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SEX-RELATED DIFFERENCES IN THE ORBITAL AREA OF BULGARIANS – A 3D LASER SCANNING

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Abstract

The present study aimed to provide up-to-date information on normal sex-related dimensions of the orbital region in young Bulgarian adults, using a 3D laser scanner. The three-dimensional coordinates of several soft-tissue landmarks on the orbits and face were obtained using a hand-held laser scanner (FastSCAN Cobra, Polhemus Inc, Colchester VT) in 95 healthy individuals (46 males and 49 females) of Bulgarian origin aged 21–30 years. From the landmarks outer and intercanthal widths, length of eye fissure, and height of the orbit were calculated and averaged for sex. The data were analyzed using descriptive statistics and paired t-test. Statistically significant difference was found in outer canthal width, both eyes fissure length, and orbital height between sexes. The differences in the inner canthal width did not reach statistical significance ($p > 0.05$). The data of the present study could serve as a quantitative characteristic of human orbital morphology. Forensic applications, evaluations of traumas, craniofacial alterations, and facial reconstruction may also benefit from the data.

Key words: Bulgarians, 3D laser scanning, orbital measurements

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Introduction. Facial morphology comprises a variety of complex characters, each influenced by genetic and environmental factors. Sex, ethnicity, race, climate, nutrition, genetic constitution, and socioeconomic status have their impact on facial development and maturation. Cephalometry is a branch of anthropometry that deals with the measurement of the head and face of living humans and cadavers. William Downs (1948) is recognized as the pioneer of cephalometric analysis and over the subsequent years, several methods of cephalometric analysis have been recommended [1]. Direct facial anthropometry is considered the gold standard in the methods of evaluation of facial dimensions. Cephalometry is a branch of physical anthropology that, through a set of standardized anthropological methods of measurement and description, analyzes the human head and its parts. To quantify facial features, landmarks have been traditionally used, taken either directly from the face or derived from photographs or radiographs. These landmarks are defined by identifiable/describable facial features, e.g., nasion, inner/outer canthi, commissures that can generate Euclidean distances, angles, and ratios [2–4]. Numerous studies conducted among adolescents and young Bulgarian men and women aimed to identify facial changes occurring during growth, and the presence of sexual dimorphism and make a quantitative analysis of individual facial areas. Direct classical cephalometry was the primary method used in the studies. The measurements were taken directly from the individuals with a set of anthropometric measuring tools [5, 6].

With the advent of new computer technology, it has become possible to obtain three-dimensional digital images of the face. Digital computerized cephalometry provides fast, non-invasive collection of three-dimensional data in digital format, which allows the creation of an electronic database. Scientific literature shows numerous studies containing reference data characterizing the face and facial regions in different ethnic groups and races [7, 8]. Age, sex, and ethnic characteristics of the various components of the orbital region have been assessed in a few recent studies [9, 10]. Similar data have not been published for the Bulgarian population so far. Anthropometric data characterizing the soft tissues in this facial area can be used in various clinical disciplines, e.g., ophthalmology, maxillofacial and reconstructive surgery, and forensic medicine. The present study aimed to provide up-to-date information on normal sex-related dimensions in individuals of Bulgarian ancestry, using a 3D laser scanning method.

Material and methods. ***Subjects.*** Ninety-five healthy Bulgarians (46 males and 49 females) aged 21–30 were enrolled in the study. Subjects with different ethnicity, history of facial injury, craniofacial anomalies, and mental disorders were excluded from the study.

Method. Collection of three-dimensional landmarks: Three-dimensional images were obtained using a hand-held laser scanner (FastSCAN Cobra, Polhemus Inc., Colchester VT). The scanner incorporates motion-tracking technology to achieve a 3D computer reconstruction of the subject's face. Two sensors, one

attached to the optics and another to a headband, are used to track both the position of the optics and any movement of the subject's head. Following instructions to keep eyes (for safety) and mouth (for uniformity) closed and to maintain a blank expression, the stripe of low-intensity laser light is manually swept smoothly over the subject's face. Four vertical sweeps are generally used to record the entire facial surface. Captured data are postprocessed to produce a single surface dataset; postprocessing parameters can be varied to alter the resolution of the final surface [11].

A set of anthropometric landmarks were placed bilaterally on each of the obtained images: exocanthion – (ex_r, ex_l); endocanthion – (en_r, en_l); orbitale – (or_r, or_l) and orbitale superius – (os_r, os_l) [12]. The procedure was performed by a single operator (Fig. 1).

