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Full Length Research Paper

Cranio-Orbito Zygomatic Normative Measurements In Adult Sudanese: CT Based Study

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The measurements of craniofacial parameters have clinical and anthropologic significance. Local data on Cranio-orbito zygomatic normative measurements reveal the pattern of changes in craniofacial features resulting from gender and age. In the present study, we provide normative data on anthropometric variation within the normal adult Sudanese measurements by using computerized tomography (CT) images and to determine the effects of age and gender on anthropometry. A systematic method was obtained to align head (CT) images for both axial and coronal assessment, and to measure the variable parameters obtained from 110 Sudanese subjects in both genders and in different age groups (≤20≥61years). To quantify the orbits: 4 measurements were collected along both orbits including orbital breadth, height, bi orbital roof and anterior inter orbital distance; 2 for zygomatic bones including bi zygomatic breadth and zygomatic arches length, 2 for cranium counting length and width were also measured. All measurements were taken in (mm). As a result; measurements of the orbita, zygomatic arches and cranium were found to be higher at the age of 51-61 years and showed similar measurements attainment at this age with no significant difference detected at various age intervals. Measurements varied significantly between the genders at p<0.05. Our study findings may be considered as reference for Sudanese, and the measurements may describe the normal morphological variants of orbits, zygomatic bone and cranium length and breadth for Sudanese. Since the anatomy of the face is of interest to many radiological fields, the radiologists must have knowledge of normal anatomy of cranio-orbito-zygomatic characteristics to determine the presence of abnormality and to help in surgical planning. We trust that the information gained from the present study will be useful to all the medical, radiological and anthropological fields.

Keywords: Orbital anthropology, zygomatic anthropology, gender prediction, CT images

INTRODUCTION

Orbits have been used in race and gender prediction of individuals (Weaver, 2010). Understanding human anatomy and racial variations concerning the ocular anatomy are of vital importance when treating or clinically evaluating patients (Husmann, 2011). Anthropometry helps to understand anatomic structures and forms the

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technique of expressing quantitatively the form of the human body and skeleton. Anthropometric studies are integral part of craniofacial surgery (Ukoha, 2011). Differences amongst species provide an important point of view to the forensic anthropometry in the process of individualization. Human skull and cranium are anthropometric tools of utmost importance in forensic researches and in analyzing ethnic and racial relations. According to the orbita ; shapes are categorized as hypsiconch, mesoconch, and chamaeconch consequently (Piquet, 1954). These categories are related to racial features. The orbital characters show differences in different races, ethnic groups and genders. Zygomatic variables showed rapid growth of the structures and demonstrated continuous growth until adulthood and presented the greatest sexual dimorphism, (Krogman and Iscan,1986; Steyn and Iscan, 1998; Monticelli and Graw, 2008; Kranioti *et al.,* 2008; Naikmasur *et al.,* 2010). Franklin et al studied skulls of South African Indians, and the measures with greatest dimorphism were bi zygomatic distance, length and height of the cranium (Franklin et al., 2005). Cranial patterns are population specific features, affected by environmental factors such as diet, climate, and culture (Iscan, 1989). However, it should be noted that the bi zygomatic width represents an important feature in evaluating the sexual dimorphism in several populations, and should always be considered in sex determination for human identification (Terada, 2012) Studies of this field are generally conducted on cadavers; lateral skull radiographs (Fawehinmi, 2008;Husmann, 2011). Furthermore, computed tomography (CT) has been used recently in the measurement of the orbita (Igbigbi, 2010; Lo, 1996). Weiss et al. stated that (CT) is the best way to evaluate the orbital cavity because of the complex anatomy of the ocular region also it can afford excellent facial bone images which help in the practice of anthropology (Weiss et al., 1987). To the best of our knowledge; no local studies have been reported for adult Sudanese cranio-orbito-zygomatic measurements. Because extra information and knowledge of facial anatomical dimensions among Sudanese is important, especially in facial surgery and forensic science and also the effects of age, gender and race have to be understood for the assessment of a measured facial anatomy as to whether it is normal or pathological, this anthropometric study aimed to characterize and research the anthropometric variations of the orbital and zygomatic anatomy among normal adult Sudanese through computed tomography scan in order to establish reference values of the normative measurements regarding the gender and age.

