Original article

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Orbital Dimensions

Sayee Rajangam, PhD*, Kulkarni R.N, MD, Lydia Quadrilos, M.Sc***, Sreenivasulu S, M.Sc******

Abstract

Context: Measurements of the orbit are part of the studies in craniometry. **Aims:** The present study reports 3 parameters of the orbit; height, breadth and orbital index. **Settings and Design:** Department of Anatomy, International Medical School, Bangalore. **Material & Method:** The measurements were taken for the right and the left orbital margins of the 51 male and 21 female skulls. **Statistical analysis:** 't' test. **Results:** The measurements of the orbit (height/ width/index) (Right: height 3.509 +/- 0.267, width 4.174 +/- 0.215, orbital index 73.55 +/- 12.89) (Left: height 3.37 +/- 0.257, width 4.082=/- 0.198, orbital index 75.273 +/- 11.132), were increased for the male. The right side measurements for the height and width were increased for both the sexes and the right orbital index for the female skulls. Significance was observed for the orbital index between the male and the female skulls for the right and the left orbits and the orbital index of the female skull between its right and left orbits. The application of the demarcation points have identified that the transverse diameters of the left and the right orbits identified 15 to 22 male skulls. Hence, the transverse diameters of the orbit could be considered as a parameter in sex determination of the skulls. **Conclusion:** The observed differences in the orbital measurements may be because of the sample size and the methodology and also the cardinal features pertaining to the skulls: subjective sex determination, age, racial and geological variations and asymmetry especially in the facial cranium.

Keywords: Male and female skulls; Orbital measurements; Height; Width; Index.

Introduction

The bony orbits are the skeletal cavities and contain the eyes, the peripheral organs of the vision. The walls of the orbits (floor, roof, medial/ lateral walls) protect the eyes from any injury and provide the points of attachment to the extra-ocular muscles, which allow the accurate positioning of the visual axis and determine the spatial relationship between the two eyes, which is considered to be essential for both the binocular vision and the conjugate movements of the eyes. The orbital cavity is approximated to that of the quadrilateral pyramids, with its base being anterior at the orbital opening and the apex in a postero-medial axis. The compromise between the protection and the good field of view has dictated that each eyeball is located anteriorly within the orbit. The eyeball occupies 1/ 5th of the volume of the orbit and the remainder of the orbital cavity is filled with orbital fat and connective tissue, as the source of support to the nerves and vessels. (Standring 2008)[1]

Metrical studies contribute to the comparison between the shapes and sizes of the skulls and its components and are carried out with the help of internationally standard techniques of craniometry, in which linear (chord) or surface distances are measured between varieties of defined cranial landmarks. The cranial points by international

Author's Affiliation: *Professor, Anatomy, **Professor & Head, Anatomy, Department of Anatomy, International Medical School, New BEL Road, MSRIT Post, Bangalore 560054, Karnataka. ***Lydia Quadrilos, Lecturer, Anatomy, Department of Anatomy, Kasturba Medical College, Manipal 576104, Karnataka.. ****Senior Lecturer, Anatomy, Senior Lecturer, Faculty of Medicine, Masterkill University College of Health Sciences, No 6, Jalan Lambah, Bandar Seri Alam 81750, John Bahru, Malaysia.

Reprint's request: Dr. Mrs. Sayee Rajangam, Professor, Department of Anatomy, International Medical School, Bangalore 560054.

E-mail: drsayee@gmail.com

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agreement, in making linear and certain angular measurements in anthropometry, is by keeping the skull in with Frankfurt plane. In general, from the 3 basic measurements of length (A), breadth (B) and height (C) indices (B/A or C/A or C/B) are calculated and stated as percentages. The most frequently used is the cranial index (CI), the ratio of the breadth of the skull to its length. The calculated CI, even though classifies the types of the skulls (dolicocranic, mesocranic, brachycranic) is known to show a high degree of variations, both within and between the populations. Because of which, it is stated, that CI application may not be of a great value in distinguishing the skulls from different geographic regions and mostly reflects the interactions between the width of the cranial base and the volume of the brain. (Lieberman et al 2000, Standring 2005).[2,3]

As part of craniometry, for the orbit, measurements are calculated and similar to CI, the orbital index (OI) is also derived (maximal orbital height/ breadth x100).

The aim and the rationale of the present study is to report three parameters measured from the right and left margins of the orbit; height (vertical diameter) and breadth (transverse diameter) and the orbital index, from the available subjectively sex determined skulls.

