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MORPHOMETRY OF EYE ORBIT FROM CT SCAN IMAGES OF GUJARATI RAJPUT POPULATION

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Abstract

The intricate anatomical structure of the human orbit houses both the neurovascular and optical machinery. Forensic specialists, maxillofacial and plastic surgeons, anthropologists, and anatomists highly value morphometric study of orbits. As shown by earlier research, orbital diameters differ according to sex, race, areas within a single race, and stages of evolution and development. The main objective of the current study is to provide baseline reference data for the Gujarati Rajput community, which is regarded as one of Gujarat's endogamous communities. CT Scan images of the skulls of 105 Adult Gujarati Rajputs were collected from Sir T. General Hospital, Bhavnagar, C.U.Shah Medical College, Surendranagar, and K.J. CT Scan Centre, Veraval, Gujarat, India. Orbital dimensions such as Orbital height and breadth were measured in RadiAnt DICOM Viewer and the Orbital Index was also calculated. The mean orbital height was 3.25 cm, the mean orbital breadth was 3.70 cm and the mean Orbital Index was 88.39. The right and left side orbits did not vary that much in height or width. The OI states that under study, the Gujarati Rajputs of India fall within the Mesoseme category. The data aid in the improved management of orbital diseases and demonstrate the variability of orbital morphology across various geographic regions.

Keywords: *Orbital morphometry, Gujarati Rajputs, CT Scan Images, Orbital Index, Mesoseme*

1. INTRODUCTION

The Greek terms anthropos (human) and metron (measure) are the roots of the word anthropometry's derivation. Anthropologists studying the variations in human body shape created anthropometry in the late 1800s.(Broz ˇ Ek & Prokopec, 2001; Mocini et al., 2023) Various research work says that nearly every database now in use contains measurements solely based on cephalometry or conventional anthropometry. (Weinberg et al., 2016) Conventional human anthropometry is a straightforward, non-invasive, and cost-effective methodology that can be easily applied in various epidemiological or clinical settings. Its goal is to gather measurements of the human body using basic instruments (such as a skinfold caliper, weight scale, meter, gauges, and compasses) at the regional and/or total body levels. (Mocini et al., 2023)(Rumbo-Rodríguez et al., 2021) Despite its broad applicability, anthropometric measurements must be conducted with precision and standardization to ensure reliability across different populations and conditions. Factors such as hydration levels, posture, and environmental influences can contribute to measurement variability, necessitating strict protocols for data collection. (Casadei & Kiel, 2023) Varied racial groups have varied morphometrics for the orbit and the skull. Furthermore, a variety of diseases may affect the orbit and its components and cause changes in the orbital structures' volume. (Boruah et al., 2021; Du et al., 2019) On either side of the nose are skeletal receptacles called the bony orbits. In addition to shielding the eye from harm, the orbital wall serves as an attachment site for six extraocular muscles.(S. S et al., 2018) In anthropometric and clinical domains, the topographic correlations between orbital borders and eyeballs are significant. The degree of eyeball protrusion in the orbit, or the anterior-posterior relationship has a significant impact on how differently the orbital region appears in different people and racial groupings.(Shin et al., 2017)(Sforza et al., 2015; Weaver et al., 2010, 2011)(Yoo et al., 2013) On dried skulls, however, direct orbital volume measures have been reported in several studies, and these direct measurements have been contrasted with those acquired using conventional