MATERIALS AND METHODS

A total of 110 patients were included in the study. Patient's ages were from≤ 20 ≥61 years. Patients were selected for facial scans. The patient's age and gender were recorded. For each patient, a prospective study was conducted on facial bone CT scans .Subjects with craniofacial defects were excluded. This study was done at Royal Care International Hospital and Antalya Medical Center in the Diagnostic Radiology Department during the period from 2013 up to 2014.

The CT scans for facial bones were performed using spiral CT (Aquilon, Toshiba Medical System Corp-Tokyo, Japan, helical mode 64 slice) and (General Electric ,helical mode 16 slice bright speed). Acquisition was obtained with a slice thickness of 2 mm, 1.25mm and FOV of 250mm, 240mm.Kvp of120, mA50 and 60 with images matrix size512X512 respectively.

Zygomatic variables dimensions were measured in(mm)for both sides: Bi zygomatic breadth (facial breadth), Zygomatic arch length as the distance between the antero lateral corner of the zygomatic buttress and the insertion of the zygomatic arch in to the squamous part of the temporal bone, both variables were measured in axial CT images .Four orbital variables were also measured including orbital breadth (maximum width of orbit measured from Dacryon bi orbital roof , Anterior inter orbital distance(anterior end of the medial orbital walls) ,Orbital height, all were measured in coronal CT. The Cranial width was measured in coronal view and was defined as the two points establishing a line that represents the greatest width of the skull. Cephalic length was also measured and was defined as the distance between most anterior and posterior point of the skull Opisthocranion to glabila. All measurements were performed by the same observer.

Statistical analyses

All data obtained in the study were documented and analyzed using SPSS program version16. Descriptive statistics, including mean ± standard deviation, were calculated. ANOVA test was applied to test the significance of differences, *p*-value of less than 0.05 was considered to be statistically significant.

RESULTS

Table 1. Shows the descriptive statistics of the cranial width and cephalic length classified according to age (≤20≥61) years

		N	Mean (mm)	Std. Deviation	Minimum (mm)	Maximum (mm)	P-value
Cranial width	≤20	8	123.351	8.19084	107.04	132.53	.918
	21-30	24	124.607	9.06433	109.95	156.60	
	31-40	31	123.880	7.18918	108.35	142.95	
	41-50	24	122.995	11.22503	110.98	168.32	
	51-60	13	125.800	7.60824	115.43	136.65	
	>61	9	125.930	4.74530	121.32	133.83	
	Total	**109**	**124.205**	**8.49326**	**107.04**	**168.32**	
Cephalic Length	≤20	8	179.312	14.33777	156.88	202.64	.833
	21-30	24	174.653	14.36868	153.91	200.68	
	31-40	31	173.680	8.11918	158.73	197.49	
	41-50	24	174.189	9.45635	157.20	188.85	
	51-60	13	177.040	15.86555	156.28	201.38	
	>61	10	175.066	6.05348	167.79	183.11	
	Total	**110**	**174.936**	**11.27125**	**153.91**	**202.64**	

Table 2. Shows the descriptive statistics of the cranial width and cephalic length classified according to gender

	Gender	N	Mean (mm)	Std. Deviation	Minimum (mm)	Maximum (mm)	P-value
Cranial Width	Male	34	126.382	7.98796	107.04	156.60	.051
	Female	75	123.217	8.58236	108.35	168.32	
	Total	**109**	**124.205**	**8.49326**	**107.04**	**168.32**	
Cephalic Length	Male	34	181.327	10.58898	167.79	202.64	.000
	Female	76	172.077	10.41621	153.91	197.49	
	Total	**110**	**174.936**	**11.27125**	**153.91**	**202.64**	

Table 3. Shows the descriptive statistics of the zygomatic variables (Bi zygomatic breadth and Zygomatic arch length (RT&LT) classified according age (≤20≥61) years

