DOI: 10.7860/JCDR/2025/79027.21992

Original Article

Anatomy Section

Head Shape and Cephalic Index Variations across Communities in Sriganganagar District, Rajasthan, India: A Cross-sectional Study

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ABSTRACT

Introduction: The exploration of craniofacial relationships and their variations has historically played a significant role in differentiating racial groups within physical anthropology. The cephalic index is an important parameter for determining the race and sex of an individual of unknown identity. It has been utilised to categorise skulls into dolichocephalic (long-headed), mesocephalic (medium-headed) and brachycephalic (short-headed) types, which have historically contributed to racial classification frameworks. Human body dimensions are influenced by biological, geological, ecological, racial, sex and age factors.

Aim: To determine the cephalic index and head shape in different communities of Sriganganagar, Rajasthan, India.

Materials and Methods: This cross-sectional study was conducted at the Department of Anatomy, Dr S. S. Tantia Medical College and Research Centre, Sriganganagar, Rajasthan, India, from September 2023 to March 2025. The study involved 1000 participants from five communities, with 200 individuals from each of Sikh, Arora, Jat, Brahman and Rajput groups, all aged 18-40 years. The cephalic index was calculated as the ratio of the maximum width of the head to the maximum length, multiplied by 100. Head measurements were taken using Vernier and spreading calipers. Data were subjected to statistical analysis to find out mean±SD and an Independent-samples t-test was used to compare two independent groups. A p-value <0.05 was considered statistically significant.

Results: The study analysed 1000 participants (n=500 males, n=500 females) across five communities in Sriganganagar. Males had a higher mean head length (19.46±1.7486 cm) and width (15.03±1.4321 cm) than females (18.20±1.2428 cm, 13.79±1.14832 cm), with a significantly higher cephalic index in males (77.23±5.9420) than in females (75.76±5.2432; p-value <0.01). The highest mean cephalic index was observed in Sikhs (81.75; n=200) and the lowest in Rajputs (71.98; n=200). Mesocephalic was the most common overall, while dolichocephalic dominated among Rajputs (79.5%; n=159) and brachycephalic among Sikhs (51%; n=102).

Conclusion: The mesocephalic head shape was most prevalent overall, with notable inter-community variations—dolichocephaly among Rajputs and brachycephaly among Sikhs—highlighting ethnic diversity in cranial morphology within the region.

Keywords: Cephalometry, Dolichocephalic, Head length, Head width, Mesocephalic

INTRODUCTION

The practice of measuring the human body has its roots in ancient Egypt, primarily aimed at depicting physical proportions in art. The term anthropometry derives from Greek, where “anthropos” signifies man and “metry” pertains to measurement. Hence, anthropometry entails the scientific study of human body size, weight and proportions [1]. India’s rich ethnic diversity means that no two individuals possess identical measurable characteristics. The Indian population is categorised using anthropometric data gathered from various groups nationwide [2].

Rajasthan’s northern region has one of the highest populations of different communities. Sriganganagar, located in the northernmost part of Rajasthan, is a demographically rich and culturally diverse district. It shares its boundaries with Punjab to the northeast and lies close to the international border with Pakistan. The region is characterised by a unique blend of communities due to historical migrations, agricultural development and its proximity to neighbouring states. Major communities residing in this region include Brahmans, Bishnois, Aroras, Jaats, Rajputs, Kumhars, Muslims and Sikhs, each with distinct cultural, linguistic and genetic backgrounds [3].

The cephalic index offers an uncomplicated numerical metric for distinguishing individuals by race, sex, or identity. It was first introduced by Swedish anatomist Anders Retzius (1796-1860) [4,5]. Cephalometric data are crucial in fields such as paediatrics, forensic medicine, plastic surgery, oral surgery, dentistry and for making diagnoses relative to normal population standards. Human body measurements are influenced by numerous factors, including ecological, biological, geographical, racial, sexual and age-related aspects [6]. Defined as the ratio of a head’s maximum width to its maximum length, the cephalic index, also known as the cranial index or index of width, categorises head shapes into groups such as dolichocephalic, brachycephalic, mesocephalic and hyperbrachycephalic [7,8].