CT.(Tandon et al., 2020) The orbital index, which represents the change in the orbital base's shape numerically, is the percent ratio of vertical to horizontal diameter.(ShenoyM, 2015) The orbital index is also an important variable because its value changes from one racial group to another, resulting in a different facial shape within distinct ethnicities. This index reveals differences not only between races but even among the same race - including two districts and periods of evolution. Documented ranges of this index among nationalistic groups may prove advantageous for skull identification. In certain situations, such as the interpretation of fossil records, the classification of skulls for forensic purposes, and molecular studies associated with the history of evolution or ethnic groups, it is essential to know the dimensions of the orbital cavity concerning skull craniometry.(A. Kumar & Nagar, n.d.) Pathologies can primarily impact bone orbit architecture during growth and development. No evidence is available regarding patterns of bone orbit asymmetry in normal persons during development. Assessing the proper anatomic relationship between both orbits is necessary to determine the exact level of asymmetry that is acceptable.(Seiji et al., 2009) In accordance with the literature, people of different ages, sexes, and ethnic backgrounds have significantly variable orbital and ocular geometries. It is believed that variations in orbit and eye anthropometry influence how the eye reacts to a traumatic impact. Studies have been conducted on age and gender-related changes in the orbits and eyes. In both males and females, ocular protrusion reduces as age increases. It was proposed that aging-related changes in orbital aperture can have an impact on eye measures.(Weaver et al., 2010) Even so, numerous literatures describe the typical morphology of the orbital components as observed on CT. Upon reviewing the literature, we were unable to locate reliable quantitative normative CT data for extraocular muscle diameters, which could be crucial for assessing a patient with possible orbital diseases like Graves' orbitopathy (GO). To properly determine whether the extraocular muscles in this case are normal, it may be important to know their diameter ranges. (Ozgen & Ariyurek, 1998) Significant racial variations exist. There could be variations in orbital volumes according to age and gender. While the numbers of male and female are frequently stated separately, age is typically ignored, and racial information is not always included.(Regensburg et al., 2011) The bony orbit-the focus of this work is also significant for maxillofacial surgeons, forensic experts, and anatomists and not only for ophthalmologists and orthodontists.(D et al., 2015)

2. MATERIAL AND METHODOLOGY

The current research was conducted on one of the Endogamous Communities of Gujarat i.e. Rajput Population in 2023. This study includes a healthy 105 adults (54 female and 51 male) aged 18-82 who belong to the Rajput Community in Gujarat state. CT Scan Images of 105 adults were collected from the Sir Takhtsinhji General Hospital, Bhavnagar, C.U.Shah Medical College, Surendranagar, and K.J. CT Scan Centre, Veraval, Gujarat, India. Morphometry was done in 105 adult skulls i.e.210 orbits were analyzed using RadiAnt DICOM Viewer. Exclusion criteria included those who had head surgery or skulls fractured at the areas of the orbit. Our study involved measuring the distance between the medial and lateral walls of the orbit to determine the orbital width.(Basu Roy, 2014) We also measured the distance between the superior and inferior margins of the orbit to determine the orbital height.(Basu Roy, 2014) To quantify these dimensions, we calculated the orbital index, which is obtained by multiplying the ratio of orbital height to orbital width by 100. (Basu Roy, 2014)Measurements of the eye orbits were tabulated in Microsoft Excel for easy handling of the data. Obtained measurements were statistically analyzed in IBM Statistical Package for Social Science (SPSS) version 26.0.0. Descriptive facts, i.e., suggestions, popular mistakes, and widespread deviation were acquired for all measurements.

3. RESULTS

The study focused on acquiring measurements from CT Scan Images of 105 individuals belonging to the Gujarati Rajput Community. The sample comprised 51 males and 54 females, with ages ranging from 18-82 years. The study found that the average orbital height for male individuals ranges from 2.67 cm to 3.92 cm on the right, and 2.85 cm to 3.87 cm on the left. According to the data available for the Gujarati Rajput population, the size of the orbit in both males and females can be described as follows. The maximum dimension for the orbit in females ranged between 2.86 cm and 3.56 cm on the right and between 2.74 cm and 3.64 cm on the left. In turn, orbital width in females was 3.27 cm – 4.12 cm on the right and 3.07 cm – 3.91 cm on the left. In the case of men, the respective measurements are 3.08 cm – 4.43 cm on the right and 3.34 cm – 4.24 cm on the left. When regarding the population of Gujarati Rajputs, the orbit height for both males and females varies from 2.67 cm to 3.92 cm on the right and 2.74 cm to 3.87 cm on the left. For the right side, the dimensions were recorded as 3.08 cm to 4.43 cm. For the left side, the measurements ranged between 3.07 cm to 4.24 cm. When both male and female participants were taken into consideration, the orbital index was found to be 88.00 for the right side and 88.78 for the left side. The orbital index was found to be 86.74 for men and 89.95 for females. The difference between the two was noted. Table 1 describes the gender-wise distribution of the subjects of the current study.

