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Upper and Lower Lip Soft Tissue Thicknesses Differ in Relation to Age and Sex

Grosores de los Tejidos Blandos de los Labios Superior e Inferior Difieren en Relación con la Edad y el Sexo

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SUMMARY: This study was performed to determine age- and sex-related differences in lip thickness. Lateral cephalometric images of 220 healthy individuals were taken and the thicknesses of the upper and lower lips were measured. The measurements were performed in three different age groups. Our results indicate that the lower lip thickness, as well as the distance between the most anterior point of contact between the upper and lower lips and the most protruding point of the upper incisor teeth, differed between the two sexes. The lips of males were thicker than those of females. Receiver operating curve analysis was performed to determine the cutoff values to differentiate thickness between males and females. Our results showed that knowledge of upper and lower lips thickness in relation to age and sex may be beneficial to forensic anthropologists, to plastic and reconstructive surgeons, and to orthodontists for more detailed examination, effective treatment, and optimised outcomes.

KEY WORDS: Cephalometry; Cutoff value; Facial soft tissue; Lower lip; Upper lip.

INTRODUCTION

The lips, located in the middle portion of the face, are important structures that contribute to beauty. Although the concept of beauty has changed throughout centuries, it has always been a subject of interest and importance to every culture. In addition, a number of investigators have emphasised facial aesthetics, specifically highlighting the impact of the position of the lips (Park & Burstone, 1986; Czarnecki *et al*., 1993). Because the lips are located in the middle of the face, proportional and structural differences in this portion have significant effects on the general appearance of the face. Even a small disproportion of the lips may decrease the aesthetic quality of the face; thus, it is essential to determine the normal standardised measurements of the lips to use them to correct disproportions. In this way, one may determine whether a patient's measurements are within two standard deviations before proceeding with surgery (Farkas & Kolar, 1987).

These measurements are not only advantageous for planning surgery and orthodontic treatment but may also be utilised for analysing intervention results. In light of such information, numerous investigators have stated that soft tissue and lip thickness were important for determining the final facial profile of a patient after treatment. Orthodontists and plastic and reconstructive surgeons have indicated the importance of this information when planning treatment (Holdaway, 1983).

A number of factors, including bone structure, teeth, soft tissue thickness, ethnic and cultural origin, sex, and age, influence face and lip characteristics (Bergman, 1999). To date, no study in our country has investigated lip thickness in relation to age. However, soft tissue thickness and age-related changes should be taken into consideration when planning a treatment around the lips, particularly in childhood (Rhine & Campbell, 1980), with a focus on volumetric differentiation and shape differences. For instance, vermilion thickness increases with age in both sexes, and while the upper lip profile flattens in men, it becomes more apparent in women (Farkas & Kolar). In this regard, Angle showed the importance of soft tissue and facial aesthetics for orthodontic treatments, and indicated that facial harmony

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and balance had significant effects on beauty and the form of the mouth (Angle, 1907). In addition, facial tissue and lip thickness measurements constitute the basis for facial reconstruction in forensic anthropology (Dumont, 1986).

In this study, we measured the thicknesses of the upper and lower lips using cephalometric analysis to investigate sex differences in patients with Class 1 dental occlusion. Our study results may significantly contribute to clinical and surgical management by orthodontists and plastic surgeons.

MATERIAL AND METHOD

This study was conducted after obtaining approval (Project No: TF2013YL13). We investigated the cephalometric images of 220 individuals aged 16–74 years who visited orthodontic clinics with various complaints. All participants and their families lived in Anatolia and were Turkish. Of the 220 participants, 87 (39.9 %) were female and 133 (60.5 %) were male. All participants had Class 1 dental occlusion and acceptable facial profiles. We excluded those with a history of previous orthodontic treatment or surgery, congenital disorders, growth and developmental disorders, and history of facial trauma. Additionally, we enrolled patients with high-quality cephalometric images and without missing teeth.

We identified three soft tissue and three hard tissue reference points on the cephalometric images, and measured the corresponding upper and lower lip thicknesses. Table I and Figure 1 demonstrate these reference points. The participants were divided into three groups according to their age: Group 1 (6–19 years), Group 2 (20–25 years), and Group 3 (26–74 years).

