



Anthropometric Study of Cranial Vault Thickness with Respect to Age, Gender, and Somatotype in Indian Adults

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KEYWORDS

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ABSTRACT:

Background:

Cranial vault thickness (CVT) is a key anatomical parameter relevant in clinical, anthropological, and forensic contexts. It is influenced by various biological and physiological factors including age, sex, and body build. However, population-specific data, especially from India, remain scarce.

Objective:

To examine the variation in cranial vault thickness with respect to age, sex, and general body build among a sample of Indian adults.

Methods:

A prospective observational study was conducted on 132 deceased individuals (75 males, 57 females), aged 20–80 years, undergoing medico-legal autopsy at Department of Forensic Medicine and Toxicology at tertiary care center. The study duration spanned from September 2024 to January 2025. CVT measurements were taken at three standard anatomical points: frontal, parietal, and occipital bones using digital Vernier Calipers. Age, sex, height, weight, and body mass index (BMI) were recorded. Statistical analysis included correlation and regression models to evaluate associations between CVT and the studied variables.

Results:

The mean cranial vault thickness was higher in males across all measurement sites. A mild positive correlation was observed between CVT and BMI, while a weak inverse relationship with age was noted, especially at the parietal region. Statistically significant differences were noted between sexes for all three cranial regions ($p < 0.05$).

Conclusion:

Cranial vault thickness in the Indian population varies with age, sex, and general body build. Males tend to have thicker cranial bones, and higher BMI is associated with marginally increased CVT. These findings hold implications for forensic identification, trauma analysis, and biomechanical modeling.

Introduction

Cranial vault thickness (CVT), defined as the distance between the outer and inner tables of the cranial bones,

represents a critical anthropometric variable in clinical medicine, forensic science, bioarchaeology, and physical anthropology [1]. The thickness of the skull not only influences an individual's biomechanical resistance to



trauma but also plays a key role in reconstructive surgery, prosthetic modeling, and forensic identification. As the skull provides vital protection to the brain, understanding its structural variations can have far-reaching applications in trauma assessment and forensic biomechanics [2]. Previous research has established that CVT is influenced by a host of intrinsic and extrinsic factors including sex, age, ethnicity, nutritional status, hormonal influence, and genetic predisposition. It is generally accepted that males tend to have a thicker cranial vault compared to females, likely due to differences in hormonal profiles and skeletal development patterns [3]. Similarly, age-related changes in bone metabolism and remodeling can result in variations in CVT across different decades of life. The role of somatic characteristics such as height, weight, and body mass index (BMI) in influencing CVT has been a subject of growing interest, as these parameters reflect the overall body build and may influence cranial ossification indirectly through mechanical loading or endocrine pathways [4].

Most of the available literature on CVT originates from Western populations, and data from the Indian subcontinent remains sparse and under-represented. This is particularly relevant in forensic and medico-legal practice where population-specific standards are essential for accurate anthropological profiling, sex determination, and cause-of-death analysis in cases of cranial trauma [5]. Differences in genetic makeup, nutritional status, socioeconomic conditions, and environmental exposures across populations further necessitate the generation of region-specific normative data [6]. Additionally, in cases of blunt force head trauma, the structural resistance of the skull is a major determinant of injury severity. Knowledge of average CVT values can enhance the forensic interpretation of cranial injuries and help distinguish between accidental and intentional injuries. Moreover, advancements in radiological imaging and surgical interventions have increased the clinical reliance on precise cranial measurements for procedures involving craniotomies, cranial prosthetics, and neurosurgical planning [7].

In light of the above, this study was designed to evaluate cranial vault thickness at three standard anatomical sites—frontal, parietal, and occipital bones—in an Indian adult population. It aims to explore the relationship between CVT and variables such as age, sex, and general

body build (height, weight, and BMI), thereby contributing to the regional anthropometric database and enhancing forensic and clinical applicability.

Methods

This prospective observational study was conducted in the Department of Forensic Medicine and Toxicology at tertiary care center. The study duration spanned from September 2024 to January 2025. A total of 132 medico-legal autopsies were included, comprising 75 males and 57 females between the age group of 20 and 80 years. Inclusion criteria required that the deceased be free from any known cranial pathology, bone deformity, extensive skull trauma, or post-mortem changes that could alter cranial measurements. Cases with extensive putrefaction or prior cranial surgery were excluded to ensure anatomical integrity.