Conducted in the Sriganganagar district of Rajasthan, this study underscores the significance of anthropometric indices in medical diagnostics and forensic research. The outcomes of this research aim to establish a foundational basis for future cephalometric studies across various communities and populations within specific geographical areas [9,10].

MATERIALS AND METHODS

A cross-sectional study was conducted in the Department of Anatomy at Dr S. S. Tantia Medical College and Research Centre, Sriganganagar, Rajasthan, India, from September 2023 to March 2025. Written informed consent was obtained from all participants. Ethical clearance for the study was granted by the Institutional Ethical Committee (Approval No. TU/EC/NEW/INST/2024/4636-11), as well as the Institutional Research Board, the Departmental Research Committee and the Research Board of Tantia University.

The study comprised 1000 participants, with 200 individuals each from five major communities: Sikhs, Aroras, Jaats, Rajputs and Brahmans.

According to the Census of India 2011, the total population of the Sriganganagar district was 1,969,168, comprising 1,043,000 males and 926,000 females [11]. For this study, the sample size was calculated using the standard formula for large populations, with a 95% confidence level (Z=1.96), an assumed proportion (p) of 0.5 to account for maximum variability and a margin of error (e) set at 5%. Based on these parameters, the minimum required sample size was estimated at approximately 457. However, considering the need for greater accuracy and representation across communities, a final sample of 1,000 participants was selected. This larger sample size enhances the reliability of the findings and ensures adequate representation from the five major communities under study.

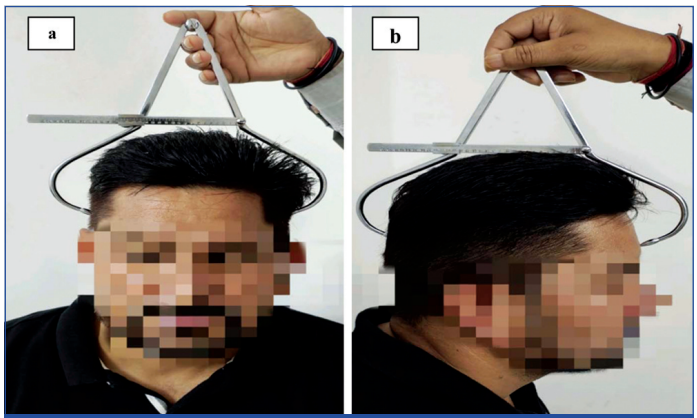
Before data collection, specific demographic areas and villages were selected based on the population density of each community. To facilitate community participation and ensure smooth execution of the study, initial discussions were held with the respective family or community leaders to explain the objectives and significance of the research. Subsequently, participants from each community were selected through random sampling.

Inclusion criteria: Both male and female participants were included in the study, provided that their parents and grandparents had no history of inter-caste or inter-religion marriages for at least three generations, ensuring ethnic purity for accurate anthropometric comparisons.

Exclusion criteria: Individuals with a history of craniofacial trauma, congenital craniofacial abnormalities, or any condition that could potentially alter natural head shape were excluded from the study.

Study Procedure

Anthropometric measurements were performed following standard cephalometric protocols. Head length was measured using spreading calipers, extending from the glabella (g)—the area above the nasal root between the eyebrows intersected by the mid-sagittal plane—to the inion (in), the most posterior point on the occipital bone along the mid-sagittal plane. Head width was measured as the maximum transverse distance between the euryon (eu) points, located at the most lateral aspects of the parietal bones. All measurements were recorded with participants seated comfortably in a chair, relaxed and with the head held in the anatomical position [Table/Fig-1].



[Table/Fig-1]: a) Head width (eu-eu); b) Head length (g-in).

The cephalic index was calculated using the following formula: Cephalic index=(Maximum Head Width (eu-eu)×100)/(Maximum Head Length (g-in)) [Table/Fig-2].