Table 1: Gender-wise distribution of the participants

Gender	Number of Participants	Percentage
Male	51	49%

Female	54	51%
Total	105	100%

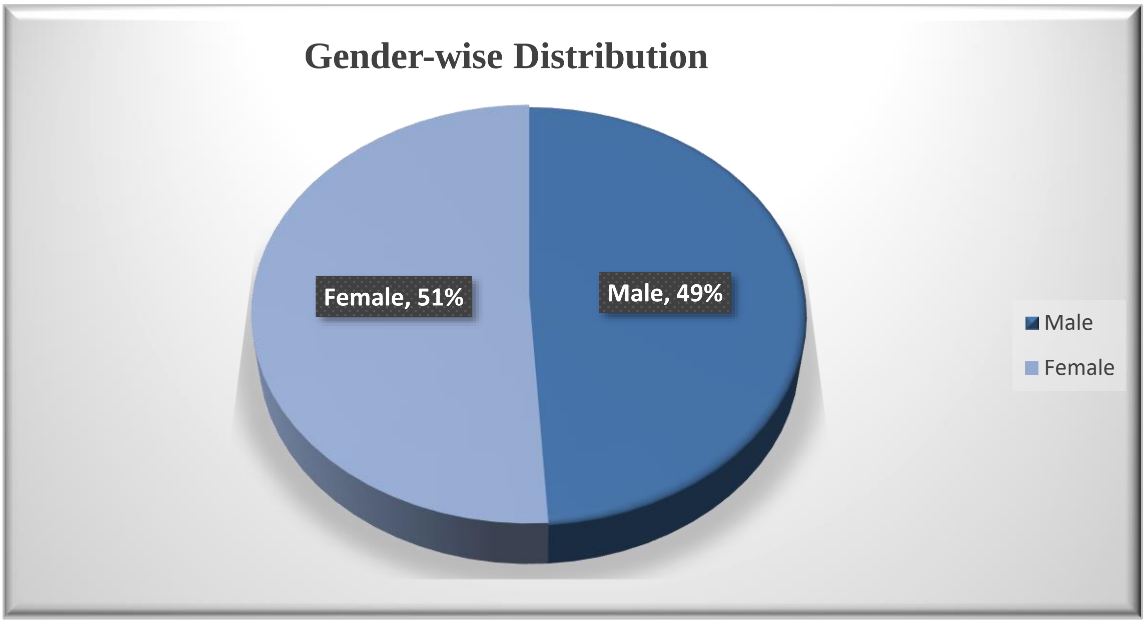

Figure 1: Graphical representation of gender-wise distribution of the participants

Figure 1 shows a Graphical representation of the gender-wise distribution of subjects.

Table 2 represents the descriptive statistics for the male, female, and combined Gujarati Rajput Subjects, including the minimum, maximum, mean, and standard deviation for the left and right orbital height and width.

Parameter	Gender	Side	Minimum	Maximum	Mean	Standard Deviation
Age	Male	-	18	82	42.67	17.96
	Female	-	18	77	48.48	17.37
	Combine	-	18	82	45.66	17.82
Orbital Height	Male	Right	2.67	3.92	3.28	0.23
		Left	2.85	3.87	3.24	0.20
	Female	Right	2.86	3.56	3.24	0.16
		Left	2.74	3.64	3.26	0.17
	Combine	Right	2.67	3.92	3.26	0.19
		Left	2.74	3.87	3.25	0.18
Orbital Width	Male	Right	3.08	4.43	3.78	0.25
		Left	3.34	4.24	3.77	0.20
	Female	Right	3.27	4.12	3.66	0.20
		Left	3.07	3.91	3.58	0.17
	Combine	Right	3.08	4.43	3.72	0.24
		Left	3.07	4.24	3.67	0.21

Table 2: Descriptive Statistics of Age, Orbital Height, and Orbital Width for the Male, Female, and Combined Gujarati Rajput Subjects

In the form of a bar diagram, Figure 2 presents a comparison of the height and width of the orbits of male and female Gujarati Rajputs.

