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EVALUATION OF LOWER FACE HEIGHTS AND RATIOS ACCORDING TO SEX

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RESUMEN

La determinación de las relaciones de altura de la cara inferior proporciona información importante para el tratamiento de ortodoncia, los enfoques quirúrgicos y la identificación fiable en lmedicina forense. Este estudio se realizó con el objetivo de determinar la altura de la índices bajos de la cara de estudiantes de la Universidad Başkent y evidenciar las posibles diferencias por sexo. El estudio se realizó en 95 mujeres y 101 varones, 18 a 25 años, un total de 196 estudiantes turcos voluntarios. Las imágenes fotogramétricas laterales fueron adquiridos por la misma persona para todos los sujetos en la posición natural de la cabeza, con la boca cerrada en la postura normal. Las imágenes se transfirieron a un entorno de computación. La determinación de seis puntos antropométricos en el plano vertical, la medición de sus distancias relativas y el cálculo de siete relaciones se realizó por la misma persona en todas las fotografías. Se observó una diferencia significativa en función del sexo de los sujetos que fue identificada en los siete parámetros medidos entre los puntos de referencia antropométricas. Cuando se evaluaron las relaciones de altura facial inferior la más grande era la altura bermellón superior / inferior proporción de altura bermellón, tanto en hombres como en mujeres, y el más pequeño era el alto / superior bermellón del labio superior altura en mujeres y el labio superior de elevación / altura de la parte inferior del rostro en los hombres. Postulamos que el conocimiento de determinados índices faciales y sus diferencias según el sexo y la raza puede servir como una guía para la planificación de la terapia en las diferentes intervenciones quirúrgicas, el control en ortodoncia y lla identificación personal.

***Palabras clave**: Análisis Facial, menores proporciones faciales, fotografías.*

ABSTRACT

The determination of the lower face height ratios provides significant information for orthodontic treatment, surgical approaches and for a reliable identification in forensic medicine. This study was conducted with the aim of determining lower face height ratios in Başkent University students and evidencing possible sex-related differences. The study was performed on 95 female and 101 male, aged 18-25, a total of 196 Turkish volunteer students. Lateral photogrammetric images were acquired by the same person for all subjects in natural head position, with their mouth closed in normal posture. The images were transferred to a computing environment. The determination of six anthropometric points in the vertical plane, the measurement of their relative distances and the calculation of seven ratios were done by the same person on all photographs. A significant difference according to the subjects' sex was identified in all seven parameters measured among the anthropometric landmarks. When the lower face height ratios were evaluated the largest one was the upper vermilion height/lower vermilion height ratio both in males and females,and the smallest one was the upper vermilion height/upper lip height ratio in female subjects and the upper lip height/height of the lower face in males. We hypothesize that the knowledge of certain facial ratios and their differences according to sex and race may serve as a guide for therapy planning in different surgical interventions, orthodontic follow-up and personal identification.

***Key Words**: Facial analysis, lower face proportions, photographs*

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INTRODUCTİON

The face is the most generally recognizable feature of the individual. It is also an important component of physical appearance. Published studies report that a newborn can focus its eyes already nine minutes after birth, targeting faces (Bates and Cleese, 2001).The human face shows wide differences depending on sex and race. The differences in harmony, symmetry, soft to bony tissue ratios and lower face height ratios have been studied by artists, orthodontists, surgeons and forensic anthropologists (Arnett et al, 1999; Farkas et al, 1980; Farkas et al, 2005). These studies have used methods such as anthropometry (Farkas et al, 2005), photometry (Stoner, 1955; Yuen and Hiranaka, 1989), cephalometry (Roos, 1977) and computerized tomography imaging (Guess and Solzer, 1989). Even though facial beauty is a relative concept with different meanings to different people, it also has a measurable ratio (the golden ratio) (Prokopakis et al, 2013; Rossetti et al, 2013).

