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ORIGINAL ARTICLE

Distribution of Morphometric Types of Craniofacial Features among Adult Rakhain Females in Bangladesh – An Anthropometric Study

Shirin Afroz[1*], Nahid Farhana Amin[2], Latifa Nishat[3], Lutfa Mustary[4]

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Correspondence to
Shirin Afroz

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ABSTRACT

Background: *Craniofacial anthropometry is a vital tool in clinical, forensic, and anthropological disciplines, yet data from minority ethnic groups in Bangladesh remain scarce. This study aimed to evaluate the distribution of craniofacial morphometric types among adult Rakhain females and analyze key interrelationships among their craniofacial parameters.* ***Methods & Materials:*** *A cross-sectional study was conducted on 100 adult Rakhain females aged 25–45 years. Seventeen craniofacial linear measurements and six craniofacial indices were recorded. Descriptive statistics and Pearson's correlation analyses were performed to identify morphometric distributions and significant inter-variable relationships.* ***Results:*** *Mesocephalic head type (56.6%) and hypereuryprosopic or mesoprosopic face types predominated. The mean cephalic index was 78.55 ± 2.90, facial index 80.84 ± 7.54, and nasal index 72.38 ± 7.54. Most participants had mesorrhine noses, narrow orbits, and wide jaws. A moderate correlation was observed between morphological face height and mandible height ($r = 0.509$, $p < 0.001$), while stature had only a weak correlation with face height ($r = 0.224$, $p = 0.025$). The majority of craniofacial variables showed no significant correlation with stature.* ***Conclusion:*** *Adult Rakhain females exhibit a distinct craniofacial morphometric pattern characterized by mesocephalic heads, broad faces, and wide mandibles. These findings provide essential ethnic-specific reference data for clinical, forensic, and anthropological use.*

Keywords: *Craniofacial anthropometry, Rakhain females, Cephalic index, Facial index, Ethnic morphometry*

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1. *Curator, Department of Anatomy, Khulna Medical College, Khulna, Bangladesh (ORCID: 0009-0003-4380-5693)*
2. *Chairman, Department of Anatomy, Bangladesh Medical University, Dhaka, Bangladesh*
3. *Associate Professor, Department of Anatomy, Bangladesh Medical University, Dhaka, Bangladesh*
4. *Resident, Department of Anatomy, Bangladesh Medical University, Dhaka, Bangladesh*

INTRODUCTION

Craniofacial anthropometry, a branch of physical anthropology, plays a critical role in the understanding of human biological diversity, clinical practice, forensic investigations, and reconstructive surgical planning. It involves the systematic measurement of cranial and facial dimensions to establish population-specific normative data and morphological classifications. Globally, anthropometry has been widely used to assist in personal identification, sex and ethnicity estimation, evaluation of congenital anomalies, and monitoring of growth and development. In forensic science, craniofacial indices are often pivotal in reconstructing identity from skeletal remains, while in clinical settings, particularly maxillofacial and plastic surgery, they provide essential preoperative and postoperative reference points [1,2]. Craniofacial morphometric typing—most commonly using cephalic, facial, nasal, and zygomandibular indices—enables classification of individuals into morphological categories such as dolichocephalic, mesocephalic, and brachycephalic. These classifications are not only helpful in differentiating among population groups but also serve as phenotypic indicators of genetic and hereditary traits. For instance, variations in cephalic index have been employed to track evolutionary patterns and ancestral origins, while nasal indices offer insight into environmental adaptations in different climatic regions [3,4]. In surgical domains, these indices help customize reconstructive procedures, ensuring harmony between functional correction and aesthetic restoration, especially for populations with distinct craniofacial configurations [5]. The significance of craniofacial measurements becomes even more pronounced when exploring population diversity. Several regional studies have demonstrated how ethnic groups from South and Southeast Asia exhibit unique morphometric patterns. For example, among the indigenous populations of Meghalaya in Northeast India, the cephalic index differed significantly between Khasi, Garo, and Jaintia individuals, reflecting intra-regional diversity within a confined geographic zone [6]. Similar trends were seen in Nepal, where Indo-Nepalese individuals had a significantly higher canthal index than Tibeto-Nepalese populations, along with pronounced sexual dimorphism [7]. These inter- and intra-ethnic differences underscore the need for population-specific data in anthropometric research. In the context of Bangladesh, a country home to over 50 officially recognized ethnic groups, anthropometric research has largely centered around the Bengali majority, leaving tribal and indigenous populations underrepresented in scientific literature. This research disparity is particularly evident for the Rakhain community, a Buddhist ethnic minority residing predominantly in the coastal belt of southern Bangladesh, with historical ties to the Arakan region of present-day Myanmar. Despite their distinct ethnic lineage and cultural identity, Rakhain females remain one of the most under-studied groups in the anthropometric domain. Only a handful of studies have explored craniofacial parameters among Rakhain adults, and