Head type	Range of cephalic index	Head shape
Hyperdolichocephalic	65.5-69.9	Very long and narrow
Dolichocephalic	70.0-74.9	Long and narrow
Mesocephalic	75.0-79.9	Medium
Brachycehalic	80.0-84.9	Broad and short
Hyperbrachy cephalic	85.0-89.9	Very broad and short

[Table/Fig-2]: Head classification according to the cephalic index.

Observer reliability: To minimise both interobserver and intraobserver variability, all anthropometric measurements were conducted by a single trained observer using standardised techniques and calibrated instruments. Each parameter—head length and head width—was measured three times and the mean of the three readings was used for analysis to ensure consistency and accuracy. This approach was adopted to reduce measurement errors and enhance the reliability and reproducibility of the data.

STATISTICAL ANALYSIS

Statistical analysis was performed using Microsoft Excel 2020 and IBM Statistical Package for the Social Sciences (SPSS) Statistics, version 23.0. Descriptive statistics, including mean, Standard Deviation (SD) and range, were calculated for head length, head width and cephalic index across all five communities. To assess differences in mean values of head length, head width and cephalic index among the ethnic groups (Sikh, Arora, Jaat, Rajput and Brahman), a one-way Analysis of Variance (ANOVA) was performed. A p-value less than 0.05 (p-value<0.05) was considered statistically significant. Independent-samples t-tests were used to determine differences in the parameters between genders.

RESULTS

The present study included a total of 1,000 participants, of whom 546 were males (54.6%) and 454 were females (45.4%) [Table/Fig-3]. The overall mean age of the participants was 32.85±7.90 years. The age and gender distribution were comparable across the groups. In the Sikh community, males had a higher mean cephalic index (82.82±2.99) than females (80.31±3.48), with a total community average of 81.75±3.496, classifying them as brachycephalic. The difference between sexes was statistically significant (p-value<0.001) [Table/Fig-4]. A gender-wise comparison of cephalic parameters revealed statistically significant differences between male and female participants [Table/Fig-5]. The Sikh community exhibited a predominantly brachycephalic head type (51%). The Rajput community showed the highest prevalence of dolichocephalic heads (79.5%) [Table/Fig-6]. The differences in head length, width and cephalic index among the ethnic groups were statistically significant [Table/Fig-7].

Gender	n (%)	Age (Mean±SD) years
Male	546 (54.6)	32.30±7.56
Female	454 (45.4)	33.40±8.40
Total	1000 (100)	32.85±7.90

[Table/Fig-3]: Gender distribution and mean age of participants.

DISCUSSION

The present study aimed to evaluate cranial morphology using the cephalic index among five major ethnic communities—Sikh, Arora, Jaat, Rajput and Brahman—residing in the Sriganganagar district of northern Rajasthan, India. The overall mean cephalic index of the population was 76.49, categorising the group as mesocephalic with distinct inter-community and gender-based variations. When compared with previous Indian studies, present study findings are broadly consistent. Bhargava I and Kher GA reported mean cephalic indices of 76.98 and 79.80 among Bhils and Berelas of Central India, respectively—both aligning with the mesocephalic classification [Table/Fig-8] [7,10,12-18]. These regional variations reflect ethnic, genetic and environmental diversity across India. On a global scale, the current study's cephalic index also aligns with findings from various mesocephalic populations, such as Igbo males of Nigeria (79.04) [Table/Fig-9] [19-26]. The findings underscore the importance of regional and community-specific craniofacial data, as head shape can vary significantly due to ethnicity, geography, heredity and environmental adaptation.