Any disproportion in the face may mar its esthetic quality. Anthropometric studies performed on the face are useful in the reconstruction of congenital craniofacial deformities, aesthetic interventions and orthodontic planning (Budai et al, 2003; Farkas et al, 1980). The face is also an important element in determining personal identity (Anić-Milosević et al, 2008; Sönmez, 2001). Facial characteristics may be used for reliable identification in cases such as dead or missing persons or the search for criminals. Facial characterization using both morphologic characteristics and measurements may be compared to a photograph to redefine the face of a dead person, or be used for comparison of faces to photographs in cases of wrong identification or missing person searches (Farkas et al, 1993; Farkas et al, 2005). The following may be listed among the characteristics to be recorded, used for the defining the particularities of body shape: nose shape and length, lip appearance; width, length and slope of the jaw. It has been defined proportions and measurements for the entire body (Hamamci et al, 2010). Farkas et al (2005) have established a data base of anthropometric measurements made on the face, characterized over a hundred ratios and performed their comparisons. These measurements include linear measurements, slopes and angles. Several studies relative to race and sex using these data bases have been published (Budai et al, 2003; Farkas et al, 1980; Farkas et al, 1993; Thuy et al, 2002). There is, however, no study of the differences among the sexes for the Turkish race that includes the lower face heights and ratios.

The objective of this study was 1) to define the ratios of measurements between different lower face anthropometric landmarks; 2) to study these lower face height ratios between the sexes

	ICC	p
Sn-Me	0,983	<0,001
Sto-Me	0,997	<0,00
Sn-Sto	0,996	<0,00
Ls-Sto	0,928	<0,00
Sto-Sm	0,956	<0,00
Li-Sto	0,968	<0,00
Sm-Me	0,993	<0,00

Table I. The evaluation of consistency between the measurements. ICC:Intraclass Correlation Coefficient

MATERIALS AND METHODS

This work was approved by decision number 13/36 dated 3/20/2013 by the Baskent University Medical School Non-interventional Clinical Study Ethical Committee (Project; KA 13/61). A total of 196 volunteer subjects (101 male, 95 female) aged 18-25, participated in the study. Persons who had former orthodontic treatment or surgery touching the face were not included in the study. Measurements for the study were performed on profile pictures taken with a 10.1 megapixel camera. The person to be photographed was seated on a chair 1 m away from a 15x15 cm mirror marked with a grid of horizontal and vertical lines 1 cm apart from each other. The purpose of these markings was to allow the seating person to fix his or her gaze on the horizontal markings in order to hold the head in the standard position. A thread with a 500 g weight hung next to the chair; pictures were taken in such a way as to have the first vertical line of the guide grid coincide with the weighted thread. The camera tripod height was 1.5 m and its distance from the subject was 1 m. All pictures were taken from the left side of the face. The camera was set for a x1.5 zoom and all pictures were taken without flash lighting, to ensure standardization. During the photographing, subjects were asked to keep their lips closed but only touching each other without pressing. The pictures were transferred to computers and the measurements performed using the Image J software. Lower face heights among the different predetermined anthropometric landmarks were measured and lower face ratios were calculated by the same investigator. Approximately 15% of all lower face measurements were randomly selected to be measured again and consistency testing was performed using the two measurements. Consistency varied between 0.928 and 0.997, showing a remarkable reliability of the measurements (Table I).

The six anthropometric landmarks used for the lower face measurements are indicated in Figure 1 and the lower face height ratios used are those shown in Table II.

The normality of variable distribution was tested by the Shapiro-Wilk test and variance homogeneity by Levene's test. Group averages for variables satisfying parametric test requirements were compared with Student's t-test and those which failed to satisfy such requirements were tested using the Mann-Whitney U test. Parameters were described as mean ± 1 standard deviation, median, lowest and highest values. Correlations between variables were evaluated using either Pearson's correlation coefficient or Spearman's rho correlation coefficient according to the character of the variables' distribution. Consistency across measurements was checked by the intraclass correlation coefficient (ICC). A p-value <0.05 was accepted as statistically significant. Data analysis was performed using the SPSS 1.0 software.

