals. With the increasing BMI from

Table 3: Evaluation of facial soft-tissue measurements between skeletal classes in different BMI groups.

Parameter (mm)	Class 1	Class 2	Class 3	*P*	1–2	1–3	2–3
	Mean±SD	Mean±SD	Mean±SD				
Obese Group							
Glabella	6.92±1.03	6.92±1.07	6.61±0.9	0.390	NS	NS	NS
Nasion	6.52±1.76	6.77±1.65	6.2±0.95	0.324	NS	NS	NS
Rhinion	3.07±0.74	2.92±0.77	2.99±0.56	0.669	NS	NS	NS
Subnasale	16.68±1.45	15.57±2.2	16.1±1.61	0.055	NS	NS	NS
Labiale superius	15.14±1.88	14.16±2.46	13.43±1.88	0.006*	0.228	0.002*	0.476
Stomion	6.75±1.91	6.18±2.7	5.94±1.23	0.262	NS	NS	NS
Labiale inferius	14.58±1.48	14.25±1.6	13.7±1	0.042*	0.768	0.020*	0.303
Labiomentale	13.31±1.88	12.9±1.65	13.12±1.59	0.632	NS	NS	NS
Pogonion	15.84±2.01	15.46±2.75	14.07±0.97	0.002*	0.900	0.000*	0.034*
Gnathion	11.22±2.17	11.74±2.46	9.59±2.17	0.001*	0.638	0.014*	0.001*
Healthy group							
Glabella	5.25±0.72	4.75±0.76	5.33±0.75	0.003*	0.015*	0.890	0.005*
Nasion	6±0.89	5.51±1.05	5.34±0.88	0.011*	0.074	0.011*	0.749
Rhinion	2.68±0.5	2.38±0.4	2.76±0.59	0.005*	0.036*	0.758	0.006*
Subnasale	14.9±2.03	12.01±1.21	13.92±1.73	0.000*	0.000*	0.092	0.000*
Labiale superius	12.53±1.47	10.87±1.35	12.74±1.51	0.000*	0.000*	0.826	0.000*
Stomion	4.34±1.23	3.62±1.28	5.71±1.12	0.000*	0.039*	0.000*	0.000*
Labiale inferius	12.8±1.25	11.97±1.47	12.17±1.67	0.055	NS	NS	NS
Labiomentale	11.35±1.62	10.45±1.53	10.08±0.99	0.001*	0.055	0.000*	0.570
Pogonion	11.99±1.15	10.82±1.58	11.27±0.72	0.000*	0.002*	0.007*	0.373
Gnathion	7.26±1.01	6.18±1	9.09±0.97	0.000*	0.000*	0.000*	0.000*
Overweight group							
Glabella	6.03±0.95	6.16±0.9	6.62±1.1	0.056	NS	NS	NS
Nasion	6.98±1.16	6.57±1.3	7.17±1.1	0.140	NS	NS	NS
Rhinion	2.86±0.51	2.7±0.68	3.09±0.66	0.056	NS	NS	NS
Subnasale	16.76±1.6	15.49±1.8	15.26±1.84	0.002*	0.013*	0.003*	0.870
Labiale superius	14.44±1.63	13.41±1.84	14.1±2.16	0.094	NS	NS	NS
Stomion	6.39±1.3	5.39±1.4	6.37±1.72	0.013*	0.024*	0.998	0.032*
Labiale inferius	14.15±1.27	13.54±1.5	13.02±1.54	0.010*	0.220	0.007*	0.341
Labiomentale	11.65±1.9	13.34±1.82	12.74±1.97	0.002*	0.002*	0.064	0.442
Pogonion	13.82±1.77	13.46±1.26	14.41±1.46	0.056	NS	NS	NS
Gnathion	9.96±1.55	8.81±1.68	10.02±1.86	0.009*	0.023*	0.989	0.019*