Community	Gender	Number (n)	Head width Mean±SD	Head length Mean±SD	Cephalic index Mean±SD	Head type	(Independent t-test) p-value
Sikh	Male	110	16.11±1.924	19.45±1.085	82.82±2.994	Brachycehalic	<0.001
	Female	90	15.95±1.459	19.86±0.929	80.31±3.484		
	Total	**200**	**15.91±0.9119**	**19.46±1.784**	**81.75±3.496**		
Arora	Male	100	14.61±0.980	18.60± 0.9212	78.54±3.924	Mesocephalic	<0.001
	Female	100	13.65±1.0024	18.30±1.4542	74.59±5.2875		
	Total	**200**	**13.90±1.1482**	**18.25±1.2523**	**76.37±5.6824**		
Jaat	Male	106	15.50± 1.624	20.20±1.9294	76.73±5.2105	Mesocephalic	<0.001
	Female	94	14.40±0.91436	19.10±1.4215	75.39±5.4924		
	Total	**200**	**14.90±1.2152**	**19.80±1.2142**	**75.25±5.2132**		
Rajput	Male	110	14.95±1.0245	20.50±1.4265	72.92±6.3245	Dolichocephalic	<0.001
	Female	90	13.55±1.2980	18.90±0.9421	71.69±6.946		
	Total	**200**	**13.75±1.4296**	**19.18±1.2421**	**71.98±6.9929**		
Brahman	Male	120	13.55±1.6903	17.70±1.9423	76.55±5.258	Mesocephalic	<0.001
	Female	80	14.52±1.7896	18.72±1.0246	77.80±5.9246		
	Total	**200**	**14.55±1.6969**	**18.80±1.3492**	**77.39±5.9864**		

[Table/Fig-4]: Mean cephalic parameters among various communities.

Gender	Number	Mean head width	Head length mean±SD	Cephalic index
Male	546	15.03±1.4321	19.46±1.7486	77.23±5.9420
Female	454	13.79±1.14832	18.20±1.2428	75.76±5.2432
Total	1000	14.45±1.2062	18.89±1.3486	76.49±5.2582
p-value		<0.01 Significant	<0.01 Significant	<0.01 Significant

[Table/Fig-5]: Mean cephalic parameters in both genders.
Independent t-test was used

regions. It's cross-sectional design limits the ability to assess cranial changes over time. Ethnic identity was self-reported, introducing potential classification bias. The analysis relied solely on the cephalic index for cranial classification, which may not fully capture the complexity of cranial morphology. Although standardised procedures were followed, minor observer-related measurement errors cannot be ruled out. Additionally, the study did not evaluate genetic, environmental, or nutritional factors that may influence cranial shape.

Community	Sex	No.	Dolicocephalic (%)	Mesocephalic (%)	Brachycephalic (%)	Hyperbrachicephalic (%)
Sikh	M	110	1 (0.92)	28 (25.45)	71 (64.50)	10 (9.09)
	F	90	12 (13.33)	38 (42.22)	31 (34.44)	9 (10)
	Total	**200**	**13 (6.50)**	**66 (33)**	**102 (51)**	**19 (9.5)**
Arora	M	100	17 (17)	68 (68)	11 (11)	4 (4)
	F	100	42 (42)	32 (32)	16 (16)	10 (10)
	Total	**200**	**59 (29.5)**	**100 (50)**	**27 (13.5)**	**14 (7)**
Jaat	M	106	29 (27.35)	72 (67.92)	5 (4.71)	0
	F	94	23 (24.46)	64 (68.08)	7 (7.44)	0
	Total	**200**	**52 (26)**	**136 (68)**	**12 (6)**	**0**
Rajput	M	110	83 (75.45)	22 (20)	5 (4.45)	0
	F	90	76 (84.44)	13 (14.44)	1 (1.11)	0
	Total	**200**	**159 (79.5)**	**35 (17.5)**	**6 (3)**	**0**
Brahman	M	120	8 (6.66)	76 (63.33)	30 (25)	6 (5)
	F	80	4 (5)	53 (66.25)	19 (23.75)	4 (5)
	Total	**200**	**12 (6)**	**129 (64.5)**	**49 (24.5)**	**10 (5)**

[Table/Fig-6]: Different type of head shape in various communities.

Ethnic group	Head length (cm)	Head width (cm)	Cephalic index
Sikh	18.62±0.88	15.22±0.71	81.75±4.10
Arora	18.43±0.91	14.74±0.68	80.02±4.25
Jaat	18.49±0.87	14.61±0.70	79.02±4.18
Rajput	18.77±0.89	13.51±0.65	71.98±4.00
Brahman	18.37±0.86	14.45±0.67	78.65±4.22
p-value (ANOVA)	<0.001	<0.001	<0.001

[Table/Fig-7]: Comparison of head length, head width and cephalic index among ethnic groups (N=1000).