		N	Mean (mm)	Std. Deviation	Minimum (mm)	Maximum (mm)	P-value
Bi zygomatic breadth	≤20	8	125.232	5.59460	114.51	134.84	.447
	21-30	24	125.206	5.55744	114.32	137.79	
	31-40	31	126.353	5.48614	117.39	141.86	
	41-50	24	124.205	5.95630	112.69	135.08	
	51-60	13	125.638	5.20907	113.71	133.09	
	>61	10	128.604	7.25494	121.60	141.86	
	Total	**110**	**125.673**	**5.75211**	**112.69**	**141.86**	
(RT)Zygomatic arch length	≤20	8	53.8075	5.52183	46.72	61.84	.175
	21-30	24	53.3671	4.40137	45.33	60.97	
	31-40	31	52.6135	3.23708	45.33	61.09	
	41-50	24	53.8533	3.87144	46.50	59.98	
	51-60	13	56.3215	4.09265	50.87	64.97	
	>61	10	53.5950	4.64752	47.68	60.73	
	Total	**110**	**53.6627**	**4.11161**	**45.33**	**64.97**	
(LT)Zygomatic arch length	≤20	8	53.9900	4.61649	46.88	60.45	.375
	21-30	24	53.3250	4.21164	44.45	59.54	
	31-40	31	52.7677	3.19349	46.01	61.49	
	41-50	24	53.3800	3.82684	45.29	60.33	
	51-60	13	55.7885	4.23683	50.57	64.87	
	>61	10	53.2350	5.62485	45.01	61.92	
	Total	**110**	**53.5113**	**4.05070**	**44.45**	**64.87**	

Table 4. Shows the descriptive statistics of the Zygomatic Variables (Bi zygomatic breadth and Zygomatic arch length (RT&LT) classified according to gender

		N	Mean (mm)	Std. Deviation	Minimum (mm)	Maximum(mm)	
	Male	34	130.504	5.52084	114.51	141.86	
Bi zygomatic breadth	Female	76	123.511	4.40018	112.69	136.11	.000
	Total	**110**	**125.673**	**5.75211**	**112.69**	**141.86**	
	Male	34	55.3291	5.00903	45.48	64.97	.004
Rt Zygomatic arch length	Female	76	52.9172	3.42159	45.33	60.97	
	Total	**110**	**53.6627**	**4.11161**	**45.33**	**64.97**	
	Male	34	55.1085	4.74253	44.45	64.87	
	Female	76	52.7967	3.50375	45.01	60.33	.005
Lt Zygomatic arch length	**Total**	**110**	**53.5113**	**4.05070**	**44.45**	**64.87**	
	Female	76	172.077	10.41621	153.91	197.49	
	Total	**110**	**174.936**	**11.27125**	**153.91**	**202.64**	

Table 5. Shows the descriptive statistics of the Orbital variables (orbital breadth, height, bi orbital roof and Anterior inter orbital distance) classified according age (≤20≥61) years

		N	Mean (mm)	Std. Deviation	Minimum (mm)	Maximum (mm)	P-value
	≤20	8	33.7525	1.58901	30.73	35.56	
	21-30	24	33.4754	2.01890	30.38	37.17	
	31-40	31	34.0906	1.86848	30.29	37.54	.224
RT orbital breadth	41-50	24	34.3963	1.48344	31.77	37.43	
	51-60	13	34.2515	1.19487	31.60	35.98	
	>61	10	35.0 450	1.94855	31.56	37.54	
	Total	**110**	**34.1043**	**1.76547**	**30.29**	**37.54**	
	≤20	8	33.7225	1.97057	30.70	36.99	
	21-30	24	33.3563	2.38650	30.08	38.89	
	31-40	31	34.4823	1.59149	31.57	36.87	.208
LT orbital breadth	41-50	24	34.4667	1.63704	32.05	37.43	
	51-60	13	33.6462	1.68643	31.26	36.88	
	>61	10	34.3320	1.78803	30.96	36.29	
	Total	**110**	**34.0655**	**1.87684**	**30.08**	**38.89**	
	≤20	8	38.5088	3.06435	32.04	41.40	
	21-30	24	38.0242	2.48952	34.05	43.78	
	31-40	31	37.3703	1.99810	32.98	41.19	.280
RT Orbital height	41-50	24	37.5188	2.92061	31.44	43.46	
	51-60	13	38.0515	3.02173	34.29	44.38	
	>61	10	39.5140	2.32270	36.29	41.73	
	Total	**110**	**37.9035**	**2.57766**	**31.44**	**44.38**	
	≤20	8	38.4925	2.86848	32.46	41.43	
	21-30	24	37.3379	2.03295	33.82	40.80	
	31-40	31	37.4606	2.04397	33.09	40.36	.123
LT Orbital height	41-50	24	37.8371	2.49004	31.44	42.43	
	51-60	13	37.9469	3.07806	33.38	43.20	
	>61	10	39.8140	3.04790	35.78	43.50	
	Total	**110**	**37.8625**	**2.48089**	**31.44**	**43.50**	
	≤20	8	64.3463	2.09627	61.88	68.53	
	21-30	24	63.7579	6.01554	50.53	76.98	
	31-40	31	65.8968	5.21181	56.19	78.18	.076
Bi orbital roof	41-50	24	61.8371	4.32144	55.08	69.30	
	51-60	13	66.2323	6.60799	55.35	74.38	
	>61	10	64.0900	4.66107	55.31	69.43	
	Total	**110**	**64.3070**	**5.33953**	**50.53**	**78.18**	