P: *P* value from one-way ANOVA test, $^*P<0.05$, *post hoc*: Tukey's HDS test and Tamhane's T2 test, 1–2: Comparison between Class 1 and Class 2 groups, 1–3: Comparison between Class 1 and Class 3 groups, 2–3: Comparison between Class 2 and Class 3 groups, SD: Standard deviation, NS: Non-significant, BMI: Body mass index

overweight individuals to obese individuals, it is seen that the soft tissues in the glabella and lower facial region are affected more by BMI. While Chu *et al.*[18] did not find any effect of sagittal and vertical hard tissue characteristics on soft-tissue thickness in the upper facial region in young adult Chinese female patients, they reported that the difference in FSTT was the highest in the upper lip in the maxilla and the mental region in the mandible. According to the study, while the thickest soft tissue in the concave and hypodivergent skeletal structure was in the maxillary region, it was in the mental region in the convex and hyperdivergent skeletal structure. De Greef *et al.*[19] reported that the upper lip and nose region FSTT of Belgian individuals in ultrasound were independent of BMI. In addition to this, the mandibular region and the cheek region were the areas affected most by BMI, and the major factor affecting soft-tissue thickness is BMI. In their study on adolescents, Buyuk *et al.*[12] stated that the glabella, pogonion, and gnathion soft-tissue thicknesses were higher in obese and overweight individuals than normally weighted individuals, while the nasion thickness was higher in overweight individuals than normally weighted ones.

In their study on the MR data of individuals aged 11–76, Johari *et al.*[20] determined that the mid-philtrum in males and the upper lip in females have thickness values changing with age. In addition, the thickness of the pogonion region in overweight males and the soft-tissue thicknesses of the nasion, pogonion, and under-chin regions in overweight females are higher in comparison to lower weight individuals

Table 4: Evaluation of facial soft-tissue measurements by different genders in different BMI groups.

Parameter (mm)	Gender		P
	Female	Male	
	Mean±SD	Mean±SD	
Obese group			
Glabella	6.69±0.95	6.93±1.05	0.232
Nasion	6.66±1.44	6.35±1.55	0.321
Rhinion	3.12±0.75	2.88±0.63	0.101
Subnasale	16.13±1.51	16.13±2.07	0.994
Labiale superius	14.28±2.33	14.24±2.07	0.929
Stomion	6±1.99	6.57±2.08	0.181
Labiale inferius	14.28±1.54	14.1±1.3	0.526
Labiomentale	13.76±1.48	12.54±1.7	0.000*
Pogonion	15.07±2.38	15.2±1.98	0.778
Gnathion	10.27±2.45	11.38±2.3	0.024*
Healthy group			
Glabella	5.35±0.75	4.92±0.76	0.005*
Nasion	5.96±1.04	5.37±0.84	0.002*
Rhinion	2.63±0.49	2.59±0.55	0.723
Subnasale	13.96±2.4	13.39±1.76	0.181
Labiale superius	12.42±2.11	11.77±1.11	0.063
Stomion	4.77±1.71	4.36±1.25	0.178
Labrale inferius	13.04±1.61	11.77±1.12	0.000*
Labiomentale	11.04±1.83	10.35±1.1	0.029*
Pogonion	11.85±1.14	11±1.28	0.001*
Gnathion	7.64±1.77	7.37±1.33	0.389
Overweight group			
Glabella	6.6±0.93	5.96±0.99	0.002*
Nasion	7.41±1.03	6.46±1.18	0.000*
Rhinion	3.19±0.56	2.61±0.58	0.000*
Subnasale	15.92±2.04	15.82±1.69	0.796
Labiale superius	14.56±1.73	13.5±1.94	0.007*
Stomion	5.99±1.5	6.12±1.57	0.687
Labiale inferius	13.8±1.81	13.4±1.13	0.205
Labiomentale	13.39±1.78	11.79±1.91	0.000*
Pogonion	14.36±1.39	13.48±1.58	0.006*
Gnathion	10.19±1.62	9.09±1.74	0.002*