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most have been limited to linear facial measurements without classifying morphometric types or exploring inter-variable correlations [8,9]. Moreover, the few Bangladeshi studies that have compared tribal with non-tribal populations, such as those involving Garo and Bengali females, demonstrate significant anthropometric differences in facial height, nasal dimensions, and ocular distances, suggesting a strong ethnic influence on craniofacial patterns [10]. However, similar comprehensive profiling has not yet been extended to the Rakhain females, particularly using standardized morphometric indices like cephalic, facial, nasal, auricular, and zygomandibular indices. This gap in the literature not only limits the scope of population-based anatomical understanding but also hinders the development of accurate forensic and clinical baselines for this unique ethnic group. Given the critical importance of generating localized craniofacial reference data for diverse populations, and the striking paucity of such studies on Rakhain women in Bangladesh, the current study aims to systematically analyze the distribution of morphometric craniofacial types among adult Rakhain females. By employing a structured anthropometric methodology, this research seeks to quantify key craniofacial dimensions, classify morphometric types, and explore inter-variable correlations, thereby contributing novel baseline data that can be applied in forensic anthropology, clinical practice, and anthropological documentation.

METHODS & MATERIALS

This cross-sectional observational study was conducted over a period of 12 months, from January 2017 to December 2017, in the coastal areas of Chawfaldondi and Sadar Upazila of Cox's Bazar district, Bangladesh, where a substantial population of adult Rakhain females resides. The study population consisted of 100 adult Rakhain females aged between 25 and 45 years who were born into the Rakhain community and had resided in the region since birth. A convenience sampling method was employed for participant recruitment, ensuring that only healthy individuals without any history of craniofacial surgery, congenital anomalies, or trauma were included. Prior to participation, written informed consent was obtained from each subject, and ethical approval for the study protocol was granted by the Institutional Review Board. Anthropometric measurements were taken in a well-lit, indoor setting using standard equipment and techniques. A total of 17 craniofacial linear measurements were recorded for each subject, along with their standing height (stature), using a stadiometer. The craniofacial parameters included maximum cranial length (g-op), maximum cranial breadth (eu-eu), head circumference (on-op), morphological facial height (n-gn), maximum facial breadth (zy-zy), biocular width (ex-ex), intercanthal width (en-en), mouth width (ch-ch), nasal height (n-sn), nasal width (al-al), left upper face depth (n-t), left maxillary depth (sn-t), left mandibular depth (gn-t), mandible height (sto-gn), mandible breadth (go-go), and left ear length and width (sa-sba and pra-pa, respectively). All measurements were taken in centimeters using spreading calipers, digital sliding calipers, measuring tape, and steel rules, following internationally accepted anthropometric landmarks. Based on these measurements, six commonly used craniofacial indices were calculated: cephalic index (CI), facial index (FI), biocular-face width index, nasal index (NI), auricular index, and zygomandibular index. Each index was computed using established formulas and used to categorize subjects into morphometric types (e.g., mesocephalic, brachycephalic, dolichocephalic; hypereuryprosopic, mesoprosopic, etc.). All data were entered into SPSS software (version 20.0) for statistical analysis. Descriptive statistics, including mean, standard deviation, and range, were calculated for all anthropometric variables. Pearson's correlation coefficients (r) were computed to assess the relationship between stature and selected craniofacial parameters, as well as between facial dimensions. Only statistically significant correlations ($p < 0.05$) were further analyzed. Additionally, the coefficient of determination (r^2) was used to quantify the strength of these relationships. All analyses were interpreted in the context of morphometric categorization and anthropometric variability within the study population.