Table 5 continue

Anterior inter orbital distance	≤20	8	25.9938	3.95182	19.60	30.29	.088
	21-30	24	25.8129	2.71478	21.28	32.37	
	31-40	31	26.6652	2.88920	21.49	32.37	
	41-50	24	24.9183	1.97551	20.80	29.17	
	51-60	13	27.5408	3.15731	20.80	33.01	
	>61	10	26.6780	2.44769	23.11	30.80	
	Total	**110**	**26.1539**	**2.82201**	**19.60**	**33.01**	

Table 6. Shows the descriptive statistics of the Orbital variables (orbital breadth, height, bi orbital roof and Anterior inter orbital distance) classified according gender

		N	Mean (mm)	Std. Deviation	Minimum (mm)	Maximum (mm)	P-Value
RT orbital breadth	Male	34	34.9550	1.77257	30.38	37.54	0.001
	Female	76	33.7237	1.63478	30.29	37.17	
	Total	**110**	**34.1043**	**1.76547**	**30.29**	**37.54**	
LT orbital breadth	Male	34	34.8959	1.83062	30.73	37.43	0.002
	Female	76	33.6939	1.78674	30.08	38.89	
	Total	**110**	**34.0655**	**1.87684**	**30.08**	**38.89**	
RT orbital Height	Male	34	38.7103	2.58897	31.44	44.38	0.027
	Female	76	37.5426	2.50602	32.04	43.78	
	Total	**110**	**37.9035**	**2.57766**	**31.44**	**44.38**	
LT orbital Height	Male	34	38.7400	2.35872	31.44	43.20	0.012
	Female	76	37.4699	2.44780	32.46	43.50	
	Total	**110**	**37.8625**	**2.48089**	**31.44**	**43.50**	
Bi orbital roof	Male	34	65.5474	5.01310	54.00	76.98	0.003
	Female	76	63.7521	5.41924	50.53	78.18	
	Total	**110**	**64.3070**	**5.33953**	**50.53**	**78.18**	
Anterior inter orbital distance	Male	34	26.7597	2.91526	19.60	33.01	
	Female	76	25.8829	2.75567	20.80	32.37	0.033
	Total	**110**	**26.1539**	**2.82201**	**19.60**	**33.01**	

Table 7. Shows the t-test and the Pearson correlation between the of the variables with the cranial width and cephalic length

		Cranial width	Cephalic Length
Bi zygomatic breadth	Pearson Correlation	.300(**)	.262(**)
	Sig. (2-tailed)	.002	.006
	N	110	110
RT Zygomatic arch length	Pearson Correlation	.042	.233(*)
	Sig. (2-tailed)	.662	.014
	N	110	110
LT Zygomatic arch length	Pearson Correlation	.013	.131
	Sig. (2-tailed)	.895	.053
	N	110	110
RT orbital breadth	Pearson Correlation	-.032	.039
	Sig. (2-tailed)	.740	.686
	N	110	110

Table 7 continue

LT orbital breadth	Pearson Correlation	.082	.141
	Sig. (2-tailed)	.396	.142
	N	110	110
RT orbital Height	Pearson Correlation	.004	.140
	Sig. (2-tailed)	.968	.143
	N	110	110
LT orbital Height	Pearson Correlation	.049	.142
	Sig. (2-tailed)	.613	.139
	N	110	110
Bi orbital roof	Pearson Correlation	.183	.038
	Sig. (2-tailed)	.057	.695
	N	110	110
Anterior inter orbital distance	Pearson Correlation	.048	.164
	Sig. (2-tailed)	.617	.088
	N	110	110

** Correlation is significant at the 0.01 level (2-tailed).* Correlation is significant at the 0.05 level (2-tailed).

DISCUSSION

The review of literature available for the orbitometry is less than the investigations for the craniometry. The parameters for the orbit, on its height, breadth diameters may be important in the investigation of the orbit especially, in the orbital floor. (Lieberman and Carthy, 1999). In a review of the literature we could not find reliable quantitative normative CT data for Sudanese normal measurements. In this study we presented the measurements of healthy normal orbital characteristics as seen on CT axial and coronal images (Table 5). Zygomatic and orbital measurements showed rapid growth of structures during the development but, instead of leveling off, the structures kept on growing until adulthood (Sayee, 2012). Our study revealed that measurements of adult were achieved and classified according to age and was found to be higher at the age of 51-61 years. Cranial, zygomatic and orbital measurements showed similar attainment at this age with no significant difference detected at various age intervals (Tables 1, 3 and 5).

