e-ISSN: 0975-5160, p-ISSN: 2820-2651

Available online on www.ijtpr.com

International Journal of Toxicological and Pharmacological Research 2024; 14(9); 39-42

Original Research Article

Anatomical Study of Cranial Capacity and Sexual Dimorphism in Dried Adult Human Skulls

Preeti Pawde[1], Pradnya Gurude[2], Suraj Prakash[3], Prashant Munjamkar[4], Ujwala Bhanarkar[5]

[1]Assistant Professor, Department of Anatomy, Dr Ulhas Patil Medical College, Jalgaon, Maharastra, India

[2]Associate Professor, Department of Anatomy GMC, Parbhani, Maharashtra, India

[3]Associate Professor, Department of Anatomy Teerthanker Mahavir Medical College & Research Center, Moradabad, UP, India

[4]Professor, Department of Anatomy Shree Shankaracharya Institute of Medical Sciences Bhilai Chattisgarh, India

[5]Assistant Professor, Department of Anatomy All India Institute of Medical Sciences, Kalyani, West Bengal, India

Received: 01-09-2024 / Revised: 12-09-2024 / Accepted: 19-09-2024

Corresponding Author: Dr. Prashant Munjamkar

Conflict of interest: Nil

Abstract

Background: Cranial capacity, like other body dimensions, is influenced by geography, race, gender, and age. This study aims to explore the gender differences in cranial capacities in human skulls from the North Indian region. The primary objective is to measure cranial capacities and assess sexual dimorphism, which may assist in determining the sex of an individual from skeletal remains.

Methods: It was made sure that all the skulls were intact and undamaged and included after sex determination based on the anatomical features. Skulls with the ambiguity of sex or those with damage were excluded from the study. The direct measurement of cranial capacity was done by sealing skull foramina with clay to prevent seed spillage. The Cranial cavities were filled with mustard seeds through the foramen magnum. The seeds were added gradually while shaking the skull to ensure full coverage. The seeds were then poured into a glass jar and transferred to a 1000 cc glass cylinder, where the volume was measured.

Results: The important findings of this study regarding the skull dimensions showed that the mean length of male skulls was Male: 168.5 ± 7.8 mm and females: 161.2 ± 9.2 mm. The cranial volume in male skulls was 1324.19 ± 35.29 cc versus in Female skulls was 1167.32 ± 50.63 cc There were clear differences in skull dimensions between males and females, with males generally having longer skulls and larger cranial capacities. Within each sex group, there is considerable variation in skull dimensions, highlighting individual differences. Most skulls in both groups fall within the mesocephalic range, indicating a typical skull size. However, a smaller percentage of individuals exhibit microcephaly or megacephaly.

Conclusion: Within the limitations of the current study, we found there is a statistically significant difference in cranial capacity between male and female skulls, with males generally having larger cranial volumes. Within each sex group, there is a considerable amount of variation in cranial capacity, indicating individual differences.

Keywords: Cranial Capacity, cranial volume, Sexual dimorphism, Skull Length.

Introduction

Cranial capacity is a measure of brain volume in vertebrates that have both a skull and a brain [1]. It is often used to estimate the size of the human brain, and it is indirectly used to determine the volume of the human brain [2]. This sub-analysis of anthropometry helps identify an individual's cranial features. Similar to other aspects of the physical structure. Cranial capacity depends on environmental, ecological, biological, geographical, racial, sex, and age factors [3]. Sex identification is very important in medicolegal cases, and the skull and pelvis are instrumental in this process [4]. It has been possible to use different parameters of the skull head, size, and shape to help differentiate human skulls based on whether they belong to males or females [5]. Cranial capacity is associated with the size of the brain, is used to identify race-based features, and is usually assessed in physical anthropological research. The majority of research works on the subject seek to

establish how basic elements, such as race, geographical location, ethnicity, and diet, affect cranial capacity [6]. In light of this, as described by Todd the accuracy of results based on measurements of the human skull shall be obtained when the two skulls belong to the same race as pointed out by Lee and Pearson [7]. Pearson also mentioned some variables such as age, sex, and whether the skull was fresh or dried could influence the measure which is why the formula cannot be used for fresh skulls [7]. Shukla et al. [8] noticed a large difference among Indian skulls; the mean value was 1370 ml with SD = 5. Thomas et al. [9] dissected various approaches to measuring cranial capacity, noting that it is still used in anthropology and clinical practice because it is proportional to the actual brain size. Hwang et al. [10] attempted to measure the cranial capacity of Korean adults by pouring rice seeds inside the cranial cavity and subsequently measuring it with a graduated cylinder which resulted in an average cranial capacity of 1470 cc in male skulls and 1317 cc in female skulls. With this background, we in the current study tried to determine the gender variations of cranial capacities in dried adult human skulls available in the department of Anatomy of our Medical College.