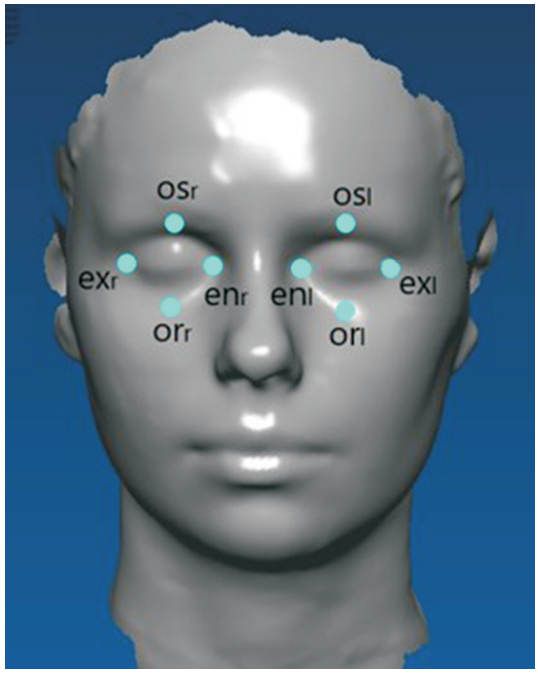

Fig. 1. Cephalometric points

Data analysis: Using these three-dimensional landmarks the following linear distances were measured (mm): eye fissure length ($en_r - ex_r$, $en_l - ex_l$), inner canthal width ($en_r - en_l$), outer canthal width ($ex_r - ex_l$), orbital height ($or_r - os_r$, $or_l - os_l$) (Table 1, Table 2).

Statistics. The measurements were analyzed with SPSS 23.0 using Student's t-test and paired t-test. The level of statistical significance was set at $p < 0.05$. The level of significance was considered weak ($p < 0.05$), moderate ($0.01 > p > 0.001$) or high ($p < 0.001$).

The study was approved by the Ethics Committee at the Medical University-

Table 1

Description of the anthropometric landmarks in the orbital region

Landmarks	Description
Endocanthion – (en_r, en_l)	The point located on the inner corner of the eye of each eye fissure
Exocanthion – (ex_r, ex_l)	The point located on the outer corner of the eye of each eye fissure
Orbitale – (or_r, or_l)	The point located at the lowest level of the infraorbital margin
Orbitale superius – (os_r, os_l)	The point located at the highest level of the supraorbital margin

Table 2

Description of the anthropometric measurements in the orbital region

Measurements	Description
Inner canthal width ($en_r - en_l$)	The linear distance between the two points endocanthion – right and left
Outer canthal width ($ex_r - ex_l$)	The linear distance between the two points exocanthion – right and left
Eye fissure length ($en_r - ex_r$, $en_l - ex_l$)	The linear distance between the endocanthion and exocanthion points on the left and right (en – ex)
Orbital height ($or_r - os_r$, $or_l - os_l$)	The linear distance between the points orbitale superius and orbitale on the left and right (os – or)

Plovdiv (protocol No. 3/07.04.22). All participants gave their written informed consent following the Declaration of Helsinki 1964.

Results. Statistically strong significant differences ($p < 0.001$) were found in three of them: outer canthal width ($ex_r - ex_l$), length of the right ($ex_r - en_r$) and left ($ex_l - en_l$) eye fissure. Weak significant differences were found in the height of right ($or_r - os_r$) and left orbit ($or_l - os_l$) ($p < 0.05$). The difference in the inner canthal width ($en_r - en_l$) between the genders did not reach statistical significance ($p > 0.05$).

The greatest difference between men and women was found in the outer canthal width – 4.26 mm, and the smallest in the inner canthal width – 0.55 mm. (Table 3).

Discussion. The data available in the literature characterizing the facial morphology of the Bulgarian population are part of anthropological studies performed through classical direct anthropometry. No reference values using new digital technologies that provide three-dimensional data for assessment of the soft tissue facial profile have been created which would serve in different clinical disciplines. Hence, out recent 3D study with laser scanning of the orbital region and sexual dimorphism in the measurements accords with the necessity of obtaining new reference values for the young Bulgarian population.