All cephalometric X-ray images were saved to a computer in the TIFF format; parametric tissue measurements were analysed using Image-J software. The 'Set measurement' function was selected to calibrate each image before measurements were performed. First, the measurement setting was calibrated with the 1-cm measurement scale included in each image, and subsequently, the exact measurements of the distances were recorded in millimetres through the 'Analyze > Set' scale menu. Following this adjustment, the lip thicknesses were measured at six designated points, and the results were obtained using the 'Analyze/Measure' menu. All data were saved in Image-J and then transferred electronically to Microsoft Excel.

For repeatability confirmation, 15 % (36 cephalometric images) of the lateral cephalometric X-ray images of the participants were randomly selected, and the same investigator repeated all measurements one month later. The consistency between the measurements was assessed. The measurement repeating coefficients were calculated using the 'group correlation' coefficient 'r'; the consistency value ranged between 0.96 and 1.00. All measurements were found to be highly reliable. The results are summarised in Table II.

Statistical analysis. The data were evaluated for normality of distribution. For continuous variables with a normal distribution, independent groups were examined using the t-test and one-way analysis of variance (ANOVA). The Mann–Whitney U-test and the Kruskal–Wallis tests were used for continuous variables without normal distributions. Categorical variables were analysed using the Chi-square test. Receiver operating curve (ROC) analysis was performed to identify the cutoff values for continuous variables. The results are expressed as the mean ± standard deviation (SD) or the median (min-max), numbers, and percentages. A value of $P<0.05$ was considered to indicate statistical significance.

Table I. Anatomic localizations of cephalometric points, and distances for lower and upper lip thickness measurements

Upper lip	**Ls**	The point denoting the vermillion border of the upper lip in the midsagittal plane
Stomion	**St**	The most anterior point of contact between the upper and lower lips. When the lips are apart at rest, a superior and inferior stomion points can be distinguished
Lower lip	**Li**	The point denoting the vermillion border of the lower lip in the midsagittal plane
Prosthion	**Pr**	The most inferior anterior point on the maxillary alveolar process between the central incisors
U1	**U1**	The protruding end-point of the maxillary incisors
Infradental	**Id**	The most superior anterior point on mandibular alveolar process between the central incisors
Pr-Ls	The distance between the most protruding point of upper lip and prosthion	
U1-St	The distance between stomion point and the most protruding tip point of upper incisor tooth	
Id-Li	The distance between the most protruding point of lower lip and the Id	