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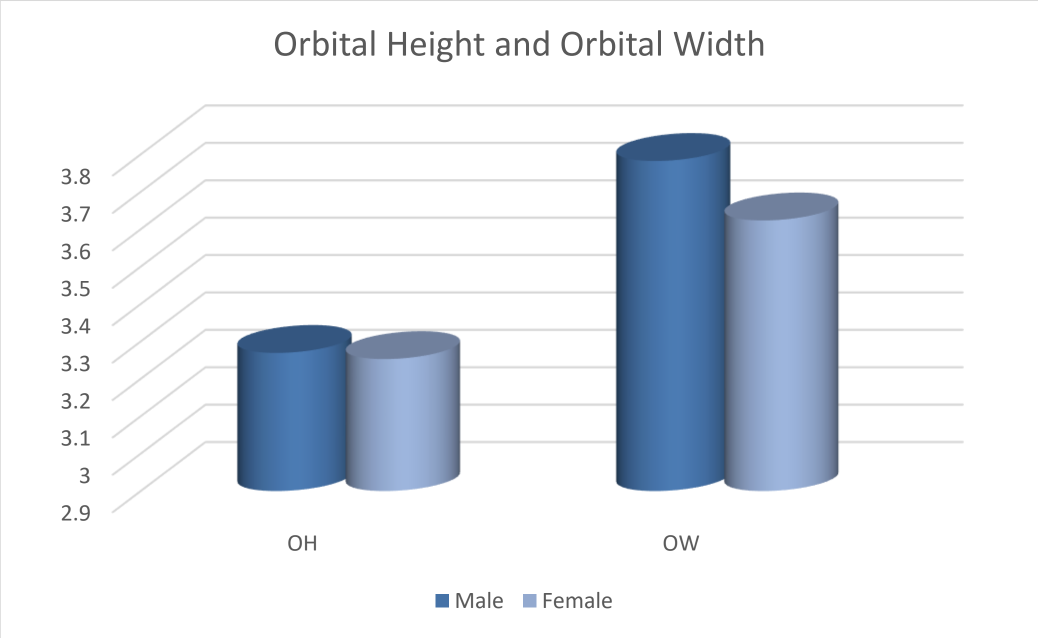

Figure 2: Comparison of Orbital height and width between male and female

As shown in Table 3, the orbital index of male, female, and combined Gujarati Rajput subjects is presented.

Parameter	Gender	Side	Mean	Standard Deviation
Orbital Index	Male	Right	87.19	8.50
		Left	86.28	6.53
	Female	Right	88.76	5.63
		Left	91.14	5.67
	Combine	Right	88.00	7.18
		Left	88.78	6.54

Table 3: Orbital Index of Right and Left Side for Male, Female, and Combined Gujarati Rajput Subjects

Table 4 shows the Orbital Index for Male, Female, and Combined for Gujarati Rajput Subjects.

Parameter	Male	Female	Combine
Orbital Index	86.74	89.95	88.34

Figure 3 compares the Orbital Index of Male, Female, and, Combined Gujarati Rajput Subjects in the form of a Bar Diagram.

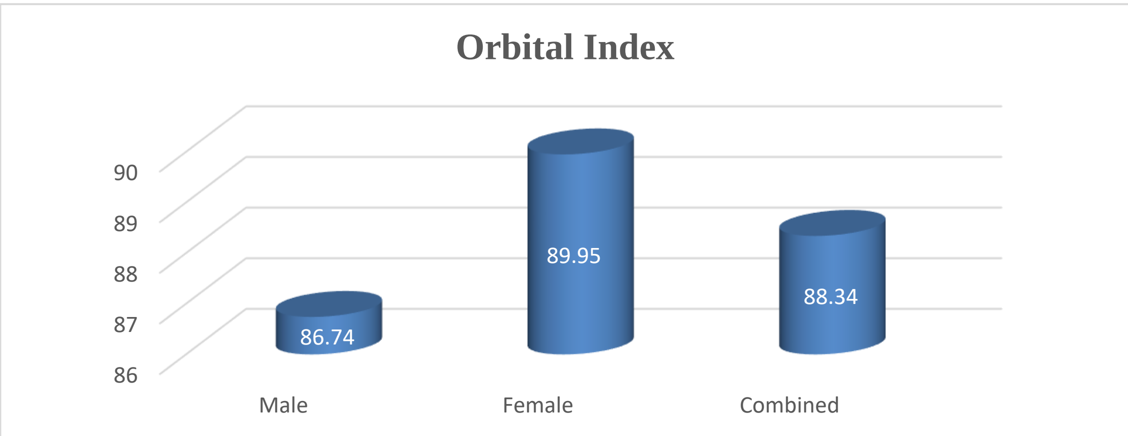

Figure 3: Comparison of the Orbital Index of Male, Female, and Combined Gujarati Rajput Subjects

