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Morphometric Analysis of the Orbit in Dry Human Skulls in Northeast Brazil

Lucas de Andrade Alexandre,[1] Tássia Santos de Melo,[2] Larissa Vilar Ferreira,[2] Jalles Dantas de Lucena,[3] André de Sá Braga Oliveira[4]

[1]Medicine Course, Federal University of Paraiba – UFPB, João Pessoa, PB, Brazil
[2]Nutrition Course, Federal University of Paraiba – UFPB, João Pessoa, PB, Brazil
[3]Medicine Course, College Santa Maria (FSM), Cajazeiras, PB, Brazil
[4]Department of Morphology, Federal University of Paraiba – UFPB, João Pessoa, PB, Brazil

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ABSTRACT

Introduction: the orbit is present in pair in the skull. It is a bone cavity that has important clinical implications, characteristics of sexual dimorphism and is anthropologically relevant in the definition of ethnicity. The objective of the present study was to analyze the morphology of orbits in cadaveric skulls of two different populations in Northeast Brazil.

Material and Methods: skulls of two different states of Brazil (Ceará and Paraíba) were categorized into three types: Megaseme, Mesoseme and Microseme. The quantitative analysis was performed by a digital caliper and included the following measurements: (1) OH: Orbital Height; (2) OB: Orbital Breadth; (3) OI: Orbital Index. The data underwent statistical analysis using the IBM SPSS 23 software, with a significance level of 5%.

Results: after excluding skulls with damaged orbits, 115 skulls were included, totalizing 230 orbits. Of these, 91 skulls were from Paraíba and 24 from Ceará. Both populations apart and together are in the microseme category. No differences were found in quantitative analysis between genders, sides or populations, except OB and OI that showed differences between the two populations studied.

Conclusion: the study of orbit is essential for the surgeon, clinician, anatomist, radiologist and professionals from other specialties, since it is a region of important clinical and surgical significance, as it may undergo morphometric changes depending on the population.

Keywords: Anatomy; Orbit; Skull; Osteology.

Introduction

The orbit is present in pair in the skull. It is a bone cavity that contains several structures: eye bulb, accessory structures of vision (eyelids, extrinsic muscles, nerves, vessels, fascia and conjunctiva) and the adipose body[1]. Seven bones make up the orbit: frontal, sphenoid, ethmoid, palatal, zygomatic, lacrimal and maxilla[2].

The orbit has particular characteristics of sexual dimorphism. Women usually present a larger and rounder orbit, while men present a square and smaller one. In addition, it also presents ethnic differences, with variation in its morphometry depending on the population, being anthropologically relevant in the definition of ethnicity[3,4].

This structure has important clinical implications, considering that it may be involved in congenital anomalies, trauma, neoplasms, vascular and endocrine disorders[5]. Its morphological and morphometric knowledge is essential, since it is a region exposed to various types of ophthalmic procedures, maxillary and facial reconstructive surgeries[4].

Thus, the objective of the present study was to analyze the morphology of orbits in cadaveric skulls of two different populations in Northeast Brazil, in order to improve anatomical knowledge for safer clinical and surgical interventions in this region.

Methods

This research was carried out at the Morphology Department of Universidade Federal da Paraíba (UFPB) and Universidade Federal do Ceará (UFC), under the approval of the Research Ethics Committee under the CAAE registration 28421319.8.0000.5188. This was an observational study.

Skulls were included in conditions of conservation that would allow accurate measurement of the variables under study. Skulls with infantile conformation and major bone degradation in the region of at least one of the orbits, which would make the analysis impossible, were excluded from the analysis. A digital caliper was used with an accuracy of 0.01 mm (Eccofer®, João Pessoa, Paraíba, Brazil).

Gender identification was performed according to Vanrell[6] criteria for cranial sexual dimorphism. The qualitative analysis was carried out according to the standard classification by Patnaik, Bala and Singla[7].