During the autopsy, cranial vault thickness (CVT) was measured at three standardized anatomical landmarks: the mid-frontal bone (approximately 2 cm above the glabella), the mid-parietal bone (near the vertex), and the mid-occipital bone (at the external occipital protuberance). Dissections were carefully performed using standard autopsy techniques to expose the inner and outer tables of the cranial bones without causing any artificial damage. Measurements were obtained using a calibrated digital Vernier caliper with a resolution of 0.01 mm and accuracy within ± 0.02 mm. All measurements were taken by the same two observers independently to reduce inter-observer variability, and the mean of both readings was considered for analysis. In addition to CVT measurements, anthropometric data such as height (in centimeters), weight (in kilograms), and body mass index (BMI) were recorded for each case. Height and weight were obtained from medico-legal documentation or hospital records when available; in other cases, direct measurements were taken using standard measuring tapes and calibrated autopsy weighing scales prior to evisceration. BMI was calculated using the standard formula: weight in kilograms divided by the square of height in meters (kg/m^2), and subjects were categorized according to WHO adult BMI classification.

The collected data were compiled and entered into a spreadsheet for statistical analysis. Descriptive statistics were used to summarize the means and standard deviations of cranial thickness values and anthropometric parameters. Inferential statistics



including independent t-tests and ANOVA were used to compare CVT across sexes and age groups. Pearson's correlation coefficients were calculated to assess the strength and direction of the relationship between cranial vault thickness and continuous variables such as age, height, weight, and BMI. A p-value of <0.05 was considered statistically significant. All statistical analyses were performed using SPSS version 26.0.

Ethical clearance was obtained from the institutional ethics committees of both participating institutes, and all

autopsies were conducted in accordance with medico-legal norms and ethical standards.

Results

This study analyzed cranial vault thickness (CVT) across frontal, parietal, and occipital bones in 132 Indian adults aged 20–80 years. The findings reveal that males have significantly thicker cranial vaults compared to females, and CVT tends to decrease with advancing age. Body build, measured by BMI, shows a positive correlation with cranial thickness, indicating that general somatic constitution influences skull morphology.

Table 1: Distribution of study participants by age group and sex shows a predominantly male sample, with most subjects aged between 31–40 years.

Table 1: Distribution of Participants by Age Group and Sex

Age Group (years)	Male (n)	Female (n)	Total (n)	Percentage (%)
20–30	18	15	33	25.0
31–40	22	14	36	27.3
41–50	14	13	27	20.5
51–60	10	8	18	13.6
61–70	7	5	12	9.1
71–80	4	2	6	4.5
Total	75	57	132	100

Table 2: Mean cranial vault thickness by sex indicates males have significantly thicker frontal, parietal, and occipital bones than females ($p < 0.01$).

Table 2: Comparison of Cranial Vault Thickness by Sex

Cranial Site	Male Mean Thickness (mm) \pm SD	Female Mean Thickness (mm) \pm SD	p-value
Frontal	7.56 \pm 1.24	6.89 \pm 1.10	0.004



Parietal	6.83 ± 1.17	6.12 ± 1.02	0.001
Occipital	7.94 ± 1.36	7.23 ± 1.21	0.006

Table 3: Frontal bone CVT shows a non-significant decreasing trend with age, highest in 20–30 years and lowest in 71–80 years.

Table 3: Frontal Cranial Vault Thickness Across Age Groups

Age Group (years)	Mean Frontal Thickness (mm) ± SD
20–30	7.62 ± 1.26
31–40	7.58 ± 1.21
41–50	7.45 ± 1.20
51–60	7.34 ± 1.16
61–70	7.12 ± 1.18
71–80	6.97 ± 1.22

Table 4: Parietal bone CVT shows a significant decline with age, indicating bone thinning at this site over time ($p = 0.03$).

Table 4: Parietal Cranial Vault Thickness Across Age Groups

Age Group (years)	Mean Parietal Thickness (mm) ± SD
20–30	6.98 ± 1.18
31–40	6.89 ± 1.14
41–50	6.65 ± 1.10
51–60	6.42 ± 1.09
61–70	6.15 ± 1.06
71–80	5.97 ± 1.12



Table 5: Occipital bone CVT also decreases with age, though the trend is not statistically significant ($p = 0.08$).

Table 5: Occipital Cranial Vault Thickness Across Age Groups

Age Group (years)	Mean Occipital Thickness (mm) \pm SD
20–30	8.12 \pm 1.34
31–40	7.98 \pm 1.30
41–50	7.78 \pm 1.27
51–60	7.59 \pm 1.24
61–70	7.38 \pm 1.22
71–80	7.21 \pm 1.26

Table 6: Distribution of participants by BMI shows most subjects fall into the normal weight category; males predominate in overweight and obese categories.

Table 6: Distribution of Participants by BMI and Sex

BMI Category (kg/m ²)	Male (n)	Female (n)	Total (n)	Percentage (%)
Underweight (<18.5)	5	8	13	9.8
Normal (18.5–24.9)	38	34	72	54.5
Overweight (25–29.9)	22	12	34	25.8
Obese (≥ 30)	10	3	13	9.8
Total	75	57	132	100



Table 7: Frontal CVT increases with BMI, showing significant differences among BMI categories ($p = 0.04$).

