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Orbital and periorbital anthropometric variations and effect of age and gender on these variables

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ABSTRACT

BACKGROUND: The objective of this study was to identify the orbital and periorbital anthropometric variations and determine the effects of age and gender on these variables. From January 2020 to July 2020, we conducted a hospital-based, descriptive, observational study.

MATERIAL AND METHODS: Three hundred and eighty individuals of age15 years and above were included in the study. Exophthalmometric value (EV) and outer inter-canthal distance (OICD) were measured [mm] on Hertel's exophthalmometer. Inner inter-canthal distance (ICD), inter-pupillary distance (IPD) [mm], palpebral fissure width (PFW), palpebral fissure height (PFH), marginal reflex distance 1 (MRD1), marginal reflex distance 2 (MRD2), lid crease height (LC), pre-tarsal show (PTS) and levator function (LF) were recorded using a millimeter ruler scale. Data were analyzed using a Microsoft Excel sheet.

RESULTS: Out of 380 subjects, there were 222 females and 158 males. Mean EV was 15.86 mm, OICD — 105.57 mm, ICD — 31.7 mm, IPD — 59.55 mm, PFW — 29.7 mm, PFH — 10.04 mm, MRD1 — 4.21 mm, MRD2 — 5.87 mm, LC — 8.31 mm, PTS — 4.24 mm and LF —14.66 mm. Significant sexual dimorphism was noted in five parameters; EV, ICD, IPD, PFH and MRD2 were significantly higher in males versus females. PFH was decreased while PTS was increased in individuals of more than 40 years.

CONCLUSION: There is a significant difference between males and females in some variables, and no difference was detected in others. Age did not significantly affect a majority of the variables.

KEY WORDS: orbit; anthropometry; exophthalmometry; marginal reflex distance

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INTRODUCTION

Orbit and periorbital area are essential for their cosmetic value and functional relevance. Their dimensions are of cardinal significance in ophthalmology, reconstructive and plastic surgery. These landmarks are also considered in the evaluation of racial descent because this area, with its characteristic features and proportions, is genetically determined [1]. These values also show changes with age and gender. Another importance of these measurements is the use in the manufacture of lenses and spectacles. In ophthalmology, diagnosis and management of pto-

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sis, microphthalmia, hypertelorism, telecanthus, and other congenital and acquired dysmorphologies require these measurements. Other orbital and periorbital disorders are typically associated with specific diseases; e.g., small palpebral fissure width is associated with fetal alcohol syndrome. Anthropometry is also of importance in forensic medicine. Because of its importance, normative data for orbital and periorbital anthropometry has been studied in different races.

There are three types of periorbital anthropometry: anthropometry of the bony orbit, periorbital soft tissue, and ocular projection. Bony orbital anthropometry includes measurement of inner inter-canthal distance (ICD), outer inter-canthal distance (OICD), and inter-pupillary distance (IPD). Periorbital soft tissue anthropometry encompasses position of eyelids, eyelid skin crease, the height of eyebrows, palpebral slant angle, the position of the medial and lateral canthi, epicanthal folds, horizontal palpebral fissure/palpebral fissure width (PFW), and vertical palpebral aperture/palpebral fissure height (PFH). Additional measurements include margin reflex distances (MRD1 and MRD2) and levator function (LF). Ocular projection is used in the assessment of orbital diseases [2]. Methods used for these measurements are manual anthropometry, two-dimensional (2D), three-dimensional (3D) photogrammetry, and 3D computed tomography (3D-CT) scan [3].

The rationale of this study was to provide a normative dataset, which can serve as a reference for oculoplastic and plastic and posttraumatic surgical interventions.

The objectives of this study were to identify the orbital and periorbital anthropometric variations in patients presented to the hospital and determine the effects of age and gender on these variables.