RESULTS

Table I presents the descriptive statistics of stature and 17 linear craniofacial measurements recorded from 100 adult Rakhain females. The mean stature was 158.17 ± 3.87 cm, ranging from 149.10 cm to 168.10 cm. The cranial dimensions revealed a mean maximum cranial length (g-op) of 18.16 ± 0.85 cm and a mean maximum cranial breadth (eu-eu) of 15.16 ± 0.56 cm. The average head circumference measured 55.76 ± 1.28 cm. Facial dimensions showed a mean morphological face height (n-gn) of 10.67 ± 0.55 cm and a mean maximum facial breadth (zy-zy) of 13.28 ± 1.03 cm. The mandible measurements indicated a mean height (sto-gn) of 3.84 ± 0.33 cm and a breadth (go-go) of 10.78 ± 0.35 cm. Nasal height (n-sn) averaged 4.93 ± 0.38 cm, while nasal width (al-al) was 3.55 ± 0.24 cm. Measurements of facial depth included left upper face depth (n-t) at 10.08 ± 0.56 cm, left maxillary depth (sn-t) at 11.45 ± 0.58 cm, and left mandibular depth (gn-t) at 14.09 ± 0.58 cm. The mean mouth width (ch-ch) was 4.61 ± 0.38 cm. Auricular parameters showed a left ear length (sa-sba) of 6.26 ± 0.45 cm and an ear width (pra-pa) of 3.06 ± 0.28 cm. The mean intercanthal width (en-en) was 3.42 ± 0.33 cm, while the biocular width (ex-ex) was 9.39 ± 0.58 cm. These measurements collectively provide a comprehensive baseline for craniofacial norms in the adult female Rakhain population (**Table I**).

Table – I: Descriptive Statistics of Stature and Linear Craniofacial Measurements

Measurement	Range (cm)	Mean ± SD (cm)
Stature	149.10–168.10	158.17 ± 3.87
Maximum cranial length (g-op)	16.20–20.00	18.16 ± 0.85
Maximum cranial breadth (eu-eu)	14.00–16.50	15.16 ± 0.56
Morphological face height (n-gn)	9.38–12.00	10.67 ± 0.55
Maximum facial breadth (zy-zy)	11.00–16.00	13.28 ± 1.03
Mandible height (sto-gn)	2.97–4.55	3.84 ± 0.33
Mandible breadth (go-go)	10.00–11.50	10.78 ± 0.35
Nasal height (n-sn)	4.00–5.89	4.93 ± 0.38
Nasal width (al-al)	2.91–4.13	3.55 ± 0.24
Left upper face depth (n-t)	9.00–11.50	10.08 ± 0.56
Left maxillary depth (sn-t)	10.00–13.00	11.45 ± 0.58
Left mandibular depth (gn-t)	13.00–15.50	14.09 ± 0.58

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Mouth width (ch-ch)	3.83–5.55	4.61 ± 0.38
Left ear length (sa-sba)	5.09–7.39	6.26 ± 0.45
Left ear width (pra-pa)	2.32–3.77	3.06 ± 0.28
Intercanthal width (en-en)	2.69–4.27	3.42 ± 0.33
Biocular width (ex-ex)	8.53–10.30	9.39 ± 0.58
Head circumference (on-op)	50.00–57.00	55.76 ± 1.28

Table II summarizes the calculated craniofacial indices among the study participants. The mean cephalic index was 78.55 ± 2.90, classifying the majority of participants within the mesocephalic category. The facial index averaged 80.84 ± 7.54, suggesting a predominance of hypereuryprosopic and mesoprosopic facial types. The biocular-face width index showed a mean of 71.06 ± 5.66, reflecting a tendency toward narrower interorbital spacing relative to facial width. The auricular index, representing the proportion between ear width and ear length, had a mean value of 48.10 ± 5.06, indicating a balanced ear morphology leaning toward round or short forms. The nasal index was measured at 72.38 ± 7.54, placing most subjects in the mesorrhine category, typical of populations with mixed ancestral traits. The zygomandibular index had a mean of 81.67 ± 6.62, indicating relatively wide mandibular dimensions in relation to midfacial breadth. Collectively, these indices demonstrate distinct craniofacial proportionality patterns in the Rakhain female population.

Table – II: Craniofacial Indices

Craniofacial Index	Mean ± SD
Cephalic index	78.55 ± 2.90
Facial index	80.84 ± 7.54
Biocular-face width index	71.06 ± 5.66
Auricular index	48.10 ± 5.06
Nasal index	72.38 ± 7.54
Zygomandibular index	81.67 ± 6.62

Table III presents the statistically significant correlations observed among selected craniofacial measurements. A weak but statistically significant positive correlation was found between stature and morphological face height (r = +0.224, p = 0.025), suggesting that individuals with greater face height tend to have slightly taller statures. A moderate and highly significant positive correlation was observed between morphological face height and mandible height (r = +0.509, p < 0.001), indicating that individuals with taller faces also tend to have greater mandibular height. Additionally, a mild but significant correlation was found between maximum facial breadth and head circumference (r = +0.302, p = 0.002), suggesting that broader faces are associated with larger head sizes in this population. These findings highlight interrelated growth patterns among craniofacial structures in Rakhain females.