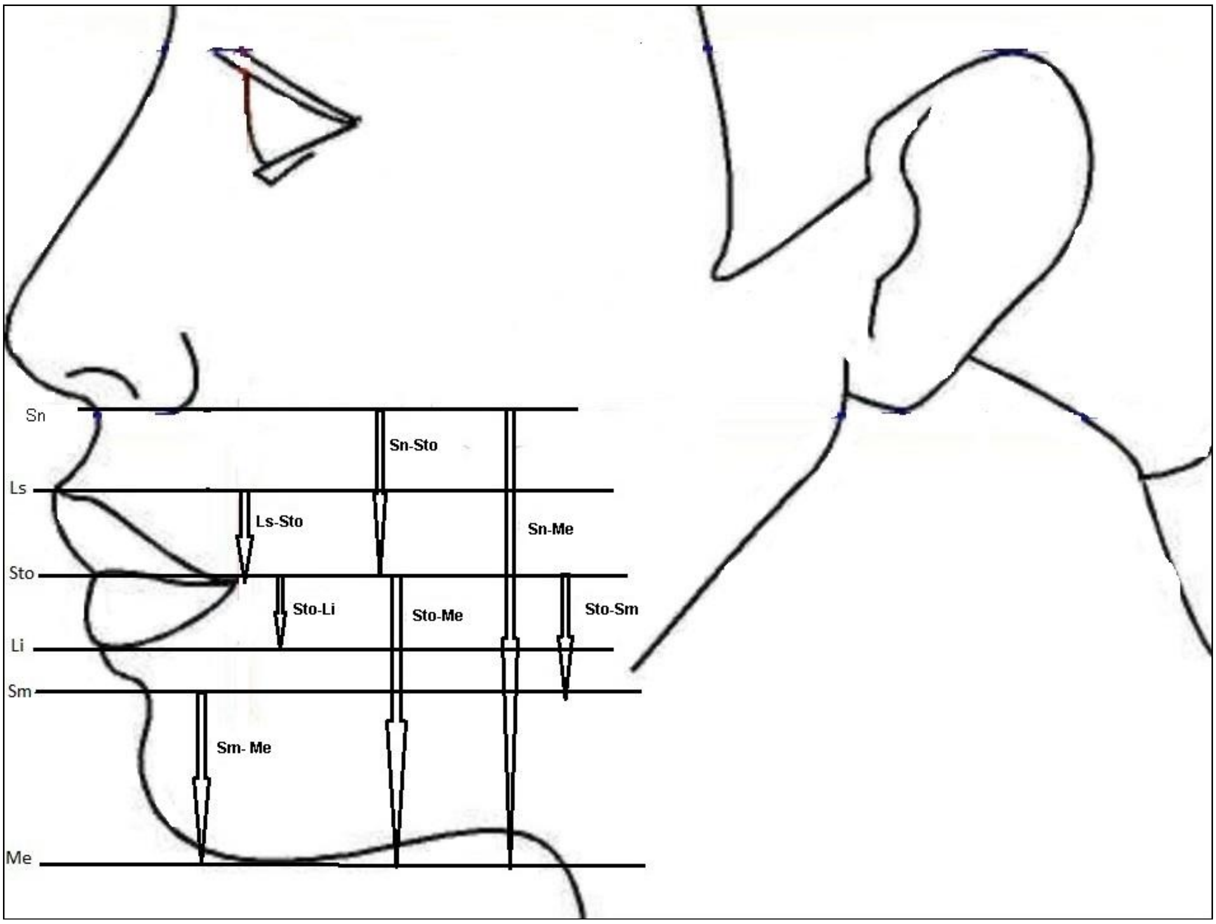

Figure I. The fallowing six landmarks used in the study Sn: Subnasal; the point where the upper lip joins the columella Ls: Labrale superior; the point that indicates the mucocutaneous limit of the upper lip Li: Labrale inferior; the point that indicates the mucocutaneous limit of the lower lip Sm:Supramentale; the deepest point of the inferior sublabial concavity and menton Sto: Stomion; The point where upper lip contacts the lower lip Me: Menton; the most inferior point of the outline of the chin.