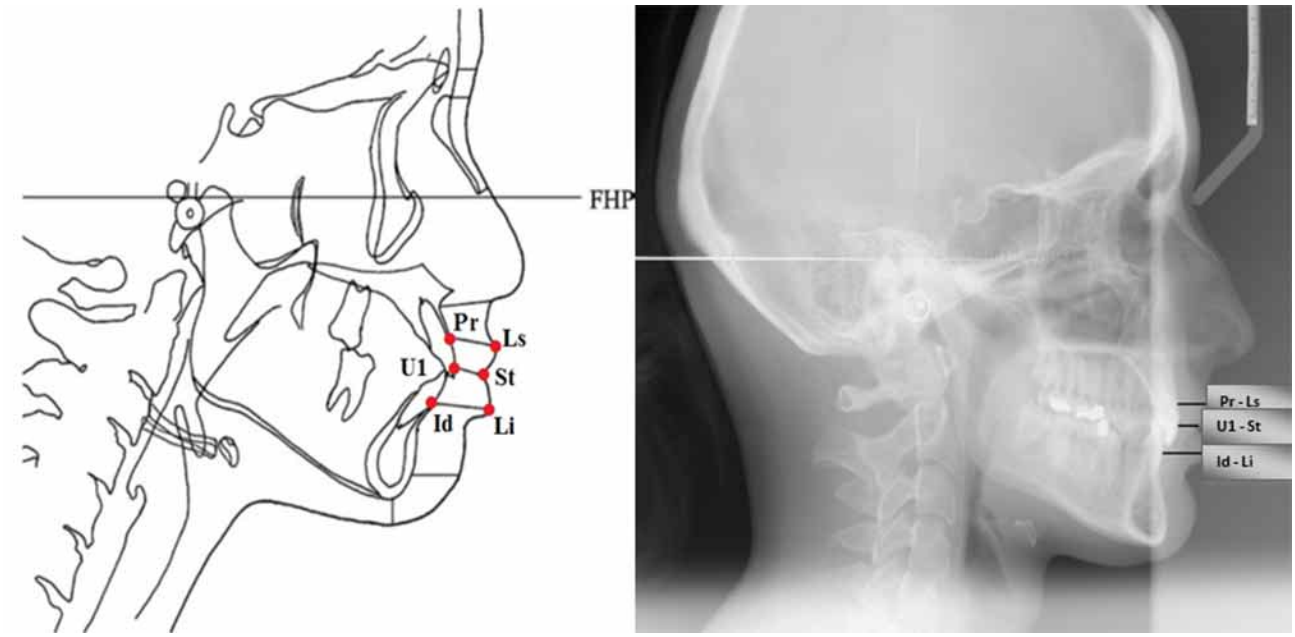

Fig. 1. The soft and hard tissue reference points, and the distances used for measurements on lateral cephalometric X-ray.

Table II. The correlation coefficients between the first and second measurements in terms of age and sex.

	Age	Pr-Ls*	U1-St*	Id-Li*
Group 1	16-19 (n=12)	0.98	0.98	0.99
Group 2	20-25 (n=12)	0.99	0.98	1.00
Group 3	26-74 (n=12)	0.99	1.00	0.96
Sex	Male (n=18)	0.98	0.99	0.97
Sex	Female (n=18)	0.99	0.98	0.97
	Total (n=36)	**0.99**	**0.99**	**0.98**

*Pr-Ls: The distance between the most protruding point of upper lip and prosthion, U1-St: The distance between stomion point and the most protruding tip point of upper incisor tooth, Id-Li: The distance between the most protruding point of lower lip and the Id.

RESULTS

A total of 220 (87 females, 133 males) cephalometric images were analysed. Of all participants, 25.0 % were in the 16–19 years age group (Group 1), 21.8 % were in the 20–25 years age group (Group 2), and 53.2 % were in the 26–74 years age group (Group 3) (Table III).

When we analysed all age groups for female and male upper lip thicknesses, there were no significant differences in Group 1 (P=0.051) (females: 23.2±4.1 mm, males: 23.2±4.1 mm). However, significant differences were observed in Groups 2 and 3 (P=0.0001). The upper lip thickness increased in men aged between 20 and 25 years, and it decreased after 25 years of age. On the other hand, the upper lip thickness decreased with increasing age in female patients (Table IV).

Analysis of the U1-St value in females and males showed that there was no significant difference in terms of sex in Group 1 (P=0.248), but significant differences were observed between females and males in Groups 2 and 3 (P=0.0001). Additionally, the U1-St value increased with age in both sexes, and the highest value was observed in Group 3 males (18.2±5.8 mm) (Table IV).

Analysis of lower lip thickness demonstrated that there was no significant difference between females and males in Group 1 (P=0.137); however, Groups 2 and 3 had significant differences in terms of sex (P=0.0001). Similar to the other two measurements (Pr-Ls and U1-St), there was no significant difference between the groups for females, but there was a significant difference for males (P=0.001) (Table IV).

ROC analysis. We performed ROC analysis to identify lip thickness cutoff values to distinguish females from males. The areas under curve (AUCs) for Pr-Ls, U1-St, and Id-Li were 0.79, 0.78, and 0.82, respectively (Fig. 2).