Regarding the gender ; for males, increased size differences compared to females were observed for left and right orbital measurements as well as the bi orbital roof and anterior inter orbital distance significantly at $p<0.05$ this was presented in (Tables4 and 6). Correlation was studied between the cranial length and width with the orbits and zygomatic bone measurements which showed significant relation between the facial breadth (bi zygomatic breadth) and bi orbital roof with cranial breath for Sudanese (Table7). Studies showed that cranial breadth was strongly associated with facial breadth (Howells, 1972; Brown, 1973; Mizoguchi, 1992a). The present analyses of male data supported that males have greater cranial measurements (length and width) as seen in (Table 2). Significant associations between cranial breadth and bi zygomatic breadth (Table 7) can certainly be found in the total sample but separate correlations between genders were not considered regarding that issue in our study. If this is not due to the small size of the present male sample, the finding may suggest that some factors relating to sexual dimorphism, such as the difference in the degree of development of masticatory muscles as mentioned previously (Yuji, 2007) produced the difference between males and females in the present results. The results of craniofacial measurements showed that cranial breadth and length were significantly associated with bi zygomatic breadth and bi orbital roof, however cranial length was significantly associated with right and left zygomatic arch length in addition, no associations were found regarding other variables. From this, it was inferred that cranial dimensions may be freely associated with facial structure. It was also found that, when a certain facial measurement was associated with one of the two cranial measurements, it was almost always cranial breadth, not cranial length. The study revealed that Sudanese measurements for the selected variables for orbits, zygomatic bone and cranial length and width; differ from what was mentioned in other studies mentioned in the literature (Yuji, 2007) The available literature on the gender and age determination and racial variation for the skulls is plenty; because they may be the reflected causes for the observed differences in the craniometry as well as for the orbitometry (Sayee, 2012). Racial/ Geographic variations: is the main cause of the difference between populations (Standring, 2005). The observed differences in the orbital measurements may be because of the sample size and also the basic features relevant to the skulls: subjectivesex determination, age, racial and geological variations. The comprehensive set of measurements collected in this study provides detailed information on orbital geometry, as well as measurement of the cranium and zygomatic bone. This set of measurements can be used for the development of fixed element models of the orbit, zygomatic bone for computational modeling purposes. Although sample size limited the ability to obtain statistically significant relationships regarding the variables anthropometry with age. When normal variation in variables anthropometry is implemented in a standard reference model statistically significant variation in injury may result. Determining injury by quantifying anthropometric variation across individuals would be valuable in explanation of injuries. As a result; measurements of the orbita, zygomatic bone and cranium contain valuable practical knowledge about genders. With this method, in the future, in larger study groups, it would be possible to classify individuals to ethnic and gender groups. We conclude that images obtained with facial-CT can be used as a method for gender evaluation. From the findings of the present study of Sudanese adults, it can be fulfilled that the cranio-orbito-zygomatic structures displayed varying degrees of sexual dimorphism. Moreover, demonstrated ethnic differences as observed from the comparisons of the Sudanese data with data obtained from other Asian studies. These findings support the requirement for different normative data to be established for different ethnic groups, gender and age categories. Clinicians need to take this information into consideration in deciding the timing of surgical interventions and when planning management for their patients. Moreover, the findings of differences between the Sudanese and other population data demonstrate that there are intrinsic ethnic differences and that patients from different ethnic groups need to be compared with norms specific to their own group. Our study findings may be considered as reference for Sudanese, and the measurements may describe the normal morphological variants of orbits, zygomatic bone and cranium length and breadth for Sudanese. Since the anatomy of the face is of interest to many radiological fields, the radiologists must have knowledge of normal anatomy of cranio-orbito-zygomatic characteristics to determine the presence of abnormality and to help in surgical planning. We trust that the information gained from the present study will be useful to all the medical and radiological and anthropological fields.

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