Ratio 1	Ls-Sto: Upper vermilion height / Sn-Sto: Upper lip hight
Ratio 2	Li-Sto: Lower vermilion height / Sto-Sm: Lower lip hight
Ratio 3	Ls-Sto: Upper vermilion height / Li-Sto: Lower vermilion height
Ratio 4	Sn- Sto: Upper lip hight / Sn-Me: Height of the lower face
Ratio 5	Sto-Sm:Lower lip hight/Sto-Me: Height of mid-point between the lips and the chin
Ratio 6	Sto-Sm: Lower lip hight / Sm-Me: Chin height
Ratio 7	Sm-Me: Chin height /Sto-Me: Height of mid-point between the lips and the chin

Table II. Relationships between vertical profile measurements in lower face

	Female(n = 95)		**Male**(n = 101)		**P**
	Mean ±SD Median	Min-Max IQR	Mean ±SD Median	Min-Max IQR	
Sn-Me	67.150±4.853 67.333	55.667–78.333 7.368	73.353±5.209 73.0	58.667–86.333 6.667	<0.001[a]
Sto-Me	44.280±8.400 45.667	18.0–69.0 5.667	50.468±5.640 50.667	18.333–59.333 4.856	<0.001[b]
Sn-Sto	23.209±7.044 21.667	16.333–49.667 3.667	22.917±3.765 22.667	15.0–51.724 2.833	<0.01 [b]
Ls-Sto	7.470±1.634 7.333	4.667–16.0 1.781	8.565±1.826 8.333	5.172–13.667 2.759	<0.001 [b]
Sto-Sm	17.183±2.094 17.0	12.667–27.667 2.471	18.373±2.531 18.333	13.0-25.0 3.667	<0.001 [b]
Li-Sto	9.925±1.208 10.0	6.667–12.667 1.356	10.492±1.929 10.667	6.333–15.517 3.00	<0.05 [b]
Sm-Me	28.899±3.670 29.0	15.333–36.0 4.333	32.491±3.302 32.759	24.333–40.333 4.833	<0.01 [a]

Table III. Verticale profile measurements in the area of the lower face. [a] Student's t test, [b] Mann Whitney-U test

RESULTS

The lower face vertical profile height measurements among different landmarks and the proportions calculated on the basis of such measurements are shown in Tables 3 and 4. A significant difference among sexes was found for all lower face measurements. For both sexes, the largest measurement was that of the lower face height (Sn-Me) and the smallest the upper vermilion height (Ls-Sto). The lower lip height (Sto-Sm) was greater than the upper (Sn-Sto). All values except the upper lip height were higher in males. All lower face measurements were different, with statistical significance, between the sexes (Table III).
The calculated height ratios and their comparison between sexes are shown in Table IV. All ratios, except Ratio 7, chin height / Height of mid-point between the lips and the chin were significantly different between male and female subjects. Ratio 1 and Ratio 4 comparisons between males and females were significant at a p<0.01 level, while the comparison for Ratios 2 (p<0.05), 3 (p<0.01), and 5 (p<0.05) was still significant, at the p<0.05 level. The smallest value for a ratio was for Ratio 4 in males (0.312±0.046) while for female subjects it was Ratio 1 (0.339±0.095). The highest, for both sexes, was Ratio 3.
The relationships among the different lower face height ratios were evaluated. Apart from an inverse correlation between chin height and lower third of face height, in all other ratios the two terms of the ratio showed a positive correlation to each other. The highest correlation in female subjects was between lower lip height and chin

height (Ratio 6), while in males it was between chin height and lower third of face height (Ratio 7). Correlations between Ratio1 (p=0.114), Ratio 3 (p=0.314) and Ratio 7 (p=0.882) for female subjects and Ratio 6 (p=0.508) in men were not statistically significant(Table IV).
The ratios of lower face were also evaluated; a statistically significant correlation was observed between upper vermilion height and upper lip height in male subjects (p<0.01). However no significant correlation was found for females. A significant correlation was also observed between upper vermilion height and lower lip height (p<0.001), and lower lip height and chin height (p<0.001) in males. However in female subjects not a significant correlation was observed between the above mentioned variables (Table V).