Table 3

Comparison of the anthropometric measurements of the orbital region between Bulgarian men and women

Variable (mm)	Sex	Mean	SD	Min	Max	Statistical significance
$en_r - en_l$	men	34.14	3.17	27.57	41.69	$p > 0.05$
	women	33.59	2.74	27.72	40.48	
$ex_r - ex_l$	men	98.85	5.00	89.05	113.72	$p < 0.001$
	women	94.59	4.04	84.32	103.54	
$ex_r - en_r$	men	34.44	2.43	28.83	39.05	$p < 0.001$
	women	32.48	1.84	28.13	36.66	
$ex_l - en_l$	men	33.38	2.45	28.19	39.33	$p < 0.001$
	women	31.56	2.39	25.58	37.04	
$os_r - or_r$	males	32.70	2.93	27.33	41.04	$p < 0.05$
	females	31.44	2.38	26.59	35.83	
$os_l - or_l$	males	32.75	2.91	27.33	41.04	$p < 0.05$
	females	31.38	2.39	26.59	35.83	

Statistically significant difference between men and women was found in measurements of the region except the inner canthal width. Lack of statistically significant difference in this indicator was also reported by Skomina et al. in Slovenian [13], Sforza et al. in the Sudanese [10], Tuncer in Turkish [14], Bayat et al. in Iranian [15], Junqueira et al. in Brazilian [8], and Othman et al. in Malaysian [16] population.

The values obtained by us for the inner canthal width (34.14 mm) in men are close to those found in Slovenian (34.9 mm) [13] and Italian (34.69 mm) [7] men. Smaller inner canthal width was found in Turkish (33.16 mm) [14], Spanish (32.52 mm) [17], and Egyptian (33.8 mm) [18] men. The largest values of the indicator were found in Chinese (40.61 mm) [9] and Malaysian (35.74 mm) [16] men.

In women, values close to ours (33.59 mm) were reported by Celebi et al. [7] in Italian (33.23 mm) women. Of all the studies cited, larger inner canthal width was found in the Slovenian (34.4 mm) [13], Egyptian (34.63 mm) [7], Malaysian (35.03 mm) [16], and Chinese (38.27 mm) [9] women.

Our values for outer canthal width (98.85 mm) agree with those of Egyptian males (98.6 mm) [18]. Significantly larger values were found in Sudanese men (111.5 mm) [10], and smaller in Brazilian (88.85 mm) [8] and Spanish (90.40 mm) [17] men.

The results obtained by us for this indicator in women (94.59 mm) are close to those obtained in Egyptian (95.8 mm) [18] women, but smaller than the results in Sudanese women (101.1 mm) [10]. In Italian (90.2 mm) [19], Spanish (86.58 mm) [17], Brazilian (85.98 mm) [8], Iranian (80.19 mm) [15], and Chinese (88.39 mm)

[9] women the values of the outer canthal width are smaller. Sexual dimorphism was found in our and all studies cited, except the study by Bayat et al. in Iranian men and women [15].

Our results for the length of the right eye fissure in men and women (34.44 mm vs. 32.48 mm) are consistent with those obtained in Italian men and women (33.4 mm vs. 32.3 mm) [19]. Significantly smaller values were found in Slovenian (27.8 mm vs. 27.3 mm) [13], Iranian (29.55 mm vs. 29.54 mm) [15] and Chinese (27.64 mm vs. 26.04 mm) [9] men and women. The widest right eye fissures (48.0 mm vs. 41.4 mm) were reported in Sudanese men and women [10]. Men presented with larger values of eye fissure than women in our and the cited studies, with the difference reaching statistical significance. No sexual dimorphism was found in the Slovenian [13] and Iranian [15] populations.

The smallest length of the left eye fissure was found in Chinese men and women (27.07 mm vs. 25.37 mm, respectively) [9] and Slovenian men and women (28.2 mm vs. 27.7 mm, respectively) [13], and the largest in Sudanese men and women (43.3 mm vs. 37.1 mm, respectively) [10]. Statistically significant difference was not found in the Slovenian [10] and Italian [7] populations.

The height of the right orbital entrance in our study (32.70 mm vs. 31.44 mm) is close to those of Egyptian males and females (32.5 mm vs. 32.1 mm, respectively) [18], but smaller than the findings in the Italian population (34.2 mm vs. 32.7 mm) [19]. Significantly larger height of the orbital entrance was found in Sudanese men and women (45.8 mm vs. 43.5 mm, respectively) [10]. Sexual dimorphism in this indicator was found in all populations, except Egyptian men and women [18].

Conclusion. The contemporary data obtained by 3D laser scanning method characterize the morphology of the orbital area and can be used for evaluation of facial growth of healthy individuals, abnormalities in various genetic diseases, and as a reference for reconstructions in aesthetic and reconstructive surgery.

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