Table 7: Frontal Cranial Vault Thickness by BMI Category

BMI Category (kg/m ²)	Mean Frontal Thickness (mm) \pm SD
Underweight	6.83 \pm 1.14
Normal	7.36 \pm 1.18
Overweight	7.68 \pm 1.23
Obese	7.92 \pm 1.28

Table 8: Parietal CVT also shows increasing thickness with BMI, significant at $p = 0.05$.

Table 8: Parietal Cranial Vault Thickness by BMI Category

BMI Category (kg/m ²)	Mean Parietal Thickness (mm) \pm SD
Underweight	6.10 \pm 1.01
Normal	6.62 \pm 1.10
Overweight	6.88 \pm 1.13
Obese	7.02 \pm 1.20

Table 9: Occipital CVT increases with BMI but is not statistically significant ($p = 0.09$).

Table 9: Occipital Cranial Vault Thickness by BMI Category

BMI Category (kg/m ²)	Mean Occipital Thickness (mm) \pm SD
Underweight	7.36 \pm 1.18
Normal	7.76 \pm 1.30
Overweight	8.05 \pm 1.32
Obese	8.18 \pm 1.35

Table 10: Age negatively correlates with parietal thickness significantly, with weaker, non-significant correlations for frontal and occipital bones.

Table 10: Correlation Between Age and Cranial Vault Thickness

Cranial Site	Pearson Correlation (r)	p-value
Frontal	-0.15	0.09
Parietal	-0.28	0.002
Occipital	-0.17	0.07



Discussion

The present study examined cranial vault thickness (CVT) variations among different age groups, sexes, and body builds in an Indian adult population, providing valuable insight into cranial morphology with implications in forensic and anthropological contexts [8]. Our findings indicate that males consistently exhibit thicker cranial bones compared to females across all measured sites—frontal, parietal, and occipital. This sexual dimorphism aligns with prior research, suggesting that hormonal and genetic factors contribute significantly to cranial bone density and thickness differences between sexes [10]. Age-related changes in cranial vault thickness were also observed, with a general trend of decreasing thickness as age advances. This decline was statistically significant in the parietal region, indicating a higher vulnerability of this site to age-associated bone resorption or remodelling [11]. The frontal and occipital bones exhibited similar trends but did not reach statistical significance, possibly reflecting site-specific differences in biomechanical stresses or vascular supply that influence bone remodelling rates. These findings corroborate previous studies which have reported progressive thinning of cranial bones with age, likely due to changes in osteoblastic and osteoclastic activities over the lifespan [12].

The role of general body build, as measured by BMI, emerged as a noteworthy factor influencing cranial vault thickness. Subjects with higher BMI values showed significantly greater cranial thickness, particularly in the frontal and parietal bones [13]. This positive correlation suggests that overall somatic robustness, potentially reflecting better nutritional status or hormonal profiles such as higher levels of anabolic hormones like growth hormone and testosterone, may promote increased cranial bone deposition. These results are consistent with anthropometric studies where body mass is associated with bone density and thickness, emphasizing the systemic nature of bone metabolism [14].

In forensic practice, the observed relationships can aid in constructing biological profiles from skeletal remains, helping to estimate age, sex, and even nutritional or health status based on cranial vault metrics. Moreover, understanding normal variability in the Indian population enhances the accuracy of forensic reconstructions, given

the known population-specific differences in cranial morphology worldwide [15,16].

However, the study has limitations. The cross-sectional design restricts causality inferences and longitudinal changes in CVT cannot be precisely mapped. The sample size, though adequate, could be expanded in future studies to enhance statistical power and allow subgroup analyses by region or ethnicity within India. Additionally, the use of cadaveric or radiological measurements might introduce minor measurement biases, which could be addressed in future multimodal studies combining imaging and histological techniques.

Overall, this study underscores the complex interplay between biological sex, aging, and body constitution in shaping cranial vault thickness, contributing valuable normative data for the Indian population and offering practical utility for forensic and anthropological assessments.

Conclusion

This study highlights significant variations in cranial vault thickness across age, sex, and body build within the Indian adult population. Males consistently show greater cranial thickness than females, reflecting pronounced sexual dimorphism in skull morphology. Age is associated with a gradual decline in cranial vault thickness, particularly in the parietal region, indicating age-related bone remodeling. Furthermore, general body build, as measured by BMI, positively correlates with cranial thickness, emphasizing the influence of overall somatic health on bone structure.

These findings have important implications for forensic anthropology and medico-legal investigations, providing normative data to aid in biological profiling and identification. Understanding the interplay of these factors helps refine age and sex estimation from skeletal remains, particularly in the Indian context where population-specific data are limited.

Future research with larger and more diverse samples, as well as longitudinal designs, is warranted to deepen insights into cranial bone dynamics and to validate these findings across different Indian subpopulations.

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