Material and Method

Seventy two skulls were collected from the Department of Anatomy, International Medical School, Bangalore and also from the 1st year Medical Students. Based on the morphology, they were differentiated into 51 male and 21 female skulls. The measurements were taken with the thread and later applied on the scale and then, the values were entered. Height was measured as the maximum distance between the superior and inferior orbital margins and the width also as the maximum distance between the lateral and medial orbital margins. The measurements were taken for the right and the left orbital margins of the male and the female skulls. The measurements were tabulated. The 't' test was applied for the 12 orbital parameters .

Results

In table 1 is given the mean, standard deviation (SD), results of the 't' test and the 'p' values for detecting the significance for the

Table 1: Orbit: Measurements: Mean, SD, 't' test and 'p' value

Height (cms)	Male (51)	Female (21)
Right	3.5 +/- 0.27	3.2 +/ 0.28
Left	3.37+/- 0.26	3.08 +/ 0.21
't' test	0.49	0.48
Width (cms)	Male (51)	Female (21)
Right	4.17 +/ 0.21	3.72 +/ 0.16
Left	4.08+/ 0.19	3.69 +/ 0.16
't' test	0.44	0.16
Orbital index (cms)	Male (51)	Female (21)
Right	73.55+/ 12.9	66.79 +/ 7.46
Left	75.27 +/ 11.13	65.03 +/ 15.77
t' test	0.14	0.14

Sl. No	Parameters	'p' value
1.	Height (male)	0.393
	Right Vs left	NS
2.	Height (male Vs female)	0.397
	Right	NS
3.	Height (female)	0.119
	Right Vs left	NS
4.	Height (male Vs female)	0.174
	Left	NS
5.	Width (male)	0.290
	Right Vs left	NS
6.	Width (male Vs female)	0.07
	Right	NS
7.	Width (female)	0.49
	Right Vs left	NS
8.	Width (male Vs female)	0.145
	Left	NS
9.	Index (male)	0.152
	Right Vs left	NS
10.	Index (male Vs female)	0.003
	Right	Significant
11.	Index (female)	0.0007
	Right Vs left	Significant
12.	Index (male Vs female)	0.028
	Left	Significant

NS: non-significant

height, width and orbital index between the right and left orbits of the male and the female.

It was observed, that the measurements of the orbit (height/ width/index and the range); whether for the right or the left side, were increased for the male. Between the right and the left side, for the male, the right side orbital measurements for the height and width were increased for the male. For the female, the height, width and the orbital index of the right side were increased than the left orbit. It also may be noted that the range in the orbital index was more for the left side for the male and the female orbits.

Significance was observed for the orbital index between the male and the female for the right and the left orbits and the orbital index of the female between its right and left orbits.

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, width and antero-posterior diameters may be important in the exploration of the orbit especially, in the orbital floor exploration. (Lieberman and McCarthy 1999)[4]

The ocular vertical diameter (23.5 mm) is rather less than the transverse and the antero-posterior diameters (24 mm). The antero-posterior diameter at birth is 17.5 mm and at puberty 20 to 21 mm; it may vary considerably in myopia (29 mm) and in hypermetropia (20 mm). In females, all diameters are on an average slightly less than in the male. (Standring 2005)[3]. In the present study too, for the male and the female, whether from the right or the left side, the vertical diameter (height) of the orbits was less than that of the transverse diameter (width) and the 3 parameters (height/ width/ orbital index) were less for the female than the findings in the male.

In 1993, fetal development of the human orbit has been studied. The development of the orbits in 70 human fetal skulls was investigated by measuring the width and height of the orbital entrance, as well as the volume and depth of the orbital cavity and the interorbital width. For determination of the orbital volume, the imprint method was used and the remaining parameters were estimated. The measurements showed a linear growth rate for the orbital width, height and depth. After transformation to the cubic root, the values of the orbital volume also demonstrated a linear increase. The orbital index (height/width x 100) expressed the change in the oval outline of the orbital entrance, during fetal development from a flat, wide form to a nearly round form at birth. No statistically significant difference between the right and left orbit was found. (Haas et al 1993)[5]. In the present study, significance was observed for the orbital index between the male and the female skulls for the right and the left orbits and the orbital index of the female skull between its right and left orbits.

The cranial index is known to show a high degree of variations, both within and between the populations. Because of which, it is stated, that its application may not be of a great value in distinguishing the skulls from different geographic regions and mostly reflects the interactions between the width of the cranial base and the volume of the brain. (Lieberman et al 2000, Standring 2005).[2,3] It may be noted that the values for the orbital axis, visual axis and optic axis varies between the individuals and depends on the angle between the orbital axes and the median plane. (Standring 2005, Standring 2008, Millodot 2009)[1,3,7]. In the present study, as stated for the cranial index, the orbital index showed variations between the male and the female orbits.