Limitation(s)

The study was geographically limited to the Sriganganagar district, which may restrict the generalisability of the findings to other

S. No.	Author(s) and year	People/region	Mean cephalic index	Head type
1	Bhargava I and Kher GA, (1960) [12]	Bhils of central India	76.98	Mesocephalic
2	Bhargava I and Kher GA, (1961) [13]	Berelas of central India	79.80	Mesocephalic
3	Shah GV and Jadhav HR, (2004) [7]	Gujrati students	80.81	Brachycephalic
4	Mahajan A et al., (2009) [14]	Medical students of Punjab	85.53	Hyperbrachycephalic
5	Yagain VK et al., (2012) [15]	Indians students (males)	77.92	Mesocephalic
6	Kumar M et al, (2013) [16]	Haryanvi Banias (Males)	66.72	Hyperdolichocephalic

7	Seema and Verma P, (2016) [17]	North Indian Population	80.85	Brachycephalic
8	Joya H et al., (2023) [10]	Tribals population, Udaipur	78.65	Mesocephalic
9	Ahmed S et al., (2018) [18]	Students of Jhalawar District, Rajasthan (Male)	74.07	Dolichocephalic
10	Sriganganagar District, Rajasthan (India) Present Study, 2025	Sikh	81.75	Brachycephalic
		Arora	76.37	Mesocephalic
		Jaat	75.25	Mesocephalic
		Rajput	71.98	Dolichocephalic
		Brahman	77.39	Mesocephalic

[Table/Fig-8]: Comparison of cephalic index in the present study with previous Indian studies [7,10,12-18].

S. No.	Author(s) and year	Population/ Region	Mean cephalic index	Head type
1	Gareia HF and Lips MW (1986) [19]	North of Europe	79.72	Mesocephalic
2	Oladipo GS and Olotu EJ, (2006) [20]	Igbo Male	79.04	Mesocephalic
3	Golalipour MJ et al., (2007) [21]	Gorgan - north of Iran	84.00	Brachycephalic
4	Vojdani Z et al., (2009) [22]	South of Iran	82.4	Brachycephalic
5	Odokuma EA and Frank P (2010) [23]	West African population	77.67	Mesocephalic
6	Eroje EM et al., (2010) [24]	Baysela state, Nigeria	78.68	Mesocephalic
7	Ilayperuma I, (2011) [25]	Srilankan Female	79.32	Mesocephalic
8	Ilayperuma I, (2011) [25]	Srilankan Male	78.04	Mesocephalic
9	Timsina RP, (2014) [26]	Medical students, Nepal	82.99	Brachycephalic
10	Present study, 2025	Sriganganagar District, Rajasthan (India) Region	76.49	Mesocephalic

[Table/Fig-9]: Comparison of cephalic index in global populations [19-26].

CONCLUSION(S)

The present study provides valuable insights into cranial morphology and cephalic index distribution among five major communities—Sikh, Arora, Jaat, Rajput and Brahman—residing in the Sriganganagar district of northern Rajasthan, India. The overall cephalic index indicated a predominance of the mesocephalic head type, with significant variations observed between genders and across different communities. Males exhibited higher mean values for head length, head width and cephalic index compared to females, confirming sexual dimorphism. Among the communities, Sikhs showed a brachycephalic trend, while Rajputs displayed a dolichocephalic pattern. These variations highlight the influence of ethnic and biological factors on cranial morphology. The findings contribute to the anthropometric database relevant for forensic, clinical and anatomical applications and underscore the importance of region- and community-specific cranial norms in population-based studies.

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PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Apr 29, 2025
- Manual Googling: Jul 28, 2025
- iThenticate Software: Jul 30, 2025 (5%)

ETYMOLOGY: Author Origin

EMENDATIONS: 6

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. No

Date of Submission: **Apr 28, 2025**
Date of Peer Review: **Jun 26, 2025**
Date of Acceptance: **Aug 01, 2025**
Date of Publishing: **Nov 01, 2025**