MATERIAL AND METHODS

Three hundred and eighty individuals aged 15 years and above visiting a hospital with problems other than the orbital and oculoplastic diseases were included. Participants with orbital, nasal, or facial disfigurement, including congenital craniofacial anomalies, previous nasal or facial surgery and trauma, high myopia, phthisis bulbi, orbital/eyelid tumors, systemic pathologies affecting facial/orbital features such as Graves' disease and aged less than 15 years were excluded. A detailed history was taken after informed consent. Exophthalmometric value (EV) and interorbital distance (IOD) were measured [mm] on Hertel's exophthalmometer. Inner inter-canthal distance (ICD), inter-pupillary distance (IPD) [mm], palpebral fissure width (PFW), palpebral fissure height (PFH), marginal reflex distance 1 (MRD1), marginal reflex distance 2 (MRD2), lid crease height (LC), pre-tarsal show (PTS) and levator function (LF) were recorded using a millimeter scale. The subjects were instructed to sit straight and adopt a primary gaze position with the examiner at the same eye level as the individual to be examined. A single observer with satisfactory experience was given the task. Table 1 shows parameters with their definitions.

Table 1. Variables with definitions

Parameter	Defining criteria as distance between
EV	Apex of cornea and lateral orbital margin (eye in primary position)
OICD	Lateral canthi of both eyes
ICD	Inner canthi of both eyes
IPD	Pupils both eyes (primary gaze)
PFW	Medial and lateral canthi of the same eye
PFH	Upper and lower eyelids in the pupillary midline (primary position of gaze)
MRD1	Corneal Light reflection and upper eyelid margin
MRD2	Corneal Light reflection and lower eyelid margin
LC	Upper eyelid lash-line to eyelid crease in downgaze
PTS	Upper eyelid lash line and skin fold at pupillary midline with eyes in primary position
LF	Distance through which eyelid can open when looking from downward to upward with pressure applied above the brow to negate the action of frontalis

The data were analyzed using Microsoft Excel sheet. Data was analyzed by independent t test. P value less than 0.05 was considered statistically significant. EV — exophthalmometric value; OICD — outer inter-canthal distance; IOD — interorbital distance; ICD — inner inter-canthal distance, IPD — inter-pupillary distance; PFW — palpebral fissure width; PFH — palpebral fissure height; MRD1 — marginal reflex distance 1, MRD2 — marginal reflex distance 2; LC — lid crease height; PTS — pre-tarsal show; LF — levator function

RESULTS

Out of 380 subjects, there were 222 females and 158 males. The mean age was 31.7 ± 13.4. Two hundred and eighty-two individuals were less than 40 years of age, and ninety-eight were 40 years and above. Significant sexual dimorphism was noted in EV, ICD, IPD, PFH, and MRD2 (significantly higher in males versus females; $p > 0.05$). PFH was decreased while PTS was increased in individuals of more than 40 years. Details are shown in Tables 2 and 3.

Table 2. Gender differences in the variables

Group Statistics						p-value
Gender		N	Mean	Std. Deviation	Std. Error Mean	
EV_R	Male	158	16.09	2.771	0.220	0.969282
	Female	222	16.13	9.898	0.664	
EV_L	Male	158	16.03	2.565	0.204	0.000312
	Female	222	15.18	2.016	0.135	
OICD	Male	158	106.86	14.253	1.134	0.061556
	Female	222	104.27	12.531	0.841	
ICT	Male	158	32.68	9.714	0.773	0.014287
	Female	222	30.71	2.894	0.194	
IPD	Male	158	60.23	6.324	0.503	0.015801
	Female	222	58.86	3.810	0.256	
PFW_R	Male	158	30.41	5.301	0.422	0.024586
	Female	222	29.41	1.820	0.122	
PFW_L	Male	158	29.72	2.876	0.229	0.097709
	Female	222	29.27	2.338	0.157	
PFH_R	Male	158	10.23	1.734	0.138	0.035177
	Female	222	9.87	1.466	0.098	
PFH_L	Male	158	10.20	1.773	0.141	0.044829
	Female	222	9.86	1.565	0.105	
MRD1_R	Male	158	4.23	1.058	0.084	0.401273
	Female	222	4.14	0.934	0.063	
MRD1_L	Male	158	4.26	1.084	0.086	0.682512
	Female	222	4.22	0.965	0.065	
MRD2_R	Male	158	6.01	0.964	0.077	0.003034
	Female	222	5.73	0.871	0.058	
MRD2_L	Male	158	5.99	0.977	0.078	0.009444
	Female	222	5.74	0.869	0.058	
LC_R	Male	158	8.22	1.561	0.124	0.184891
	Female	222	8.43	1.523	0.102	
LC_L	Male	158	8.23	1.539	0.122	0.438052
	Female	222	8.36	1.616	0.108	
PTS_R	Male	158	4.12	1.356	0.108	0.139426
	Female	222	4.34	1.552	0.104	
PTS_L	Male	158	4.13	1.336	0.106	0.1322
	Female	222	4.36	1.529	0.103	
LF_R	Male	158	14.84	1.710	0.136	0.0598
	Female	222	14.49	1.837	0.123	
LF_L	Male	158	14.84	1.715	0.136	0.051865
	Female	222	14.47	1.834	0.123	