The available literature on the sex determination, age determination and racial/ geological 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.

Sex determination: (Standring 2008, 2005)[1,3] For many crania, the sex determination is difficult because, the variation is greater within than between the sexes. Sexual differences are detected in measurements; the mandible, orbits, tooth size and pattern of dental eruption did not reach the level of discrimination, to allow the accurate and reliable assessment. The defining characteristics of sex in adults, therefore became male oriented and reflected the effects of the increased mass of muscles of the mastication, which are attached to the mandible and the muscles associated with maintaining the erect head. It is reported that using the skull alone, sex can be predicted with over 80% accuracy in the adult. Generally, male skulls are more robust/ thicker bones in neuro-cranial vault; more marked muscle origins and insertions (temporal and nuchal lines); prominent external occipital protuberances/ mastoid processes; large frontal sinuses/ glabella/ superciliary arches/ tooth size/ maxillary arch; pronounced supra-orbital ridges/ square shaped superior margins of orbits. Female skulls are more gracile/ forehead higher/ more vertical/ more rounded/clear retention of the frontal eminences in the female. The obvious genetic and racial variations must be considered when attempting to assign the sex from the skulls.

Age determination: (Standring 2008)[1]

Age being a continuous variable, the relationship between chronological age and skeletal maturity is closest in the juvenile years and therefore greater accuracy is achieved in the prediction of age from the juvenile than from the adult. The dental and the chronological age show a stronger correlation than the skeletal and chronological age. The differences in the skulls between the two sexes are seen only after puberty. Adult males tend to be larger than females in a number of features due to a combination of faster rates of growth during puberty and longer period of growth.

Racial/ Geographic variations: (Standring 2005)[3]

Several major studies assessed the variations in cranial shape among and between the populations. Variations in the shape of the human cranium are far greater within than between the populations. It is reported that some features are evident for the shapes of the cranium from the populations of different geographic origin.

The determination of racial or genetic origin is difficult to achieve, although the physical and forensic anthropological scientists insist on doing that. In the migrant modern world, it has become restrictive. In spite of the overlap, there exists the representation. Geographical origin and the recognized physical traits enabled the 4 traditional races of man: Caucasoid, Negroid, Mongoloid and Australoid. The Indian subcontinent is included in the Caucasoid The skull has a rounded to long shape (dolicocephalic); steep forehead; narrow nasal aperture/ a prominent nasal spine/ a steeple shaped nasal root; moderately developed supraorbital ridging/ narrow interorbital distance; prominent chin; long and narrow palate; not overly prominent cheek bones and a tendency to maxillary protrusion or mandibular retrusion.

The current research on racial discrimination is by genetic markers; hence, the skeletal indicators now play a significantly reduced role. (Bamshead and Olson 2003)[7].

In the present study, for the orbital measurements, the skulls were subjectively sexed. Still, for the vertical and transverse diameters of the orbit, the formula of the demarking points (Jit and Singh 1966)[8] was attempted to find out the best parameter towards the sex determination of the skull. The demarking points of the present study were assumed to spread over the 3 SD values over and above the mean value of the vertical and transverse diameter. (Table 2)

Table 2: Orbit: Measurements: Demarking points (DP)

Orbit- Height				
-	Right		Left	
Height (cms)	Male (51)	Female (21)	Male (51)	Female (21)
Mean	3.5	3.2	3.37	3.08
SD	0.27	0.28	0.26	0.21
3 x SD	0.81	0.84	0.78	0.63
DP	3.2+ 0.84=> 4.04	3.5- 0.81=< 2.69	3.08+ 0.63=> 3.71	3.37- 0.78=< 2.59
n & % of the male or female skulls beyond DP	3/51= 5.88	NIL	6/51= 11.76	NIL
Width (cms)	-	-	-	-
Mean	4.17	3.72	4.08	3.69
SD	0.21	0.16	0.19	0.16
3 x SD	0.63	0.48	0.57	0.48
DP	3.72+ 0.48=> 4.2	4.17- 0.63=< 3.54	3.69+ 0.48=> 4.17	4.08- 0.57=< 3.51
n & % beyond DP	22/51= 43.13	NIL	15/51= 29.41	NIL

In the male, the demarcation points for the vertical diameters of the right and the left orbits have contributed to a certain extent towards the sex determination. On the other hand, the transverse (width) diameters; especially in the right side have identified that 22 skulls could be definitely male. For the female, the demarcation points for the orbits' vertical and transverse diameters have not contributed towards the sex determination of the skulls.