P: P value from Student's t-test, $^*P<0.05$, SD: Standard deviation, BMI: Body mass index

of the same sexes. Likewise, the nasion value in normally weighted females was found to be higher than those with lower weight, and the glabella, nasion, rhinion, pogonion, and under-chin thicknesses in overweight individuals were higher than those in normally weighted individuals of the same sexes. Wang *et al.*[21] found all soft-tissue thicknesses except pogonion in individuals aged 18–26 to be higher among males. Eftekhari-Moghadam *et al.*[22] reported that, in adult individuals of Iranian origin, the nasion, mid-philtrum, upper and lower lip, and under-chin soft tissues are thicker in males, and the clearest measurements in sex determination could be listed, respectively, as mid-philtrum, upper lip, nasion, lower lip, and under-chin tissues. In addition, they showed a positive correlation of BMI with the right and left frontal tubers and a negative correlation of it with the upper lip. In the CBCT examinations of Indian adults, Meundi and David[23] found a difference between males and females in all age groups in terms of the nasion, mid-philtrum, and labiale superius region soft-tissue thicknesses, while they could not find a difference in the zygion region at any age interval. Similarly, according to the study, there is a significant difference in the glabella, nasion, mid-nasal, subnasale, mid-philtrum, labiale superius, mid-supraorbital and infracanine region soft-tissue thicknesses between males and females at the ages of 17–20. De Greef *et al.*[19] reported that, among Belgian adults, the only FSTT where the intersex difference exceeded 2 mm is the lateral orbital edge. While the upper and lower lip regions are higher in males than females by 1–1.5 mm, the cheek region in females is higher than males by 1 mm. Buyuk *et al.*[12] could not find a difference between males and females in obese groups in terms of FSTT. There was a significant difference between the sexes in the nasion, rhinion, and pogonion values in the overweight group and all parameters except nasion and stomion in the normally weighted group, while all measurements except the gnathion in the normally weighted group were higher among the males than the females. In their study on the CT examinations of Chinese adults, Dong *et al.*[24] determined the thickest FSTT in the cheek and the thinnest one in the forehead and nasal bridge in both sexes for underweight, normally weighted, and obese groups. In both sexes, with increasing BMI, there were increases in all soft-tissue thicknesses. In both males and females, while there was a difference in almost all measurements among the BMI groups, the number of parameters with differences among the females was higher than that for the males. In our study, in the obese group, the labiomentale region among the females and the gnathion region among the males were thicker. Likewise, according to the results, while the subnasale and stomion thicknesses did not show an intersex difference in all BMI groups, the labiomentale thickness was the only parameter with differences in all groups. In addition, in similarity to the study by Buyuk *et al.*,[12] the difference between the sexes in terms of the soft-tissue thicknesses was much lower in the obese group than the other groups.

Ohrn *et al.*,[25] among adolescent individuals whose craniofacial hard tissue measurements they made, reported that the number of parameters which showed differences among the female individuals in terms of the obese and normally weighted groups was higher than those among the male individuals. In addition, the most noticeable difference for both sexes was in the mandibular length. While the mandible was more prognathic in obese individuals of both sexes, the maxilla was found to be prognathic in females. Again, according to the study, the SN length was higher in

Table 5: Evaluation of cephalometric measurements between different BMI groups.

Parameters	Obese group	Healthy group	Overweight group	*P*	*Post-hoc*		
	Mean±SD	Mean±SD	Mean±SD		O-S	O-OW	S-OW
SNA	81.62±2.96	81.38±3.82	82.47±3.68	0.079	NS	NS	NS
SNB	79.43±3.8	79.18±4.1	80.22±4.06	0.169	NS	NS	NS
ANB	2.21±3.07	2.26±3.08	2.26±3.47	0.992	NS	NS	NS
Wits	−1.17±2.66	−0.79±4.43	−1.32±3.49	0.576	NS	NS	NS
NPerp-A	−0.63±2.15	−2.12±3.44	−0.22±1.73	0.000*	0.001*	0.397	0.000*
NPerp-Pog	−2.82±4.47	−5.73±6.9	−2.31±4.57	0.000*	0.001*	0.820	0.000*
Co-A	80.88±4.21	75.98±7.87	77.17±8.52	0.000*	0.000*	0.001*	0.686
Co-Gn	105.26±6.15	99.93±10.85	103.48±11.37	0.001*	0.000*	0.086	0.455
SNPog	80±3.59	80.06±3.77	80.97±3.81	0.133	NS	NS	NS
SN-GoMe	34.44±5.46	30.71±5.24	31.6±5.33	0.000*	0.000*	0.001*	0.472
Gonial angle	130.6±6.9	127.56±8.04	129±7.71	0.020*	0.014*	0.319	0.380
PP/SN	7.42±2.76	7.37±2.94	7.42±2.33	0.988	NS	NS	NS
PP/GoMe	28.35±6.3	25±5.72	25.22±5.67	0.000*	0.000*	0.001*	0.964
S-Go	73.99±7.16	67.52±7.93	70.89±8.77	0.000*	0.000*	0.019*	0.023*
N-Me	110.27±7.75	105.09±11.79	106.3±10.2	0.001*	0.001*	0.838	0.008*
SN	65.08±2.87	58.91±7.14	60.72±7.32	0.000*	0.000*	0.000*	0.240
MandCorp/SN	101.82±7.65	99.04±6.41	103.03±7.9	0.001*	0.019*	0.638	0.000*