	Female(n = 95)		**Male**(n = 101)		**P**
	Mean ±SD Median	Min-Max IQR	Mean±SD Median	Min-Max IQR	
Ratio 1	0.339±0.095 0.344	0.126–0.727 0.092	0.379±0.085 0.373	0.147–0.648 0.119	<0.001 [a]
Ratio 2	0.440±0.113 0.431	0.269–1.067 0.111	0.473±0.114 0.463	0.262–0.951 0.161	<0.05 [a]
Ratio 3	0.763±0.188 0.731	0.469-1.548 1.079	0.834±0.195 0.816	0.472–1.474 0.241	<0.05 [a]
Ratio 4	0.347±0.111 0.321	0.254-0.892 0.639	0.312±0.046 0.310	0.237-0.691 0.031	<0.001 [b]
Ratio 5	0.411±0.141 0.374	0.271-1.019 0.061	0.368±0.067 0.362	0.256-0.768 0.054	<0.05 [b]
Ratio 6	0.606±0.122 0.591	0.40-1.196 0.136	0.571±0.097 0.570	0.339-0.844 0.119	<0.05 [a]
Ratio 7	0.690±0.236 0.637	0.311-1.625 0.057	0.654±0.134 0.638	0.522-1.655 0.065	0.954 [b]

Table IV. **Relationships between vertical profile measurements in the lower face.** [a] Student's t test. [b] Mann Whitney-U test.

DISCUSSION

Lower face height measurements were performed by the photometric method in this study. Different methods may be used for face measurements. The first is the direct height measurement by anthropometric procedure. This is a robust, simple and non-invasive method necessitating only minimal equipment. It demands, however, a certain amount of experience and it is impossible for other investigators to copy the procedure and reproduce the results (Bozkir et al, 2004; Fraser et al, 2003). Another procedure, based on analysis of photographs, uses indirect anthropometric and photogrammetric methods. Photographs are easy to obtain and provide a lasting record. Fewer measurements, however, maybe made with the direct method; errors are made in defining bony landmarks and measuring angles on a photograph may be difficult (Hauston et al, 1986). A third method is that of cephalometric imaging. The use of x-rays and the superposed, two-dimensional imaging of three-dimensional structures are seen as disadvantages of this method, which may lead to errors in analyzing soft tissue landmarks. A fourth method consists of obtaining the topographic data of the three-dimensional anthropometric face. This last method is relatively non-invasive (Jacobs, 2001; Legan and Burstone, 1980).
Several investigators dwelt on the differences between anthropometric and cephalometric measurements. Anatomic levels of anthropo-

metric and cephalometric landmarks have been measured in healthy patients and those of patients with facial abnormalities, and the relationships between the two analyzed (Arnett and Bergman, 1993; Nanda et al, 1990). Budai et al (2003) measured facial heights for landmarks they had defined in 306 subjects and calculated the rations, separately by anthropometric and by cephalometric methods, aiming to characterize differences. Comparison of the two sets of results showed significant differences for almost all measurements. The authors reported that cephalometric measurements were smaller than the anthropometric ones, while photogrammetric values were closer to the original (Budai et al, 2003; Liou et al, 2004).