Table III. Age groups in relation with sexs

Age groups	Male n (%)	Female n (%)	Total n (%)
Group 1 (16-19 years)	20 (36.4)	35 (63.6)	55 (25.0)
Group 2 (20-25 years)	26 (54.2)	22 (45.8)	48 (21.8)
Group 3 (26-74 years)	87 (74.4)	30 (25.6)	117 (53.2)
Total	133 (60.5)	87 (39.5)	220 (100.0)

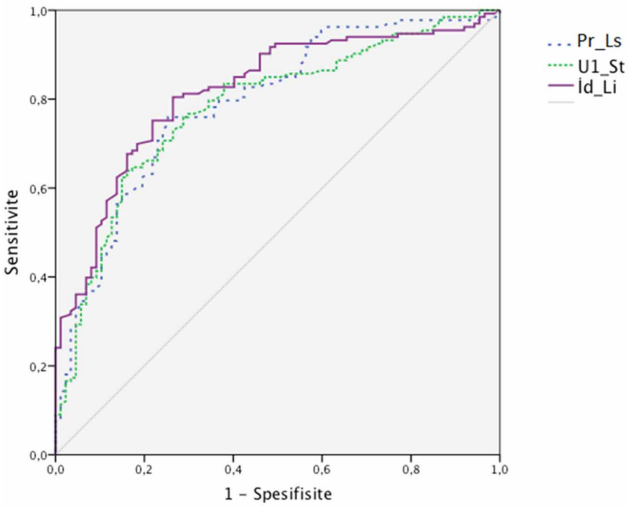

Fig. 2. ROC curve of upper lip (Pr-Ls), lower lip (Id-Li), and junction of upper and lower lips (U1-St) measurements regarding sex (Pr-Ls: The distance between the most protruding point of upper lip and prosthion, U1-St: The distance between stomion point and the most protruding tip point of upper incisor tooth, Id-Li: The distance between the most protruding point of lower lip and the Id).

Table IV. Distribution of Pr-Ls, U1-St, and Id-Li measurements in relation with age groups and sex.

	Age Group	Sex		Total (mm)	[1]p
		Male (mm) Mean±SD Median (Min-Max)	Female (mm) Mean±SD Median (Min-Max)	Mean±SD Median (Min-Max)	
Pr-Ls (mm)	**Group I**	25.9±6.2	23.2±4.1	24.2±5.1	0.051
	(16-19 years)	25.8 (14.2-35.7)	23.3 (15.1-31.2)	24.6 (14.2-35.7)	
	Group II	30.0±4.5	22.8±3.9	26.7±5.5	**0.0001**
	(20-25 years)	30.9 (21.3-39.7)	22.9 (17.0-29.7)	26.1 (17.0-39.7)	
	Group III	28.5±5.2	22.6±5.6	27.0±5.9	**0.0001**
	(26-74 years)	28.0 (18.8-41.4)	21.1 (16.4-36.2)	27.2 (16.4-41.4)	
	[2]p	**0.034**	0.895	**0.008**	
U1-St (mm)	**Group I**	11.7±4.0	10.6±3.4	11.0±3.7	0.248
	(16-19 years)	11.9 (4.4-18.1)	10.3 (3.8-18.3)	10.6 (3.8-18.3)	
	Group II	13.9±4.5	9.2±3.3	11.7±4.6	**0.0001**
	(20-25 years)	13.8 (6.4-24.1)	9.8 (4.2-14.2)	12.1 (4.2-24.1)	
	Group III	18.2±5.8	12.5±5.4	16.8±6.2	**0.0001**
	(26-74 years)	17.9 (6.8-32.4)	11.4 (6.0-24.8)	16.8 (6.0-32.4)	
	[2]p	**0.0001**	0.140	**0.0001**	
Id-Li (mm)	**Group I**	28.1±5.1	26.3±3.6	26.9±4.2	0.137
	(16-19 years)	29.6 (17.8-34.1)	27.0 (18.3-33.6)	27.2 (17.8-34.1)	
	Group II	30.0±3.0	24.7±2.4	27.6±3.8	**0.0001**
	(20-25 years)	30.0 (25.4-35.8)	24.7 (20.7-30.0)	26.8 (20.7-35.8)	
	Group III	32.3±5.1	26.2±4.4	30.8±5.6	**0.0001**
	(26-74 years)	31.7 (19.1-45.0)	25.9 (17.8-34.2)	30.8 (17.8-45.0)	
	[2]p	**0.001**	0.229	**0.0001**	

The cutoff values obtained by ROC analysis and the corresponding sensitivity and specificity values of the three parameters are shown in Table V. The cutoff values were as follows: 25.8 mm for Pr-Ls (71 % sensitivity, 77 % specificity), 12.3 mm for U1-St (77 % sensitivity, 70 % specificity), and 28.0 mm for Id-Li (81 % sensitivity, 74 % specificity). A measurement higher than the specified values indicates that the individual is male.