P: *P* value from one-way ANOVA test, *$P<0.05$, *post hoc*: Tukey's HDS test and Tamhane's T2 test, H-OW: Comparison between healthy and overweight groups, H-O: Comparison between healthy and obese groups, OW-O: Comparison between overweight and obese groups, SD: Standard deviation, NS: Non-significant, BMI: Body mass index

Table 6: Evaluation of cephalometric measurements by gender in different BMI groups.

Parameters	Healthy		*P*	Obese		*P*	Overweight		*P*
	Female	Male		Female	Male		Female	Male	
	Mean±SD	Mean±SD		Mean±SD	Mean±SD		Mean±SD	Mean±SD	
SNA	82.3±2.92	81.01±2.89	0.033*	81.52±3.74	81.27±3.92	0.736	83.29±3.29	81.74±3.89	0.042*
SNB	79.92±3.97	78.99±3.61	0.235	79.42±4.3	78.98±3.96	0.590	80.76±4.05	79.73±4.06	0.224
ANB	2.46±3.39	2±2.76	0.471	2.22±3.22	2.3±2.99	0.893	2.56±3.44	2±3.51	0.441
Wits	−0.47±2.16	−1.79±2.92	0.015*	−0.7±4.64	−0.87±4.3	0.846	−0.44±3.02	−2.11±3.73	0.021*
NPerp-A	−0.78±1.89	−0.49±2.38	0.512	−2.6±4.05	−1.74±2.84	0.227	−0.3±1.81	−0.16±1.66	0.710
NPerp-Pog	−2.47±3.75	−3.14±5.04	0.466	−5.49±7.09	−5.92±6.79	0.757	−3.1±5.6	−1.6±3.28	0.126
Co-A	76.56±8.69	75.46±7.11	0.503	82.3±4.49	79.76±3.63	0.002*	80.45±7.21	74.23±8.6	0.000*
Co-Gn	98.98±12.08	100.78±9.66	0.422	107.61±5.97	103.39±5.66	0.000*	106.93±11.07	100.39±10.83	0.005*
SNPog	80.59±3.47	79.47±3.65	0.130	80.49±3.93	79.71±3.64	0.295	81.6±3.68	80.4±3.87	0.130
SN-GoMe	32.51±3.98	36.18±6.03	0.001*	28.98±4.39	32.08±5.49	0.002*	30.54±4.76	32.56±5.66	0.067
PP/SN	6.66±2.64	8.09±2.72	0.011*	6.31±2.55	8.2±2.98	0.001*	6.21±1.85	8.51±2.19	0.000*
PP/GoMe	27.9±5.4	28.75±7.05	0.519	24.62±5.09	25.3±6.2	0.548	25.17±4.36	25.26±6.67	0.939
Gonial angle	131.07±8.56	130.17±5	0.538	128.24±8.24	127.03±7.91	0.446	128.08±5.28	129.82±9.35	0.267
S-Go	66.67±8.4	68.28±7.48	0.327	76.79±7.56	71.76±6.01	0.000*	74.59±7.28	67.56±8.73	0.000*
N-Me	103.3±12.1	106.7±11.4	0.162	113.4±7.92	107.78±6.7	0.000*	109.93±8.61	103.03±10.5	0.001*
SN	57.88±7.88	59.83±6.34	0.186	66.13±2.75	64.26±2.72	0.001*	63.68±6.37	58.06±7.14	0.000*
MandCorp/SN	101.68±7.23	101.94±8.07	0.868	98.8±6.36	99.23±6.49	0.734	102.65±7.72	103.37±8.12	0.663