As data is normally distributed with regard to gender and age, the independent t-test has been used for analysis.

EV — exophthalmometric value; OICD — outer inter-canthal distance; IOD — interorbital distance; ICD — inner inter-canthal distance, IPD — inter-pupillary distance; PFW — palpebral fissure width; PFH — palpebral fissure height; MRD1 — marginal reflex distance 1, MRD2 — marginal reflex distance 2; LC — lid crease height; PTS — pre-tarsal show; LF — levator function; L — left eye; R — right eye

Table 3: Effect of age on orbital and periorbital anthropometry

Age group [years]		N	Mean	SD	SE Mean	p-value
EV_R	< 40	282	15.49	2.457	0.146	0.104353
	> 40	98	17.92	14.619	1.477	
EV_L	< 40	282	15.46	2.324	0.138	0.286343
	> 40	98	15.74	2.212	0.223	
OICD	< 40	282	104.91	11.412	0.680	0.283474
	> 40	98	106.59	17.708	1.789	
ICT	< 40	282	31.76	7.583	0.452	0.27023
	> 40	98	30.89	2.896	0.293	
IPD	< 40	282	59.21	5.533	0.330	0.148671
	> 40	98	60.06	3.217	0.325	
PFW_R	< 40	282	29.91	4.141	0.247	0.454938
	> 40	98	29.58	2.051	0.207	
PFW_L	< 40	282	29.40	2.736	0.163	0.457333
	> 40	98	29.62	2.073	0.209	
PFH_R	< 40	282	10.17	1.552	0.092	0.001966
	> 40	98	9.59	1.630	0.165	
PFH_L	< 40	282	10.16	1.601	0.095	0.001416
	> 40	98	9.54	1.754	0.177	
MRD1_R	< 40	282	4.31	0.951	0.057	7.49E-06
	> 40	98	3.80	0.994	0.100	
MRD1_L	< 40	282	4.36	0.949	0.056	4.58E-05
	> 40	98	3.88	1.115	0.113	
MRD2_R	< 40	282	5.88	0.914	0.054	0.306246
	> 40	98	5.77	0.939	0.095	
MRD2_L	< 40	282	5.86	0.913	0.054	0.565737
	> 40	98	5.80	0.952	0.096	
LC_R	< 40	282	8.32	1.477	0.088	0.685678
	> 40	98	8.40	1.716	0.173	
LC_L	< 40	282	8.28	1.520	0.090	0.662768
	> 40	98	8.37	1.761	0.178	
PTS_R	< 40	282	4.15	1.363	0.081	0.023329
	> 40	98	4.54	1.736	0.175	
PTS_L	< 40	282	4.18	1.351	0.080	0.050814
	> 40	98	4.51	1.700	0.172	
LF_R	< 40	282	14.68	1.705	0.102	0.417231
	> 40	98	14.51	2.022	0.204	
LF_L	< 40	282	14.67	1.701	0.101	0.428435
	> 40	98	14.50	2.037	0.206	

SD — standard deviation; SE — standard error; EV — exophthalmometric value; OICD — outer inter-canthal distance; IOD — interorbital distance; ICD — inner inter-canthal distance, IPD — inter-pupillary distance; PFW — palpebral fissure width; PFH — palpebral fissure height; MRD1 — marginal reflex distance 1, MRD2 — marginal reflex distance 2; LC — lid crease height; PTS — pre-tarsal show; LF — levator function; L — left eye; R — right eye

DISCUSSION

It is a well-known fact that not only there is diversity in anthropometry among different races, but also there are age and gender variations within the same race and ethnic group [4]. We carried out this investigational survey and compared our data with other studies. A comparison of our results with some of the previous studies is shown in Table 4.