Table V. The cutoff values obtained by ROC analysis, and the corresponding sensitivity and specificity values for three parameters.

	Cutoff value	Sensitivity	Specificity
Pr-Ls*	24.0	0.80	0.60
	24.7	0.76	0.64
	24.8	0.76	0.66
	25.5	0.74	0.75
	25.8	**0.71**	**0.77**
	27.0	0.60	0.80
U1-St*	11.2	0.84	0.60
	11.8	0.80	0.66
	12.3	**0.77**	**0.70**
	12.7	0.74	0.72
	13.4	0.68	0.77
	13.8	0.65	0.80
	14.8	0.60	0.85
Id-Li*	26.7	0.85	0.60
	28.0	**0.81**	**0.74**
	28.1	0.78	0.74
	28.2	0.75	0.75
	28.8	0.73	0.78
	29.0	0.70	0.82
	29.6	0.65	0.84
	29.9	0.60	0.86

*Pr-Ls: The distance between the most protruding point of upper lip and prosthion, U1-St: The distance between stomion point and the most protruding tip point of upper incisor tooth, Id-Li: The distance between the most protruding point of lower lip and the Id.

DISCUSSION

In this study, we attempted to identify the age- and sex-related upper and lower lip soft tissue differences in individuals with normal growth and development who did not have previous orthodontic treatment or facial surgery.

Facial tissue thickness may be affected by environmental and genetic factors, and can also be impacted by age and sex (Williams *et al*., 1995; Smith & Buschang, 2001). The first study on this topic was performed by His *et al*., which investigated European men and women in 1885. Following that study, Kollman and Bruchly conducted similar studies in 1898 (Dumont). Michelow & Guyuron (1995) investigated the skeletal and soft tissue component measurements of the chin. Their results demonstrated that linear length was wider in men than women, all tissue thicknesses were significantly higher in men compared to women, and facial dimensions were proportional in both sexes (Michelow & Guyuron). In our study, the measurements of the three parameters demonstrated that the lip thickness values of men were higher than those of women. Furthermore, Pr-Ls were significantly different in all age groups.

In our study, the thickness of the upper and lower lips increased with age in all groups, and this increase was more significant in men ≥ 25 years of age. el-Batouti *et al*. (1994) investigated Norwegian children aged 6–18 years and demonstrated that facial parameters were different between females and males during the same growth period. In that study, facial height increased more in males between 6–18 years, and the sex differences were more apparent after 12 years of age (el-Batouti *et al*.). The results of the aforementioned study and our results are very similar. In our study, the thickness of the upper and lower lips was greater in men. There was no significant difference between thicknesses in Group 1, whereas Groups 2 and 3 demonstrated significant differences between sexes (upper lip thickness: Group 1, P=0.051; Group 2, P=0.0001; Group 3, P=0.0001; and lower lip thickness: Group 1, P=0.137; Group 2, P=0.0001; Group 3, P=0.0001).

Bishara *et al*. (1998) investigated the soft tissue profile changes of subjects aged 5–45 years and demonstrated that the majority of soft tissue profile changes in women were observed between 10 and 15 years of age, whereas they occurred between 15 and 25 years of age in men. The authors stated that the upper and lower lips protruded the most in relation to the aesthetic plane between 15 and 25 years of age (Bishara *et al*.). In our study, the majority of tissue thickness changes were observed between 16–19 years in females, and after 26 years in males. Formby *et al*. (1994) analysed the longitudinal growth changes in Class 1 individuals comprising 24 men and 23 women aged 18–42 years. They reported that lower lip thickness increased and upper lip thickness decreased with age. They also stated that hard tissue changes were finalised in men by 25 years of age, while soft tissue changes continued after 25 years of age, similar to the changes observed between 18 and 25 years. However the authors showed that both hard and soft tissue changes continued with an increasing fashion after 25 years as compared to the 18–25 year period in women (Formby *et al*.). In our study, we found similar results for upper lip

thickness values; upper lip thickness increased in both sexes until 25 years of age, but decreased between 26–74 years. However, this was not true for lower lip thickness.