P: *P* value from Student's *t*-test, *$P<0.05$, SD: Standard deviation, BMI: Body mass index

obese individuals, while the upper anterior facial height was lower in obese female participants. Sadeghianrizi *et al.*[26] found the SN, mandibular length, corpus length, maxillary length, and lower anterior and posterior face heights in obese adolescent female and male patients to be higher and the mandibular plane angle to be lower in comparison to healthy individuals of the same sexes. While the maxillary plane angle was lower in obese female patients, obese individuals of both sexes had a more convex profile, and the number of parameters showing differences in the females was higher than those in the males. In their study on adolescent individuals, Olszewska[17] reported that the mandibular length, corpus length, midfacial length, and lower anterior face height of both male and female obese individuals were significantly higher than healthy individuals of the same sexes. In addition, the maxillary length and SNA angle in female participants with high BMI and the posterior face height in obese male participants were higher. In both sexes, the highest difference was in the mandibular length. In our study, considering the BMI and skeletal parameters, it was observed that, in the sagittal direction, as the BMI increased, the mandible and maxilla were positioned toward the anterior, and the maxillary and mandibular lengths increased. In the vertical direction, it was seen that the anterior and posterior face heights increased with the increasing BMI. The anterior cranial base length was higher in the obese individuals. In the evaluation based on sex, while the SNA and Wits values of the female participants in the healthy group were higher than the males, the effective midfacial and mandibular length, anterior and posterior face heights, and SN length among the female individuals in the obese and overweight groups were higher than those in the males. The SN-GoMe and PP/SN values were higher among the male in all groups. Moreover, while the number of hard tissue parameters showing difference between the sexes was almost the same in the obese and overweight groups, it was very low in the healthy groups.

In their study on individuals at the ages of 18–26, Wang *et al*.[21] reported that the stomion thickness of Class III individuals was higher than those of Class I and Class II individuals, and all FSTT except for the rhinion showed an increase with increased BMI. Between the sexes, the upper lip, stomion, and lower lip thicknesses of Class I male individuals, the glabella and rhinion thicknesses of Class II male individuals, and the upper lip and rhinion thicknesses of Class III male individuals were higher than those of female individuals. In their study on individuals at the ages of 19–26, Chu *et al*.[18] reported that the subnasale, labiale superius, and stomion soft-tissue thicknesses decreased from Class III to Class II in the maxillary region in sagittal evaluation. In addition, in the mandibular region, the labiale inferius, labiomentale, and pogonion soft tissues were significantly thinner than Classes I and II. Furthermore, no significant difference was observed among various skeletal types at the glabella, nasion, rhinion, and gnathion points. Considering the effect of the skeletal characteristics on the relationship between the BMI and FSTT in our study, it was seen that the effect of skeletal classification on soft tissues was much higher in the healthy group than those in the obese and overweight groups. The region where the skeletal classification showed a difference among the obese and overweight individuals was the lower face region, while there was no significant difference in the upper face region.

CONCLUSION

- Soft-tissue thicknesses increase as the BMI value increases, and the glabella and mandibular regions are the region most affected by BMI. This should be taken into account when performing dentomaxillofacial treatments where visualization in the patient profile is important.
- The relationship of most soft-tissue parameters with BMI shows a variation based on sex. While the subnasale and stomion thicknesses do not show a difference between the sexes in all BMI groups, the labiomentale thickness is the only parameter that shows a difference in all groups.
- Craniofacial morphology reveals significant differences between overweight and obese adolescent patients and normally weighted individuals.
- In the changes in different sexes in different BMI groups in terms of craniofacial morphology, the effective midfacial length, effective mandibular length, anterior and posterior face heights, and SN values of the female individuals in the obese and overweight groups are found higher in comparison to those in the male individuals.

COMPLIANCE WITH ETHICAL STANDARDS

Human rights statements

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008.

Authors' contributions

AK: Conceived the ideas and methodology, interpreted the data, led the writing and editing and final approval of manuscript, collected the data, and statistical analysis. EG: Conceived the ideas and methodology, interpreted the data, led the writing and editing, and final approval of manuscript.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent.

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Conflicts of interest

There are no conflicts of interest.

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