Table – III: Significant Correlation Results

Correlation pair	Correlation coefficient (r)	p-value
Stature vs Morphological face height	+0.224	0.025
Morphological face height vs Mandible height	+0.509	<0.001
Max facial breadth vs Head circumference	+0.302	0.002

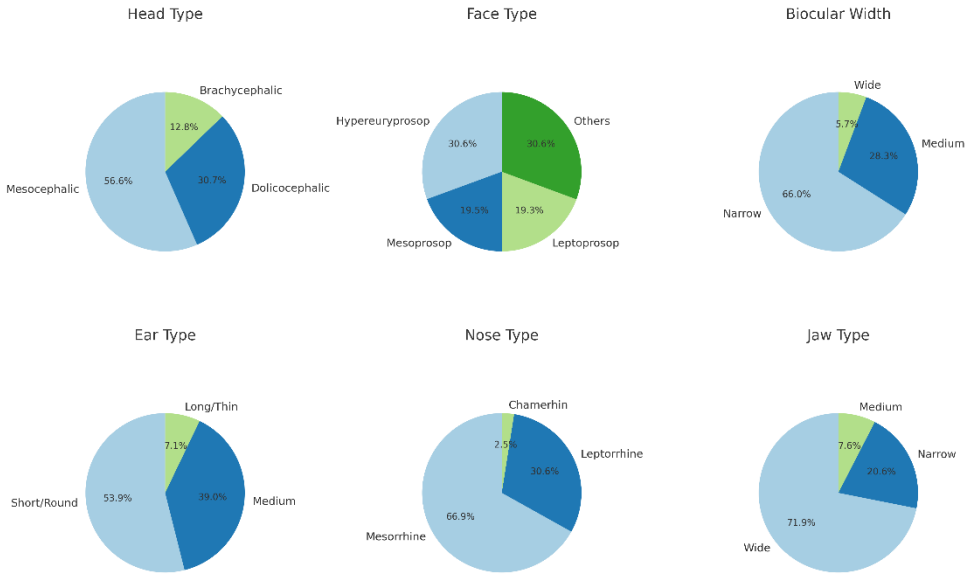

Figure – 1: Morphometric Types

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Figure 1 illustrates the distribution of morphometric types among adult Rakhain females based on craniofacial indices. In terms of head shape, the majority of participants were classified as mesocephalic (56.6%), followed by dolichocephalic (30.7%) and brachycephalic (12.8%). Regarding facial type, hypereuryprosopic and "other" facial forms were equally common (30.6% each), while mesoprosopic (19.5%) and leptoprosopic (19.3%) types were less prevalent. The biocular width index revealed that most participants had narrow interorbital spacing (66.0%), with fewer classified as medium (28.3%) and wide (5.7%). For ear morphology, over half of the participants had short or round ears (53.9%), while 39.0% had medium ears, and 7.1% exhibited long or thin ears. Nasal classification showed a clear dominance of the mesorrhine type (66.9%), followed by leptorrhine (30.6%), with only a small proportion categorized as chamerhin (2.5%). Finally, in terms of jaw morphology, the majority of individuals had wide jaws (71.9%), followed by narrow (20.6%) and medium (7.6%) types. These distributions highlight distinct ethnic morphometric characteristics within the Rakhain female population.