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Table 1. Orbit types by Patnaik, Bala and Singla[7]. N = 115 skulls

Category	OI (%)	Race
1. Megaseme (Large)	≥ 89	Orientals. Yellow races, except the Eskimos
2. Mesoseme (Intermediate)	83-89	Caucasians. European, English
3. Microseme (Small)	≤ 83	Africans. Black

The quantitative analysis included the following measurements: (1) OH: orbital height, which corresponds to the largest vertical diameter of the orbit; (2) OB: orbital breadth, which is the transverse diameter from the point called dacryon (d) - intersection between the frontal, lacrimal and maxilla bones - to the point called ectoconchionec (ec) - intersection of the lateral edge of the orbit with the line that divides the orbit along the longest axis; (3) OI: orbital index, obtained by dividing OH by OB and multiplying the result by 100. (Figure 1)

Figure 1. Orbit's measurements. Anterior view. OH – Orbital Height; OB – Orbital Breadth; d – dacryon; ec – ectoconchionec. (Collection Research)

A comparison of the variables OB, OH and OI was performed between the genders of both study populations, as well as between both sides. In addition, comparisons were also made between diameters of both populations (UFPB and UFC), with both genders and sides together.

The data underwent statistical analysis using the IBM SPSS 23 software. Categorical variables were described by frequencies. The normality analysis was performed by the Kolmogorov-Smirnov test, the difference between medians of nonparametric variables by the Wilcoxon and Kruskal-Wallis tests and the difference between means of parametric variables by the Independent Samples t Test. Values of $p \leq 0.05$ were considered significant.

Results

After excluding skulls with damaged orbits, 115 skulls were included, totalizing 230 orbits. Of these, 58 (50.4%) were female and 57 (49.6%) were male. The sample consisted of 91 (79.1%) skulls from the Morphology Department of UFPB and 24 (20.9%) from UFC. UFPB had 46 female skulls and 45 males, while UFC had 12 male and 12 females. (Table 2)

Table 2. Distribution of skulls analyzed in the study. N=115 skulls

	Female	Male	Total
UFPBa	46	45	91
UFCb	12	12	24
Total	58	57	115

a – Federal University of Paraíba; b – Federal University of Ceará.

The qualitative analysis was done considering each population studied and both. Using the OI, both populations apart and together are in the category microseme, according to the standard classification by Patnaik, Bala and Singla[7]. On UFPB, 85,16% of the orbits were Microseme, 12,64%, Mesoseme and 2,2%, Megaseme. On UFC, 58,3% were Microseme, 25%, Mesoseme and 16,7%, Megaseme. Considering both populations, 79,6% of the orbits were Microseme, 15,2%, Mesoseme and 5,2%, Megaseme. (Table 3)

Table 3. Distribution of orbits' categories according to Patnaik, Bala and Singla[7] in skulls of Northeast Brazil. N = 250 orbits.

Population	Median OI (%)	Category	Distribution
UFPBa	78.28	Microseme	85.16% - Microseme; 12.64% - Mesoseme; 2.2% - Megaseme
UFCb	82.16	Microseme	58.3% - Microseme; 25% - Mesoseme; 16.7% - Megaseme
Total	78.78	Microseme	79.6% - Microseme; 15.2% - Mesoseme; 5.2% - Megaseme

a – Federal University of Paraíba; b – Federal University of Ceará.

Without differentiating gender, side or population, linear measurements showed that the mean of orbital breadth (OB) was 41.87mm ± 2.50 (31.13 - 48.52) and the median of orbital height (OH) was 33.00mm, IQR = 3.00 (28.60 - 41.20). In addition, the median of orbital index (OI) was 78.78mm, IQR = 7.04 (53.70 - 115.28) (Table 4)

Considering the side, orbits were divided into left and right. On the left, the median of OH was 33.20, IQR

2.67 (28.60 - 41.20), the median of OI was 78.72, IQR 7.58 (53.70 - 108.57) and the mean of OB was 42.08 ± 2.64 (31.13 - 47.60). On the right, the median of OH was 32.70, IQR 3.10 (28.92 - 38.92), the median of OI was 78.79, IQR 6.76 (67.57 - 115.28) and the mean of OB was 41.66 ± 2.34 (33.76 - 48.52). There were no differences between the right and left orbits (p<0.05). (Table 4)

Table 4. Morphometric analysis, considering the gender and sides of orbits in Northeast Brazil. Data were expressed as Mean (mm) ± SD (Minimum - Maximum) for OB measurement and Median (mm) - Interquartile Range (Minimum - Maximum) for OH and OI measurements. N= 250 orbits.