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4. DISCUSSION

The current research has been conducted on the Rajput community residing in Gujarat, located in the western region of India. The current study examined CT scan Images of 105 Rajput adults who were in good health, focusing on assessing orbital dimensions, namely orbital height and orbital width. Numerous studies have quantitatively assessed the orbital dimensions across various populations, showing notable variability linked to geographic and ethnic differences. Noteworthy findings include:

Nigerian Population: Ukoha et al. (2011) and Bankole et al. (2012) found that Nigerian males typically have orbital dimensions with an average height of 33.01 ± 3.22 mm and a width of 42.24 ± 2.64 mm, highlighting slight variations within the same geographic area. (Bankole et al., 2012; Ukoha U, 2011)

North Indian and Other Asian Populations: Research by Jaswinder Kaur et al. (2012) and Rajeev Kumar et al. (2013) on North Indian skulls showed average orbital heights of around 32 mm, with comparable widths. Mekala D. et al. (2015) and Senthil Kumar et al. (2015) reported similar dimensions in South Indian skulls, emphasizing regional consistency. (D et al., 2015; Kaur et al., 2012; R. Kumar, n.d.; Senthil Kumar & Gnanagurudasan, 2015)

Egyptian and Middle Eastern Data: Studies by Fathy et al. (2014) and Ragab Slima et al. (2020) on Egyptian populations revealed average orbital heights of approximately 35 mm and widths exceeding 40 mm, suggesting slighter larger orbital dimensions compared to Indian counterparts. (Fetouh & Mandour, 2014; Ragab Slima & Ragab, 2020)

Table No. 5 shows the comparison of the orbital dimensions of the current research with some other studies of various populations.

Author	Year	Population Studied	Orbital Height (mm)	Orbital Width (mm)
			Male (R/L) / Female (R/L)	Male (R/L) / Female (R/L)
Ukoha U(Ukoha U, 2011)	2011	Nigerian Male	R: 31.90, L: 31.45	R: 36.03, L: 34.98
Jaswinder Kaur (Kaur et al., 2012)	2012	Indian (North)	R: 31.90, L: 32.20	R: 39.70, L: 38.80
Leko Bankole J (Bankole et al., 2012)	2012	Nigerian (lkwerre, Kalabari)	Lkwerre: M: 44.06/ F: 44.26 Kalabari: M: 42.87/ F: 42.44	Lkwerre: M: 42.87/ F: 42.37 Kalabari: M: 41.14/ F: 41.14
Ebeye O. A (EBEYE OA & OTIKPO O, N.D.)	2013	Nigerian	M:33.01/ F: 31.92	M:42.24 / F:40.82
Rajeev Kumar (R. Kumar, n.d.)	2013	Indian (North)	R:36.20, L: 35.80	R: 41.40, L: 41.60
Fathy A. Fetouh (FETOUH & MANDOUR, 2014)	2014	Egyptian	M:35.57/ F: 35.12	M:43.25/ F: 42.37
Anil Kumar (A. KUMAR & NAGAR, N.D.)	2014	Indian (North)	R: 33.47, L: 33.56	R: 42.06, L: 41.88
Mekala D (D et al., 2015)	2015	Indian (South)	M:36.2 / F: 34.5	M:42.9 / F: 40.5
NARASINGA RAO B. (RAO & PADMINI, 2015)	2015	Indian (South)	R: 32.62, L: 32.89	R: 36.5, L: 36.41
Senthil Kumar (SENTHIL KUMAR & GNANAGURUDASAN, 2015)	2015	Indian (South)	M:31.56, / F: 32.86	M:41.44/ F: 41.23
Navneet Lal (LAL ET AL., 2016)	2016	Sri Lankan	M:32.24,32.74 / F: 32.35,32.65	M:41.47,40.63/ F: 38.91,38.27
Niraj Pandey (AGRAWAL ET AL., 2017; PANDEY ET AL., N.D.)	2016	Nepalese	R: 34.44, L: 33.79	R: 38.08, L: 37.00
Jagriti Agrawal (AGRAWAL ET AL., 2017)	2017	Indian (Central)	R:33.25, L: 23.58	R: 39.53, L: 39.26
Nagaraj S. (NAGARAJ. S ET AL., 2017)	2017	Indian (South)	R: 32.02, L: 32.83	R: 37.01, L: 35.02
Naren Sarkar (SARKAR & MUKHOPADHYAY, 2018)	2018	Indian (Eastern)	M:34.96,35.22 / F: 35.63,35.86	M:39.86,39.93 / F: 39.00,39.17
Roli Joshi (JOSHI ET AL., 2018)	2018	Indian (North)	M: 38.8/ F: 31.2	M: 42.64/ F: 40.85
Varsha Kanjani (KANJANI ET AL., 2019)	2019	Indian (North)	M:30.65,31.32/ F:28.68,28.98	M:32.61,33.48/ F:30.31,30.94
Shaikh Amjad (HUSSAIN RIYAZ ET AL., 2020)	2019	Indian (Central, Maharashtrian)	R: 33.70, L: 32.23	R: 38.90, L: 37.48
Sumi Ghorai (CHAKKA SREEKANTH1, N.D.; GHORAI, 2019)	2019	Indian (Eastern)	M:32.46,31.86/ F: 29.13,32.57	M:39.14, 38.77/ F: 38.33, 38.67