	Gender	n	Spear. rho	p
Ratio 1	Male	101	0.267	<0.01
	Female	95	0.163	0.114
Ratio 2	Male	101	0.342	<0.001
	Female	95	0.366	<0.001
Ratio 3	Male	101	0.371	<0.001
	Female	95	0.105	0.314
Ratio 4	Male	101	0.625	<0.001
	Female	95	0.589	<0.001
Ratio 5	Male	101	0.557	<0.001
	Female	95	0.392	<0.001
Ratio 6	Male	101	0.067	0.508
	Female	95	0.656	<0.001
Ratio 7	Male	101	0.666	<0.001
	Female	95	- 0.015	0.882

Table V. The correlations between the components of the ratios

In our study, we used the affordable, easy method of digital photography and a magnification calibrated to the original values on the "Image J" software. The reliability of the above mentioned method had been proofed by Ferrario et al. (2003) and now is accepted as valid (Ferrorio et al, 2003). Advantages and limitations of photogrammetry of course should be taken in to consideration. However it is obvious that this method is ideal for calculating ratios. This method is also convenient for measuring angles since their measurement is not influenced by magnification (Farkas et al, 1980; Ferrorio et al, 2003). Knowledge of linear measurements and lower face ratios may provide valuable data for orthodontic and surgical planning aiming to modify facial heights. Deciding on the therapy without surgical intervention for moderate abnormalities thus becomes easier. It is also useful in deciding how to modify changes in the dimensions, foresee the result of surgical intervention or evaluating the effect of orthodontic treatment on the face (Park and Burstone, 1986).

In order to determine the morphology of lower face and to evaluate the dimensional and proportional values in the present study six anthropometric landmarks were used. Lower vermilion height was greater than the upper vermilion height both in male and female subjects. However significant difference was observed between the two sexes. Anić-Milosević et al (2008) also found the upper vermilion height to be smaller than the lower vermilion height similar with the findings of Bishara et al (1998). The difference between these values was greater in our study than reported by the other authors. They reported that this value was not detected to be different in males and females (Anić-Milosević et al, 2008).

All values except the upper lip height were, in the present study, higher in males than in females. When examining sex-related differences, all values revealed themselves as being higher in male subjects. Anić-Milosević et al.et al (2008) found a greater upper lip height in males than in females (23.55 and 20.57 mm, respectively, $p \leq 0.001$), and also reported that their result were similar with those of Park and Burstone (1986), Yuen and Hiranaka (1989), Arnet and Bergman (1993). Contrary to the results of the present study Anić-Milosević et al (2008) reported the ratio of upper vermilion height over lower vermilion height did not show any significant difference between males and females. Their remaining values were lower in the female than in the males, while in our study the upper lip height was greater in the female subjects. Thuy et al (2002) have performed and compared different measures of the face among Thailand Chinese and North American groups. Height of the lower face (Sn-Me) was 69.6 mm in the Chinese group, 67.5 mm in the Thai group. Anić-Milosević et al (2008) measured 71.16 mm in the males and 63.47 mm in the females. This value was 73.353±5.209 and 67.150±4.853 mm, in male and female subjects, respectively, in our study, similar with the results of both the latter mentioned reports.