As for the geographic distribution and racial origin of the skulls; it may be noted that they were from Karnataka, India and belonged to

Appendix 1: Orbit- Measurements: Mean & SD

Sl. No	Male- Right			Male- Left		
-	Height (cms)	Width (cms)	Index	Height (cms)	Width (cms)	Index
1	3.9	4.9	79.59	3.8	4	95
2	3.8	4.4	66.36	3.6	4.7	76.59
3	3.9	4.3	50.69	3.8	4.1	52.68
4	4	4	100	3.9	4	97.5
5	3.5	4.5	77.77	3.5	4	87.5
6	3.7	4.1	50.24	3.6	4.2	65.71
7	3.7	4.1	50.24	3.6	4.4	61.81
8	3.3	4	82.5	3.8	4.4	66.36
9	3.5	4.5	77.77	3.2	4	80
10	3.5	4	87.5	3.5	3.9	69.74
11	3.4	4.5	75.55	3.5	4	87.5
12	3.5	4	87.5	3	4.3	69.76
13	3.4	4	85	3.2	4.4	72.72
14	3.1	4.2	90.47	3.3	4.3	76.74
15	3.2	4.5	71.11	3	4.3	69.76
16	3.2	4.3	74.41	3.2	4	80
17	4	4.5	68.88	3.1	4	77.5
18	3.8	4.1	52.68	4	4	100
19	3.8	4.2	90.47	3.4	3.9	67.17
20	3.5	4.3	61.39	3.5	3.9	69.74
21	3.5	4	87.5	3.2	4.4	72.72
22	3.4	4.2	80.95	3.5	4	87.5
23	3.1	4	77.5	3.3	3.9	64.61
24	3.4	4	85	3.3	4	82.5
25	3.9	4.2	52.85	3.1	3.9	79.48
26	3.2	3.9	62.05	3.2	4.1	78.04
27	3.5	3.9	69.74	3.6	3.9	52.3
28	3.6	4.5	80	3.5	4	87.5
29	3.5	3.9	69.74	3.3	4	82.5
30	3.4	4	85	3.5	3.8	52.1
31	3.1	4.1	75.6	3.1	4.1	75.6
32	3.3	4	82.5	3	4.1	73.17
33	3.1	4.4	70.45	3.1	4	77.5
34	3.2	4.3	74.41	3.1	4.2	73.8
35	3.4	4	85	3	3.6	63.33
36	3.2	3.9	62.05	3.3	4	82.5
37	3.2	4.1	78.04	3.3	4	82.5
38	3.7	4	92.5	3.1	4	77.5
39	3.5	4.2	63.33	3.2	4.1	78.04
40	3.3	4.1	60.48	3.1	4.1	75.6
41	4	4.5	68.88	3.9	4.4	68.63
42	3.7	4.4	64.09	3.4	4.3	79.06
43	3.8	4.1	52.68	3.4	4.3	79.06
44	3.5	4	87.5	3.6	3.9	52.3
45	3.9	4.1	55.12	3.3	4	82.5

Sl. No	Female- Right			Female- Left		
-	Height (cms)	Width (cms)	Index	Height (cms)	Width (cms)	Index
1	3.3	3.9	64.61	3.4	3.8	69.47
2	3.7	3.9	54.87	3.5	3.6	57.22
3	3.6	3.8	54.73	3.5	3.9	69.74
4	3	3.5	65.71	3.1	3.6	66.11
5	3	3.5	65.71	3.1	3.5	68.57
6	3.1	3.7	63.78	3	3.9	76.92
7	2.9	3.9	74.35	2.9	3.7	78.37
8	3.4	3.8	69.47	3	3.8	78.94
9	3.8	3.9	57.74	3.4	3.7	51.89
10	3.2	3.4	54.11	3	3.4	68.23
11	3.3	3.7	69.18	3.2	3.7	66.48
12	3	3.8	78.94	3	3.6	63.33
13	2.8	3.7	75.67	2.9	3.3	67.87
14	2.9	3.8	76.31	2.7	3.8	71.05
15	3	3.8	78.94	3	3.7	61.08
16	2.9	3.4	65.29	2.9	3.9	74.35
17	3.1	3.6	66.11	2.9	3.8	76.31
18	3.2	3.8	64.21	3.1	3.7	63.78
19	3.5	3.9	69.74	3.2	3.7	66.48
20	3.1	3.7	63.78	2.9	3.6	60.55
21	3.4	3.8	69.47	3.1	3.9	79.48

the traditional race of Caucasoid. The age determination based on the maxillary alveolar arches indicated that the skulls could be towards adult and old age.

The observed differences in the orbital measurements may be because of the sample size and the methodology and also the cardinal features pertaining to the skulls: subjective sex determination, age, racial and geological variations and asymmetry especially in the facial cranium.

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