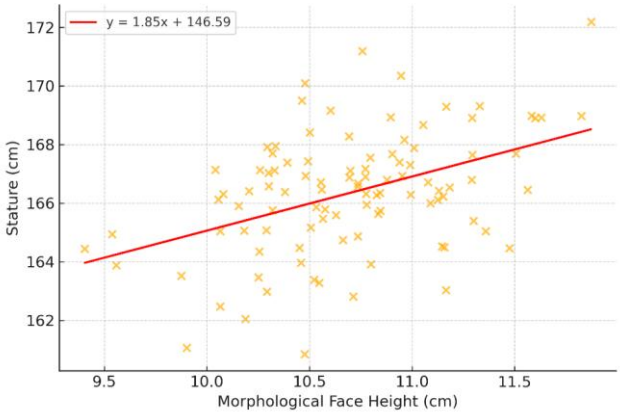

Figure – 2: Stature Vs Morphological Face Height

Figure 2 depicts the scatter plot illustrating the relationship between stature and morphological face height among adult Rakhain females. A weak but statistically significant positive correlation (r = +0.224, p = 0.025) was observed between these two parameters. The regression line fitted to the data (y = 1.85x + 146.59) suggests that individuals with greater facial height tend to be slightly taller. Despite moderate dispersion in the data, the upward trend indicates a consistent linear association, supporting the finding that morphological face height can serve as a mild predictor of stature within this population.

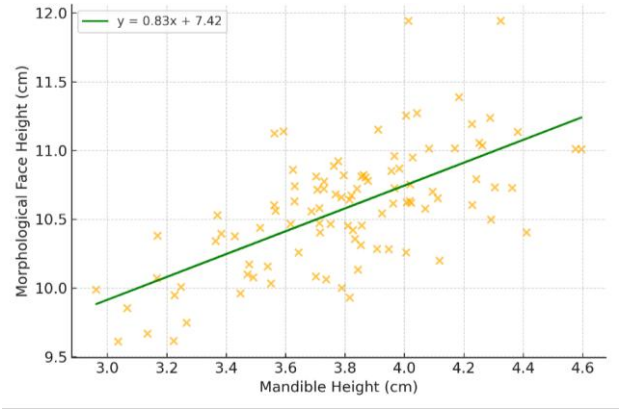

Figure – 3: Morphological Face Height Vs Mandible Height

Figure 3 presents the scatter plot showing the relationship between morphological face height and mandible height. A strong and statistically significant positive correlation was observed between the two parameters (r = +0.509, p < 0.001). The regression line (y = 0.83x + 7.42) demonstrates a linear trend, indicating that increases in mandible height are consistently associated with increases in facial height. This finding suggests a proportional growth relationship between the lower and vertical dimensions of the face in adult Rakhain females.

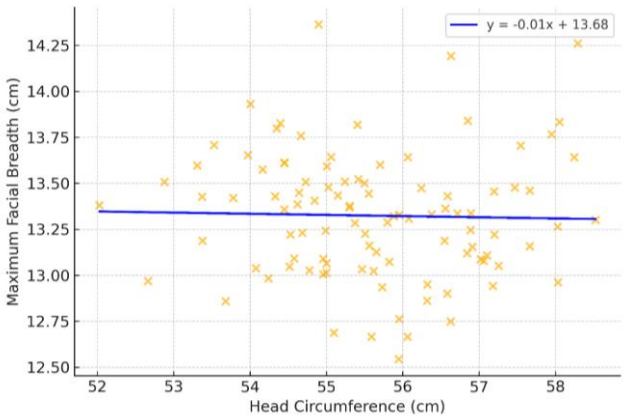

Figure – 4: maximum Facial Breadth Vs Head Circumference

Figure 4 shows the scatter plot analyzing the correlation between maximum facial breadth and head circumference. A mild positive but statistically significant correlation was found (r = +0.302, p = 0.002), although the regression slope (y = -0.01x + 13.68) visually appears minimal, suggesting a relatively flat trend. This indicates that while a statistical relationship exists, the practical predictive value of head circumference for facial breadth may be modest within this population.

DISCUSSION

This study presents a comprehensive morphometric profile of adult Rakhain females, an underrepresented ethnic group in anthropometric literature, through detailed analysis of craniofacial linear measurements and derived indices. The findings reveal that the Rakhain females exhibit a characteristic craniofacial pattern dominated by mesocephalic head types (56.6%), hypereuryprosopic and mesoprosopic facial types, mesorrhine nasal structure, narrow interorbital spacing, and a distinctly wide mandible. These features align with broad-faced, mid-skull populations described in other South and Southeast Asian anthropometric studies, yet also reflect unique proportions within the Rakhain group [6]. The mean stature in this sample was 158.17 ± 3.87 cm, which is notably higher than that of Garo females (152.79 ± 5.62 cm), another indigenous Bangladeshi group, suggesting ethnic variability in body size and craniofacial scaling [11]. The cranial length (18.16 ± 0.85 cm) and breadth (15.16 ± 0.56 cm) among Rakhain females are consistent with mesocephalic classification, aligning with findings among Tamil and Nepalese populations, reinforcing the cranial typology within South Asian groups [12,13]. The head circumference in this study (55.76 ± 1.28 cm) is notably larger than reported in Bengali tribal women (51.56 ± 1.49 cm), suggesting a broader neurocranial vault in Rakhain females [11]. Facial indices support a predominance of broad faces, with a mean facial index of 80.84 ± 7.54 and over 30% categorized as hypereuryprosopic, similar to patterns observed in Nepalese and Indian medical students and Latvian children [14,15]. These