Variables	Left	Right	p value	Female	Male	p value	Total
OH	33.20 - 2.67 (28.60 - 41.20)	32.70 - 3.10 (28.92 - 38.92)	.157[c]	33.00 - 2.73 (28.60 - 41.20)	32.80 - 3.40 (28.90 - 40.50)	.196[e]	33.00 - 3.00 (28.60 - 41.20)
OI	78.72 -7.58 (53.70 - 108.57)	78.79 - 6.76 (67.57 - 115.28)	.767[c]	78.91 - 6.42 (66.35 - 103.50)	78.30 - 7.40 (53.70 - 115.28)	.454[e]	78.78 - 7.04 (53.70 - 115.28)
OB	42.08 ± 2.64 (31.13 - 47.60)	41.66 ± 2.34 (33.76 - 48.52)	.198[d]	41.96 ± 2.46 (31.13 - 47.60)	41.79 ± 2.54 (33.76 - 48.52)	.621[d]	41.87 ± 2.50 (31.13 - 48.52)

OH – Orbital Height; OI – Orbital Index; OB – Orbital Breadth; IQR – Interquartile Range; c – Wilcoxon test; d – Independent Samples t Test; e – Kruskall-Wallis test.

Considering the gender, orbits were divided into female and male. On female, the median of OH was 33.00, IQR 2.73 (28.60 - 41.20), the median of OI was 78.91, IQR 6.42 (66.35 - 103.50) and the mean of OB was 41.96 ± 2.46 (31.13 - 47.60). On male, the median of OH was 32.80, IQR 3.40 (28.90 - 40.50), the median of OI was 32.80, IQR 3.40 (28.90 - 40.50) and the mean of OB was 41.79 ± 2.54 (33.76 - 48.52). There were no differences between genders (p<0.05). (Table 4)

Then, the orbits were divided into two populations: UFPB and UFC. On UFPB, the median of OH was 32.90, IQR 3.10 (28.60 - 40.50), the median of OI was 78.28, IQR 6.83 (53.70 - 108.57) and the mean of OB was 42.28 ± 2.28 (36.3 - 47.6). On UFC, the median of OH was 33.52, IQR 2.28 (28.92 - 41.20), the median of OI was 82.16, IQR 8.62 (70.86 - 115.28) and the mean of OB was 40.30 ± 2.71 (31.13 - 48.52). When comparing the two studied populations, there were statistically significant differences in the variables OI and OB. (Table 5)

Table 5. Morphometric analysis, considering the orbits of two different populations in Northeast Brazil. Data were expressed as Mean (mm) ± SD (Minimum - Maximum) for OB measurement and Median (mm) - Interquartile Range (Minimum - Maximum) for OH and OI measurements. N= 250 orbits.

Variable	UFPB	UFC	p value for comparison
OH	32.90 - 3.10 (28.60 - 40.50)	33.52 - 2.28 (28.92 - 41.20)	.1194[e]
OI	78.28 - 6.83 (53.70 - 108.57)	82.16 - 8.62 (70.86 - 115.28)	.0000025[e]
OB	42.28 ± 2.28 (36.3 - 47.6)	40.30 ± 2.71 (31.13 - 48.52)	.000015[d]

OH – Orbital Height; OI – Orbital Index; OB – Orbital Breadth; IQR – Interquartile Range; e – Kruskall-Wallis test; d – Independent Samples t Test.

Discussion

Skull morphometric parameters, including orbital height, breadth and index, are important for ophthalmology, oral and maxillofacial surgeons and neurosurgeons, as well as to distinguish an individual's gender and ethnicity. These measures vary due to age, sex, race and regions[3,4]. Prior knowledge of these measures is crucial for their correct clinical application, given that it varies from one population to another.