Chakka Shreekanth (CHAKKA SREEKANTH1, N.D.)	2020	Indian (South)	M:37.7, 37.5 / F: 35.6, 35.6	M:44.8, 44.7/ F: 41.9, 41.8
Dalvinder Singh (SINGH ET AL., 2020)	2020	Indian (North)	M: 32.90, 32.16/ F: 32.05, 32.82	M: 40.16, 39.80 F: 39.06, 39.68
Shireen Ragab Slima (KHAN ET AL., 2021; RAGAB SLIMA & RAGAB, 2020)	2020	Egyptian	M: 33.29, 33.59/ F: 34.61, 34.40	M: 39.11, 39.22/ F: 37.01, 37.07
Zeba Khan (KHAN ET AL., 2021)	2021	Indian (Central, Maharashtrian)	R: 35.8, L: 35.7	R: 40.0, L: 40.7
Prashant Chakraborty (CHAKRABORTY ET AL., 2023)	2023	Indian (Eastern)	M:32.2,32.32/ F: 31.09,30.77	M:38.9, 38.9/ F: 37.12, 36.71
Present study	2024	Indian (Western)	M: 2.67, 2.85/ F: 2.86, 2.74 (cm)	M: 3.08, 3.34/ F: 3.27, 3.07 (cm)

M: Male, F: Female, R: Right, L: Left
Table 4: Comparison of the orbital dimensions with some of the prior studies

Orbital Index is classified into three categories. By having an orbital index of 89 or higher, the Megaseme type is characteristic of yellow races, which have a round orbital opening. On the other hand, the Mesoseme type, which has an orbital index between 89 and 83, is typically found in the white race. Finally, the Microseme type, which has an orbital index of 83 or less, is typical of black races, which have a rectangular orbital opening.(A. Kumar & Nagar, n.d.) The study found an orbital index of 88.34 for the Gujarati Rajput population falls in the Mesoseme Category, with male subjects at 86.74 considered as a Mesoseme and females at 89.95 Considered as a Megaseme but near to Mesoseme range.
Below, Table No. 6 shows a comparison between the orbital index of the current study with some of the prior studies.