broad-faced traits are often associated with genetic and environmental adaptation and underscore the distinct ethnic morphometry of the Rakhain community. Similarly, the nasal index (72.38 ± 7.54) corresponds to the mesorrhine classification in over two-thirds of the participants—comparable to Bangladeshi Santal females and Indian populations with nasal indices in the 70–75 range [16,17]. These data indicate consistency with regional mesorrhine norms while emphasizing ethnic specificity in nose width and height ratios. Ear morphology also varied, with an auricular index of 48.10 ± 5.06 reflecting short to round ear types in 53.9% of participants. While few studies quantify auricular index in healthy populations, comparative data from craniofacial syndromic studies have noted similar index ranges among females with smaller ear dimensions [18]. The zygomandibular index (81.67 ± 6.62) further highlights the dominance of wide-jawed morphotypes (71.9%) among Rakhain females, paralleling mandibular prominence seen in Nigerian ethnic groups such as the Igbo and Yoruba [19]. Notably, correlation analyses revealed that most craniofacial variables had no significant linear association with stature, with only three statistically significant yet modest correlations: stature with morphological face height (r = 0.224, p = 0.025), face height with mandible height (r = 0.509, p < 0.001), and facial breadth with head circumference (r = 0.302, p = 0.002). These findings are consistent with studies among Indian and Nigerian populations, where many craniofacial dimensions—despite anatomical relevance—showed weak or no linear predictive value for stature [20,21]. Regression analyses from Indian datasets similarly reported low slopes and minimal explanatory power, cautioning against overreliance on craniofacial variables for height prediction [22]. The regression slope for stature versus facial height in this study (slope = 1.85) and the nearly flat slope between head circumference and facial breadth (slope = –0.01) emphasize the weak predictive utility of these metrics despite their statistical significance. Similar observations were made in craniofacial studies in Sudan and Egypt, where significance was not matched by slope magnitude or clinical relevance [23]. Conversely, the moderate correlation between face height and mandible height (r = 0.509) with a regression slope of 0.83 demonstrates a proportionally aligned growth pattern in lower facial structures—comparable to facial vertical integration seen in Croatian and Saudi Arabian populations [24]. Overall, the Rakhain females display a well-defined craniofacial pattern characterized by mesocephaly, broad low faces, mesorrhine noses, and wide mandibles—features that collectively distinguish them from other tribal and non-tribal Bangladeshi groups. While some craniofacial measures correlate modestly with each other and with stature, most remain population-specific, with limited generalizability for biometric prediction. These findings contribute essential normative data for an ethnically unique group and underscore the importance of context-specific morphometric databases in both clinical and anthropological applications.

LIMITATIONS

This study focused solely on adult Rakhain females aged 25–45 and excluded males, children, and elderly individuals. Moreover, all data were manually collected, which may introduce minor inter-observer variability despite standardization.

CONCLUSION

This study provides a comprehensive anthropometric profile of adult Rakhain females, an ethnically distinct minority group in Bangladesh. The findings reveal a predominant mesocephalic head type, broad and low facial structure, mesorrhine nasal features, narrow orbital spacing, and notably wide jaws—together constituting a morphometric pattern unique to this population. While most craniofacial parameters showed limited correlation with stature, the moderate association between facial height and mandible height underscores a proportionally integrated lower facial region. These results contribute valuable normative data for the Rakhain community and enhance the regional anthropometric database essential for clinical, forensic, and anthropological applications.

RECOMMENDATION

Future studies should expand sample size and include both sexes across broader age ranges to establish sex- and age-specific reference values. Comparative anthropometric analyses across multiple ethnic minorities in Bangladesh will provide a more inclusive understanding of population diversity. Additionally, advanced imaging tools like 3D facial scanning could complement manual measurements, enhancing precision and allowing integration with digital surgical planning, forensic facial reconstruction, and population genetics research.

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