According to the standard classification by Patnaik, Bala and Singla[7], the mean OI of both populations (UFC and UFPB) in the present study belongs to the Microseme category. Pires *et al* have also studied a Brazilian population, in the Southeast region, and have reported a higher mean OI (88.72)[4]. This group can be placed under the Mesoseme category, different to our results. The reported difference may have occurred due to regional, genetic and environmental factors or due to the smaller sample analyzed in their study (n = 77). (Table 6)

Mekala, Shubha and Rohini carried out their study in a South Indian population, which can be placed under the Mesoseme category, also different to our results, given that they found higher values of OI[8]. Dhanwate and Gaikwad had the same classification finding as the previous study, but in a population from the West of India[3]. Kumar and Nagar also conducted a study in a Indian population, but in the North, with findings that correlate to the Microseme category, the same found in our study[9]. This difference between North and South may have happened due to the same reasons as in Brazil and shows that, in the same country, different regions may present different orbit types. (Table 6)

Other studies had different orbit types considering ours. A study in China with CT scans placed the population in the Mesoseme category[10]. In Nigeria, a study had the Megaseme classification[11]. On the other hand, studies in Egyptian and Kenyan populations had the same classification as this study, Microseme[5,12]. (Table 6)

The present study analyzed 230 orbits and concluded that there were no differences between the parameters when comparing the right orbit with the left one, as well as between genders. Regarding the orbit index, in the female gender it had a higher value compared to the male gender. (Table 4). This difference, however, does not present statistical significance to associate

Table 6. Comparison of orbit types with previous studies.

Study	Skull number	Population	OI (%)	Category
Pires *et al*, 2016[4]	77	Brazilian (Southeast)	88.72	Mesoseme
Mekala; Shubha; Rohini, 2015[8]	200	Indian (South)	85.8	Mesoseme
Dhanwate; Gaikwad, 2016[3]	98	Indian (West)	87.47	Mesoseme
Kumar; Nagar, 2014[9]	68	Indian (North)	79.65 (right) 80.49 (left)	Microseme
Ji *et al*, 2015[10]	64 CT scans	Chinese	87.42 (female) 83.33 (male)	Mesoseme
Ukoha *et al*, 2011[11]	70	Nigerian	89.21	Megaseme
Fetouh; Mandour, 2014[5]	52	Egyptian	83.50 (female) 82.27 (male)	Mesoseme(female) Microseme(male)
Jeremiah; Pamela; Fawzia, 2013[12]	150	Kenyan	83.48 (female) 82.57 (male)	Mesoseme (female) Microseme(male)
Present Study	115	Brazilian (Northeast)	78.78	Microseme

OI – Orbital Index.

with sexual dimorphism in these populations. This higher value found for OI in females is similar to that found in other studies carried out in India, Egypt and Kenya[3,5,8,10,12]. (Table 7)

In this study, there were no significant asymmetries between the OI of right and left orbits, as also seen by studies in India, Egypt and Nigeria[3,5,11]. The same was found by Ji *et al*, in their study carried out in the Chinese population, as well as Mekala *et al*, in a population of South India, where OI on the right side is a little higher than the left side[8,10]. These variations in OI inside the same population may be due to genetic and environmental factors and also to different craniofacial growth patterns arising from ethnic and racial differences. (Table 7)

Regarding the OB and OH diameters, no significant differences were found between genders. These results are similar to the discoveries of Dhanwate and Gaikwad, in a population of India, that also found no significant differences between the OH and OB diameters when comparing the sexes[3]. A study in Brazil with CT scans found a statistically significant difference in OB between genders, but not in OH, like studies in Egypt and China[5,10,13]. Other study in India, on the other hand, found significant differences between the genders in both parameters ($p < 0,001$)[8]. (Table 8)

When comparing the OH and OB diameters on the right and left orbits, it is noted that the left side presents higher values than the opposite side. However, this difference is not statistically significant. This difference was also not statistically significant in studies in Brazil, China, Nigeria and India, but, in these last 3 countries, the right side generally presented higher values, which is the opposite of our study[8,10,11,13]. Other study in India found that the only statistically significant difference was that the right orbital breadth was higher than the left one, which is different to the findings of our study[3]. (Table 8)

Considering the two populations of our study, when comparing the values of the right and left side of the OB diameter of both sexes between the two populations studied, it was observed that the orbits of Ceará showed a smaller breadth compared to Paraíba ($p < 0.001$). (Table 5). This difference may be due to environmental and genetic factors, given that Ceará people are known to have a flat head[10].