In addition to other parameters, Basciftci *et al*. (2004) measured Pr-Ls in a study investigating Class 1 individuals. The mean upper lip thickness was 15.22±2.39 mm in men and 12.58±2.30 mm in women (mean age 22.61 years); there was a statistically significant difference between the sexes (Basciftci *et al*.). In our study, the participants in Group 2 (20–25 years), showed greater values compared with individuals in the study by Basciftci *et al*., and there was a significant difference between the two sexes. Mohammed *et al*. (2011) investigated cephalometric images of 60 Malaysian (30 females and 30 males) individuals aged 20–24 years. In our study, the lower lip was thicker than the upper lip in Groups 1 and 3 in both sexes; however, the two lips had similar measurements in male individuals (Pr-Ls: 30.0±4.5 mm; Id-Li: 30.0±3.0 mm) and the thickness of the upper and lower lips was different in Group 2 females (Pr-Ls: 22.8±3.9 mm; Id-Li: 24.7±2.4 mm). Kalha *et al*. (2008) investigated the soft tissue thickness of 60 individuals (30 males, 30 females) from South India. Similar to our results, they found that upper and lower lip soft tissue thickness was significantly higher in males compared with females (Kalha *et al*.).

Similar to our study, some researchers have highlighted the importance of sex on soft tissue thickness (Chaconas & Bartroff, 1975; Kurkcuoglu *et al*., 2011a, 2011b) while others have not (Bishara *et al*.). Our results in Groups 1 and 2 were similar to the results of the studies performed with other ethnic groups in terms of the greater thickness of the lower lip, compared with the upper lip. In addition, the thickness of the upper lip was greater in men than women in our study and in previously reported studies performed on different ethnic groups.

We found that the cutoff values of three lip thickness parameters obtained using ROC analysis were good statistical indicators to differentiate between sexes. We were unable to compare our results with those of other studies, as we are the first study to report cutoff values. However, our results enable prediction of sex with a high specificity and high sensitivity, and may provide a basis for future studies. In addition, we believe that our results will be useful for performing and analysing the results of facial surgical procedures to correctly determine facial harmony, for chin surgery and aesthetic procedures, and for diagnosis and treatment.

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KARACA BOZDAG, Z.; KURKCUOGLU, A.; USTDAL, A.; CAM, Y. & OGUZ, O. Grosores de los tejidos blandos de los labios superior e inferior difieren en relación con la edad y el sexo. *Int. J. Morphol., 35(2)*:852-858, 2017.

RESUMEN: Este estudio se realizó para determinar las diferencias en el grosor de los labios relacionadas con la edad y el sexo. Se tomaron imágenes cefalométricas laterales de 220 individuos sanos y se midió el grosor de los labios superior e inferior. Las mediciones se realizaron en tres grupos de edades diferentes. Nuestros resultados indicaron que el grosor del labio inferior, así como la distancia entre el punto más anterior de contacto, entre los labios superior e inferior y el punto más sobresaliente de los dientes incisivos superiores, difieren entre los dos sexos. Los labios de los hombres eran más gruesos que los de las mujeres. Se realizó un análisis de la curva de operación del receptor para determinar los valores de corte para diferenciar el espesor entre hombres y mujeres. Nuestros resultados demostraron que el conocimiento del grosor de los labios, superior e inferior, en relación con la edad y el sexo puede ser beneficioso para los antropólogos forenses, cirujanos plásticos y reconstructivos y para los ortodoncistas al momento de realizar un examen detallado, e implemantar un tratamiento más eficaz, alcanzando resultados optimizados.

PALABRAS CLAVE: Cefalometría; Descuento del valor; Tejido blando facial; Labio inferior; Labio superior.

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