The human face has dimorphic features between the sexes. Especially after puberty in males face bigger in size. The immunocompetence handicap hypothesis posits that testosterone is responsible for the development of male secondary sex traits but it also has a negative impact on the immune system. Therefore, only high-quality (i.e. healthy, good ‘genes’) men can afford to display these characteristics without suffering the costs of parasite loads (Karter et al, 1992). We found the Sto-Sm height to be smaller than Sn-Sto in both sexes, but with a wider difference in the female subjects. This result is compatible to those reported by Anić-Milosević et al (2008) but conflicting with those of Bishara et al (1998). There is a parallelism between our study and the report by Farkas et al (1980). We found the lower lip height (Sto-Sm) to be higher in the male subjects. The vertical face height was larger in males than in females as reported by Anić-Milosević et al (2008). Park and Burstone (1986) could not detect such a sex-dependent difference in vertical chin height. While studying facial heights, they found the subnasal to chin height (Sn-Me) to be greater in males. The lower face height (Sn-Me) was divided in three vertically aligned segments; the largest of these was chin height (Sm-Me) and the smallest lower lip height (Sto-Sm), similar with the findings of Farkas et al (1980). Budai et al (2003) performed measure-ements on the face to compare anthropometric and cephalometric measurements. The value that we determined for lower face height (Sn-Me) in female subjects (67.15±4.85 mm) was lower than the anthropometric measurement result and greater than the cephalometric one, while it was larger than what was found by both other methods in male subjects (73.35±5.21mm). Budai et al (2003) reported that the results obtained by these two methods were significantly different from each other. Upper lip height measurements, however, are similar to those in our study. We compared the Ratio 4 results, used by Budai et al (2003), to our study. This ratio by cephalometric measurements was higher than that of the present study (41.1 for females and 42.7 for males) but the one by anthropometric measurements was lower (females 36.2, males 35.2) (Budai et al, 2003; Bates and Cleese, 2001). Ratio 4 in our study was 37.7±0.11 in females and 31.2±0.05 in males, i.e. closer to the anthropometrically determined values.

In general, there is a great variability of the individual measurements, allowing great variation in proportions, which is one of the most important requirements for individuality (Legan and Burstone, 1980). The proportion of the lower face height is relatively constant throughout develop-ment (Farkas et al, 1980), but in patients with excessive lower face height, it is necessary to control the vertical dimension (Anić-Milosević et al, 2008).

Seven indexes have been determined in the study. Statistically significant differences were found for all parameters except Ratio 7. While Ratios 1, 2 and 3 were higher in male subjects, the reverse was true for Ratios 4, 5 and 6. Anić-Milosević et al (2008) reported, in their evaluation of ratios, that a sex-related difference was present for Ratio 3 only. The results were found to be compatible when comparing the values out of both studies. In Budai et al (2003) report Ratio 7 results were statistically different according to the anthropometric or cephalometric acquisition method (Budai et al, 2003). Even though close to the Ratio7 determined in our study, these values were somewhat smaller. Farkas et al (2005) divided the lower third of the face in three segments and reported lower lip height as the smallest of the three. That same study indicated that upper vermilion height was smaller than lower vermilion height in both sexes. Both these results are parallel to those of our study. Farkas et al (2005) found Ratio 5 to be greater in females than males (41.20 vs 39.70%, respectively). This result is different than reported by us and by Anić-Milosević et al (2008). The chin proportion in relation to the lower third of the face (Ratio 7) showed no sex-related differences. In males, the chin occupied 65.4% and 69.0% in females of the facial area below the labial fissure. Farkas et al (2005) found no gender differences (males 61.9%; females 62.9%).The percentage of the contribution of the upper lip height, chin height and lower lip height to the lower face height is very similar to those presented by Farkas et al (2005). As for Anić-Milosević et al (2008), they found a Ratio 7 of 58.75% in females and 60.21% in males, lower than our results.

Upper lip height, lower face height and chin height contribute in similar proportions to lower face height. Generally, a large variability of individual measurements entails a large variation in facial ratios, which is the most important requirement for individuality (Sönmez, 2001; Thuy et al., 2002; Yuen and Hiranaka, 1989).

Anthropometric measurements are useful not only in planning surgical interventions but also in evaluating the results of such interventions. Comparable, appropriate standards are neces-sary for surgery planning. To this end the first step is performing measurements in the patient, the second the comparison of first step data with the standard and the third the planning of surgical intervention using anthropometric results. Reconstructive operations aim to provide a functional and aesthetic correction for children and adults (Arnett et al, 1999; Park and Burstone, 1986).

In conclusion, besides playing an important role in orthodontic diagnosis and treatment planning, vertical factors and facial ratios also are very important for plastic surgeons in determining operational approaches, as they also are for personal identification. We believe that this study is of pioneering value in the absence of prior similar work on the Turkic race.

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