In addition, it is noted that the orbit index (OI) also showed differences when comparing the two states ($p < 0.001$). The importance of the orbital index lies in its use for the interpretation of fossil records, the classification

Table 7. Comparison of OI (%) between both sexes and sides with previous studies.

Study	Skull number	Population	Female OI	Male OI	Right OI	Left OI
Dhanwate; Gaikwad, 2016[3]	98	Indian (West)	87.88	87.47	87.28	87.66
Fetouh; Mandour, 2014[5]	52	Egyptian	83.50	82.27	82.62	82.72
Mekala, Shubha; Rohini, 2015[8]	200	Indian (South)	85.46	84.62	85.22	84.82
Jeremiah; Pamela; Fawzia, 2013[12]	150	Kenyan	83.48	82.57	-	-
Ukoha *et al*, 2011[11]	70	Nigerian	-	89.21	88.54	89.91
Ji *et al*, 2015[10]	64 CT scans	Chinese	87.42	83.33	85.55	85.46
Present Study	115	Brazilian	78.91	78.30	78.79	78.72

OI – Orbital Index.

of the skull in forensic medicine and the explanation of trends in evolutionary and ethnic differences. Normal values of orbital indexes are vital measurements in the assessment and diagnosis of craniofacial syndromes and post-traumatic deformities. Knowledge of normal values of a particular region or population can be used to treat abnormalities and produce the best aesthetic and functional results[10,14,15]. Regarding the OH diameter, there were no statistically significant differences between the two populations.

Thus, comparisons with different studies demonstrate that there is a wide variability in orbit morphometry, due to genetic, environmental, ethnic, racial factors, measurement methods and sample sizes. It is important to note that this variability occurs between different countries and inside the same country.

Conclusion

This study shows that, considering the orbital index, the orbits of the studied populations can be placed under the Microseme category. There were no differences between the sides and no sexual dimorphism in orbits analyzed. In addition, when comparing the two populations studied, no differences were found between the height of the orbits, however, there were differences in the breadth and the orbital index, possibly being related to environmental, regional and genetic factors.

The study of orbit is essential for the surgeon, clinician, anatomist, radiologist and professionals from other specialties, since it is a region of important clinical and surgical significance, as it may undergo morphometric changes depending on the population.

Table 8. Comparison of OH and OB between both sexes and sides with previous studies.

Study	Skull number	Population	OH (mm)				OB (mm)			
			Male	Female	Left	Right	Male	Female	Left	Right
Dhanwate; Gaikwad, 2016[3]	98	Indian (West)	32.52	32.43	32.39	32.64	37.3	36.96	37.08	37.52
Pereira *et al*, 2019[13]	113 CT scans	Brazilian	34.92	34.35	34.67	34.67	44.15	42.00	43.22	43.20
Fetouh; Mandour, 2014[5]	52	Egyptian	35.57	35.12	-	-	43.25	42.37	-	-
Ji *et al*, 2015[10]	64 CT scans	Chinese	33.35	33.22	33.28	33.45	40.02	38.00	39.1	38.94
Mekala; Shubha; Rohini, 2015[8]	200	Indian (South)	36.20	34.50	35.30	35.50	42.90	40.5	34.98	36.03
Ukoha *et al*, 2011[11]	70	Nigerian	-	-	31.45	31.9	-	-	34.98	36.03
Present Study	115	Brazilian	32.80	33.00	33.20	32.70	41.79	41.96	42.08	41.66

OH – Orbital Height; OB – Orbital Breadth.

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Corresponding author
Jalles Dantas de Lucena
E-mail: jallesdantas@gmail.com