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Morphometric Analysis of the Orbital Area in Young Bulgarians with 3D Laser Scanning

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The present study aimed to make a 3D morphometric analysis of the orbital area in young Bulgarians. The study included 95 healthy individuals (46 males and 49 females) of Bulgarian origin aged 21-30 years. Three-dimensional coordinates of soft-tissue landmarks were determined in the orbital area using hand-held laser scanner. Using the landmarks outer canthal and intercanthal distances were measured. The individuals were categorized according to the measurements obtained for each distance. In the intercanthal distance most of the males were in the category middle and females in the category narrow. In the outer canthal distance most of the males were in categories wide and very wide and females in the category wide. Statistically significant differences between sexes were found in three categories of the outer canthal distance – middle, wide and very wide ($p<0.05$). The method provides quantitative information for anatomical and anthropometric descriptions, medical evaluations, and forensic medicine.

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

Introduction

The age, gender, and ethnic characteristics of the various components of facial morphology have been the subject of numerous anthropometric studies aimed to create a database that will be useful for scientists or other medical professionals. Many of the studies are focused on the study of the orbital area. Orbitofacial anthropometry plays a key role in the assessment of dysmorphic syndromes, hypertelorism, facial injuries, in the diagnosis of abnormalities of the neural crest [11]. Deference values characterizing

this area have been established for different ethnic groups and races: Chinese men and women [5], Italian [3, 12], Sudanese, [13], Egyptian [1], Indian [11], Pakistani [4] and Turkish [2]. Data on the morphology of the orbital region in different age groups of the Bulgarian population were obtained by the methods of classical direct cephalometry [6, 7, 8,17]. In this method, the measurement in the orbital area is applied with the help of sliding calipers. Measurements with such sharp instruments near the orbital region may pose some risk, especially when interacting with examinations in very young or non-connecting patients [5]. With the advent of new computer technologies, it is possible to create three-dimensional digital images of the face, in which it is possible to make a quantitative analysis of the volume and area of individual facial structures – eyes, nose, mouth and lips, chin and ears. Digital cephalometry is a fast and non-invasive method that avoids the compression of soft tissues, the possibility of making mistakes when repeatedly collecting data from the subjects. [14]. Different methods for acquiring digital images are used in other areas of physical anthropology, such as craniometry [9, 10] and forensic medicine [16]. The **aim** of this study is to make a morphometric characteristic of the orbital region and to report the most common orbital categories among young Bulgarians using 3D laser scanning.

Material and Methods

Subjects: Ninety-five healthy Bulgarians (46 males and 49 females) aged 21-30 years were included in the study. Individuals with ethnicity different from Bulgarian, history of facial injury, craniofacial anomalies and mental disorders were excluded from the study. The participants were previously informed about all the procedures and gave their consent to participate in the study.

Collection of three-dimensional landmarks: Three-dimensional images were obtained using a hand-held laser scanner (FastSCAN Cobra, Polhemus Inc., Colchester VT). On each of the obtained images a set of 3D anthropometric landmarks were placed bilaterally: exocanthion – (ex_r, ex_l); endocanthion – (en_r, en_l) [15] (**Table 1**). The procedure was performed by a single operator (**Figure 1**).

Table 1. Description of the landmarks

Landmarks	**Description**
Endocanthion – (en_r, en_l)	The point located on the outer corner of the eye of each of the eye fissure.
Exocanthion – (ex_r, ex_l)	The point located on the inner corner of the eye of each of the eye fissure.

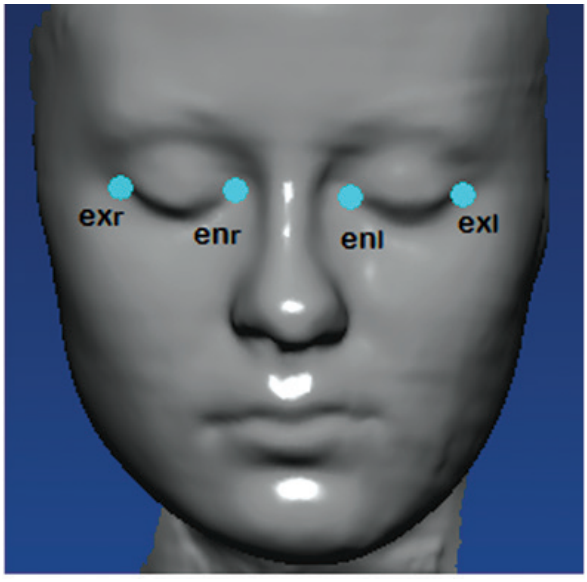

Fig. 1. Three-dimensional images.

Data analysis: Using these three-dimensional landmarks the intercanthal distance (en_r – en_l) and outer canthal distance (ex_r – ex_l) were measured (mm) (**Table 2**). Based on the measurements obtained for the intercanthal distance (en-en) the individuals were divided into five groups (after M. Popov)(cited by 17):

– very narrow	x-27 mm
– narrow	28-33 mm
– middle	34-39 mm
– wide	40-45 mm
– very wide	46-x mm

Based on the values obtained for the outer canthal distance (ex-ex) the individuals were divided into five groups (after M. Popov):

– very narrow	x-69 mm
– narrow	70-79 mm
– middle	80-89 mm
– wide	90-99 mm
– very wide	100-x mm

Statistics: Data were analyzed using descriptive statistics (mean±standard deviation / proportion±standard error), t-test (numeric variables) and z-test (categorical variables). Level of significance was set at $p<0.05$.