Author	Year	Population	Gender	N	Orbital Index	Category
Masniari Novita (NOVITA ET AL., N.D.)	2006	Indonesian	Unknown	Flores-10 Batak-11 Klaten-10	106.63 99.26 102.73	Megaseme
Ukoha U (KAUR ET AL., 2012; UKOHA U, 2011)	2011	Nigerian	Male	70	89.21	Megaseme
Jaswinder Kaur (KAUR ET AL., 2012)	2012	Indian (North)	Unknown	30	81.65	Microseme
Leko Bankole J (BANKOLE ET AL., 2012)	2012	Nigerian	Male Female	I: 150 K:150	Male: 103.33 Female: 105.25 (Ikwerres) Male: 103.98 Female: 102.98 (Kalabari)	Megaseme
Rajeev Kumar (FETOUH & MANDOUR, 2014; R. KUMAR, N.D.)	2013	Indian (North)	Unknown	20	84.39	Mesoseme
Fathy A. Fetouh (FETOUH & MANDOUR, 2014)	2014	Egyptian	Male Female	30 22	82.27 83.50	Microseme Mesoseme
Anil Kumar (A. KUMAR & NAGAR, N.D.)	2014	Indian (North)	Unknown	65	R:79.65 L:80.49	Microseme
Mekala D (D ET AL., 2015)	2015	Indian (South)	Male Female	105 95	84.62 85.46	Mesoseme
Navneet Lal (LAL ET AL., 2016)	2016	Sri Lankan	Male Female	34 16	82.6 79.98	Microseme
Jagriti Agrawal (AGRAWAL ET AL., 2017)	2017	Indian (Central)	Unknown	50	84.48	Mesoseme

Nagaraj S. (Nagaraj. S et al., 2017)	2017	Indian (South)	Unknown	100	87.39	Mesoseme
Niraj Pandey (PANDEY ET AL., N.D.)	2018	Nepalese	Unknown	38	91.03	Megaseme
Roli Joshi (JOSHI ET AL., 2018)	2018	Indian (North)	Male Female	132 83	83.45 77.96	Mesoseme Microseme
Shaikh Amjad (HUSSAIN RIYAZ ET AL., 2020)	2019	Indian (Maharashtrian)	Unknown	31	R: 86.63 L: 85.99	Mesoseme
Sumi Ghorai (GHORAI, 2019)	2019	Indian (Eastern)	Male Female	70 30	R:82.93, L:82.17, R: 76, L: 84.23	Microseme
Chakka Sreekanth (CHAKKA SREEKANTH1, N.D.)	2020	Indian (South)	Male Female	57 43	R: 90.2, L: 88.13 R: 87.34, L: 87.03	Megaseme Mesoseme
Dalvinder Singh (SINGH ET AL., 2020)	2020	Indian (North)	Male Female	45 41	R: 82.09, L: 80.94 R: 82.18, L: 82.89	Microseme
Shireen Ragab Slima (RAGAB SLIMA & RAGAB, 2020)	2020	Egyptian	Male Female	168 132	R: 85.16, L: 86.66 R: 92.72, L: 92.82	Mesoseme Megaseme
Zeba Khan (KHAN ET AL., 2021)	2021	Indian (Maharashtra)	Unknown	60	R: 89.37 L: 89.31	Megaseme
Prashant Chakraborty (CHAKRABORTY ET AL., 2023)	2023	Indian (Eastern)	Male Female	71 30	R: 83.09, L: 83.23 R: 83.83, L: 83.85	Misoseme
Present Study	2024	Indian (Western)	Male Female	51 54	86.74 89.95	Mesoseme Megaseme

M: Male, F: Female, R: Right, L: Left

Table 5: Comparison of the orbital index with some of the prior studies

5. CONCLUSION

The study provides crucial orbital morphometric data for the Gujarati Rajput population, essential for plastic surgery, maxillofacial and neurosurgical procedures, and eye protective equipment design. The orbital index (OI) is valuable in forensic and anthropological investigations, determining unknown individuals' identities. The findings suggest that Rajput skulls can be classified as Mesoseme, with a mean orbital index of 88.34 in the Gujarat region. These findings have significant medical and forensic implications, emphasizing the need for continued morphometric studies across India.

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DECLARATIONS

Ethical approval**-** The authors received approval for this research from the Ethical Committee of the Gujarat University, Institutional Ethics Committee (Non-Interventional), Ahmedabad.
(Ref. No: GU-IEC(NIV)/02/PhD/027).

Conflict of interest: The authors declare that there is no conflict of interest.

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