Material and Methods

This study was done in the Department of Anatomy, Medical College. 80 dried adult human skulls were included in the study out of which 50 were males and 30 were females. It was made sure that all the skulls were intact and undamaged and included after sex determination based on the anatomical features. Skulls with the ambiguity of sex or those with damage were excluded from the study.

The skulls were placed on the rubber ring and their lengths were taken from glabella to inion. To establish the breadth, the distance from the two parietal eminences above the zygomatic arch was considered. The heights of the vertebrae and the bones of the countertop were measured from the basion (the anterior margin of the foramen magnum in the median plane) to the bregma using spreading calipers. In the case of each parameter, the average of the three measurements that were made was calculated. The Skull foramina was sealed with clay to prevent seed spillage. The Cranial cavities were filled with mustard seeds through the foramen magnum. The seeds were added gradually while shaking the skull to ensure full coverage. The seeds were then poured into a glass jar and transferred to a 1000 cc glass cylinder, where the volume was measured. The skulls were classified as Microcephalic: Males: Cranial volumes below approximately 1350 cc are typically considered microcephalic. Females: Cranial volumes below approximately 1200 cc fall into this category. Mesocephalic: Males: Cranial volumes between 1350 cc and 1450 cc. Females: Cranial volumes between 1200cc and 1300cc. Megacephalic: Males: Cranial volumes above 1450cc are categorized as megacephalic. Females: Cranial volumes above 1300cc. The data was statistically analyzed using a Z test, with significance set at $p < 0.05$.

Results

Out of the total 80 dried skulls which included 50 male skulls and 30 female skulls. The measurement of the length of skulls was done. Table 1 shows the comparison of skull lengths (in millimeters) between male and female skulls. Males generally have larger skulls than females. The majority of skulls in both groups fall within the 161-180 mm range. The mean skull length in males was 173.65 ± 20.5 mm and the mean length of female skulls was 169.89 ± 10.33 mm. The results suggest that there is a degree of sexual dimorphism in skull length, with males tending to have longer skulls than females. This is consistent with findings from previous studies.

Table 1: Distribution of Length (mm) of the skulls included in the study

Length of skull in mm	Male	Female	Total(%)
<150	1(2.0%)	3(10.0%)	4 (5.0%)
150-160	1(2.0%)	4(15.0%)	5 (6.25%)
161-170	11(22.0%)	6(20.0%)	17 (21.25%)
171-180	28(56.0%)	13(40.0%)	41 (51.25%)
181-190	9(18.0%)	4(15.0%)	13 (16.25%)
Total	50(100%)	30(100%)	80 (100%)

Table 2 provides a comparison of cranial volumes (in milliliters) between male and female individuals. The data is categorized into three groups: microcephalic, mesocephalic, and megacephalic. A higher percentage of females were classified as microcephalic compared to males. The majority of individuals in both groups fell into the mesocephalic category, indicating a typical skull size. A slightly higher percentage of males were classified as megacephalic compared to females. The results suggest a potential difference in cranial volume distribution between males and females. Males tend to have a slightly higher proportion of individuals with larger cranial volumes (megacephalic), while females have a slightly higher proportion with smaller cranial volumes

(microcephalic). Within each group, there is a significant amount of variation in cranial volume. This highlights the individual differences that exist even within the same-sex category.

Table 2: Direct cranial volume (mL) distribution of skulls studied

Cranial volume measurement (mL)	Male	Female	Total(%)
Microcephalic	15 (30.0%)	10 (33.3%)	25 (31.25%)
Mesocephalic	30 (60.0%)	17 (56.67%)	47 (58.75%)
Megacephalic	5 (10.0%)	3 (10.0%)	8 (10.0%)
Total	50(100%)	30(100%)	80 (100%)

Table 3 presents a comparison of cranial capacity (in cubic centimeters or cc) between male and female skulls. Male skulls have a slightly larger range of cranial capacities compared to female skulls. Male skulls have a significantly higher mean cranial capacity (1324.19 cc) than female skulls (1167.32 cc). Female skulls exhibit a slightly higher standard deviation (50.63 cc) compared to male skulls (35.29 cc), indicating greater variability in cranial capacity among females. The observed p-value of 0.0192 suggests that the difference in mean cranial capacity between males and females is statistically significant. The results confirm the existence of sexual dimorphism in cranial capacity, with males generally having larger skulls than females.