Table 2. Description of the measurements

Measurements	**Description**
Intercanthal distance (en_r-en_l)	The linear distance between the two points endocanthion – right and left
Outer canthal distance (ex_r-ex_l)	The linear distance between the two points exocanthion – right and left

Results

The results of the categorization in the outer canthal and intercanthal distance for males and females are shown in **Tables 3-5**.

In the intercanthal distancemost of the males fell in the categories middle and narrow (54.3%and 41,3%, respectively). In the category wide intercanthal distancemales appeared in small percentage (4.3%). No individuals fell in the categories very narrow and very wide intercanthal distance. Most of the females were in the categories narrow (53.1%) and middle (44,9%).Only 2,0% of the females fell in the category wide and none in the categories very narrow and very wide. No statistically significant difference in the categories was found between males and females ($p > 0.05$).

The results from the categorization of the outer canthal distance in males showed that most of them fell into the categories wide and very wide (52.2% and 45.7%, respectively). The percentage of subjects in the category middle was small (2,0%), and no subjects were found in the categories narrow and very narrow.

In the females most of the subjects were in the category wide (75,5%). In the categories middle and very widethe females appeared in close percentages (14,3% and 10,2%, respectively). No subjects fell in the categories narrow and very narrow. Statistically significant differences between both sexes were found in three of the categories – middle, wide, and very wide ($p<0.05$).

Table 3. Linear measurements in the orbital region

Variable (mm)	**Sex**	**Mean**	**SD**	**Min**	**Max**	**Statistical significance**
Intercanthal distance **en_r-en_l**	males	34,14	3,17	27,57	41,69	p>0,05
	females	33,59	2,74	27,72	40,48	
Outer canthal distance **ex_r-ex_l**	males	98,85	5,00	89,05	113,72	**p<0,001**
	females	94,59	4,04	84,32	103,54	

Table 4. Intercanthal distance (enr-enl). Distribution of the individuals into categories (after M. Popov)

Categories	Males %	Females %	p
very narrow	0	0	p> 0,05
narrow	41,3	53,1	p> 0,05
middle	54,3	44,9	p> 0,05
wide	4,3	2,0	p> 0,05
very wide	0	0	p> 0,05

Table 5. Outer canthal distance(exr-exl). Distribution of the individuals into categories (after M. Popov)

Categories	Males %	Females %	p
very narrow	0	0	p> 0,05
narrow	0	0	p> 0,05
middle	2,2	14,3	**p< 0,05**
wide	52,2	75,5	**p< 0,05**
very wide	45,7	10,2	**p< 0,05**

Discussion

The results obtained by us in the distribution by categories showed that most of the males were with middle intercanthal distance and females with narrow. In both sexes, the subjects did not fall into the extreme categories very wide and very narrow. Most of the females presented with wide outer canthal distance, while males presented with close values for the categories wide and very wide. Statistically significant difference in the distribution by categories between sexes was found in the outer canthal distance.

To validate the three-dimensional (3D) laser scanning system in recording the facial morphology, the results of our study were compared with the results of a national study (17) including adult individuals of Bulgarian origin, aged between 30 and 40 years. The validation was performed in three aspects including accuracy, precision and reliability.

In the intercanthal distance in both studies most of the males fall into the category middle, 54.3% and 56.7% respectively. In the category narrow males appear in close percentages (41.3% and 35.4%, respectively). The percentage of males in the category wide is low – 4.3% in our study and 5.7% in the control study. In both studies, no males fall into the category very wide.The highest percentage of males and females fell into the categories narrow and middle intercanthal distance. The females are in high percentage in the category narrow – 53.1% in our study and 49.0% in the control study. In the category middle intercanthal distance the percentages of the females were 44.9% and 44.7%, respectively. In the category wide intercanthal distance the percentage of females was very low in both studies (2.0% and 1.6%, respectively). In both studies, no females fell in the category very wide intercanthal distance and 4.7% of females from the previous study fell into the category very narrow.

In the outer canthal distance in both studies, the most of the males fall into two of the categories – wide and very wide. In the category very wideouter canthal distance the percentage of males in our study is 45.7%, and 43.4% in the control study. In the category wideouter canthal distance males appear equally in both studies – 52.2%. The percentage of males in the category middle outer canthal distance is very low -2.2% in our and 4% in the control study. In both studies no subjects are found in the categories very narrow and narrow. In the females most of subjects in both studies fall into the category wide outer canthal distance – 75.5% in our study and 65.4% in the control study. In the categories middle and very wide intercanthal distance, the percentages of females are lower in both studies. In the category of middle outer canthal distance the females appear in 14.3% in our study and in 18.1% in the control one, and in the category very wide in 10.2% and 16.2%, respectively. In both studies, no females fall into the category very narrow, while in the category narrow, no subjects are found in our study and only 0.2% of the subjects in the control study.

Conclusion

The categorization in the outer canthal distance shows that most of the males and females are with wide outer canthal distance. In terms of intercanthal distance most of the males fall in the category middle, and females in the category narrow. Sexual dimorphism is found only in the outer canthal distance. The results of the categorization are similar with the literature data for both sexes suggesting that the 3D laser scanning system is accurate, precise, and reliable to record the facial morphology for both clinic and research purposes.

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