Table 4. Comparison of data from different studies (average of male and female values were taken in [6])

	Current research	Koreans [5]	White Americans [6]	Black Americans [6]	Turkish [7]	Egyptians [7]	Iranians [7]	Chinese [7]
OICD	105.57	87.9	–	–	93.95	87.65	85.8	90.53
ICD	31.7	38	34.24	34.99	30.35	31.35	25.95	36.53
IPD	59.55	62.8	63.31	67.5	62.35	–	–	–
PFW	29.7	25.5	29.5	31.9	31.8	31.15	30.8	27.22
PFH	10.04	–	10.45	10.2	10.35	–	–	9.4

OICD — outer inter-canthal distance; ICD — inner inter-canthal distance; PFW — palpebral fissure width; PFH — palpebral fissure height

Literature shows that IPD, PFW, and ICD in African Americans (AA) are more significant than the Caucasians [6]. When we compared these values with our study, all figures were more minor than African Americans (Tab. 4). Mean EV was also greater in AA (17.83 mm) than Caucasians and Punjabis [8]. Only the PFH was greatest in white Americans, and OICD was significant in our group.

In another study, PFH was compared among Thai, Chinese, Thai-Malay, and Thai-Chinese [9]. It was 9.5, 9.0, 10.2, and 9.6 mm, respectively. PFH in our population was greater (10.04 mm) than Thai, Chinese, and Thai-Chinese but slightly lesser than Thai-Malay (10.2 mm). In the same study, the PFW, EV, and LF were more significant than our group. However, the MRD1 and LC in these ethnic groups were lesser than in our study. Another finding was the absence of an upper lid crease and an epicanthal fold in a more significant number of individuals from the Chinese population.

When the ICDs of Chinese and Koreans were compared with our study, there was a considerable difference in these values: 31.7 mm in our group vs. 36.53 mm in Chinese *vs*. 38mm in Koreans. In other studies**,** Turkish [10], Indians [11], North American whites [12], and African-Americans [12] also had lesser values of ICD than Chinese and Koreans. Iranians had the smallest ICD — 25.95 mm [7]. In a recently published data, Indians had greater PFW and PFH than the Chinese [13]. Values of PFW and PFH in our study were also greater than Chinese.

Flament et al. used 3600 photographs of women's eyes from six different regions of the world (Africa, China, Hispania, India, Japan, and Caucasians). The study showed that the Asians had a more oblique orientation of their eyes versus the horizontal inter-pupillary line. In all ethnicities, aging caused significant changes in the height and orientation of the eyes [14].

In this particular study, EV, ICD, IPD, PFH, and MRD2 were significantly higher in males versus females ($p > 0.05$). In Chinese, males had larger orbital values than females except for PFH. This was in contrast to our study in which PFH was significantly higher in males than females. Another difference was that PFW was substantially larger in Chinese females, which was not significantly different in our study.15,16 Turkish study showed sexual dimorphism similar to our research [17, 18]. In a Nigerian study, the gender difference was observed only for brow height ($p = 0.029$) [19].

Contrary to our results, in an Indian study, there was a statistically significant difference in the PFW ($p < 0.001$) and OICD ($p < 0.05$) between males and females [20]. However, there was no significant difference in the PFH ($p > 0.05$) and ICD ($p > 0.05$) between the two sexes in Indians but in our study, PFH was significantly higher in males.

According to one study, EV decrease with age (average reduction of 0.06 mm/year) [20]. In our study, there was a significant decrease in PFH after 40 years but not in EV. PTS also showed increased values after 40 years [9, 20]. Both of these findings are explained by senile ptosis.

The strength of this study is that we analyzed 11 parameters and compared them with research from other parts of the world. More data from different parts of Pakistan is needed to complete a dataset from the Pakistani population. The limitation of this study is that the measurements were taken manually with a chance of human error. Further studies using CT scan and photogrammetry should be done to affix the results of this study.

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