Table 3: Range, Mean, and SD Of Cranial Capacity in Male and Female Skulls

Gender	Male	Female
Range (cc)	1250-1430	1150-1380
Mean (cc)	1324.19	1167.32
Std. Deviation	35.29	50.63
Observed p-value	0.0192*	

* Significant

Discussion

Several studies have used cranial capacity estimates that applied several methods, such as linear measurements, packing techniques, and radiography. The most precise and reliable method is when the cranial capacity is directly measured by filling the space in the dry skulls with mustard or rye seeds and then transferring them to a cylinder. The smaller the size of the filler the better quantification as there will be less space loss in close packing. Therefore, in the current study for dry skulls, we also used the mustard seeds for direct estimation of the cranial capacity. In the current study population, the cranial capacity was found to be 1324.19 cc in males and 1167 cc in females using the direct method of estimation. In the calculation of the cranial volume using Lee Pearson's formula, the mean cranial volume was 1295.67 cc in males and 1175.54 in females. The Spheroidal formula yielded values of 1310. 24 cc in males and 1125.54 cc in females, which is consistent with the current study [11, 12]. Differences may arise as these values were derived from formulas based on linear skull dimensions. The cranial capacity of male and female students from Mugla University, Turkey, was determined from the linear head dimensions, and the mean values obtained were 1411.64 ± 118.9cc for males and 1306 ± 162.9 cc for females. This study revealed that the males had larger mean values for cranial capacity than the females ($p<0.05$). In the same manner, in the present study, the F-Ratio was highly significant indicating a significant sexual dimorphism in the skulls. In a similar study by MB Maina et al. [14] with 300 participants; 150 males and 150 females analyzed cranial dimensions and got the cranial capacities of the male (mean 1424.4 ± SD 137. 9 ccs) were significantly greater than females (mean 1331.3 ± SD 201.8 cc) ($P < 0.001$). Cranial length and height were significantly larger in males, a finding consistent with the present study. In Hwang et al. [10] study, using rice seeds, cranial capacity was determined to be 1470 ± 107 cc in males and 1317 ± 117 cc in females. Similarly, Lalwani et al. [15] in a study of 100 male and 60 female skulls mean capacities of 1302cc were recorded. The range of value for male skulls was from 1070 – 1560 cc and the mean value was 1302.95 ± 108.8 cc in close agreement with the observations of this study with the mean capacity of males being 1324.19cc. For females, they found the range was 1000 to 1420 cc and the mean value was 1179.92 ± 97.08 cc in the current study the mean values of females were 1167.32 again in agreement with their observations. Lalwani et al. [15] found highly significant sexual dimorphism with z-test values of p were 0.01 in agreement with the results of the current study. All these studies indicate that the amount of cranial capacity is indeed greater in the male population than in the female population. The appears to be an agreement with the results of this estimation across all the authors with different ethnicities and races that there is a significant sexual dimorphism in the

cranial capacity between males and females with males having larger volume than females.

Conclusion

Within the limitations of the current study, we found there is a statistically significant difference in cranial capacity between male and female skulls, with males generally having larger cranial volumes. Within each sex group, there is a considerable amount of variation in cranial capacity, indicating individual differences. The majority of skulls in both groups fall within the mesocephalic range, indicating a typical skull size. However, a smaller percentage of individuals exhibit microcephaly or megacephaly. While the data suggests a genetic component to cranial capacity differences, environmental factors and population-specific characteristics may also play a role.

References

1. Eboh DE, Okoro EC, Iteire KA. A Cross-sectional Anthropometric Study of Cranial Capacity among Ukwuani People of South Nigeria. Malays J Med Sci. 2016 Sep;23(5):72-82.
2. Pearson, K. Correlation of the intellectual ability with size and shape of head. Proceedings of the Royal Society 1902; 69:333.
3. M.J. Golalipour, K.R. Hosseinpour. Estimation of the cranial capacity and brain weight of Iranian female newborns. Eur J Anat 2006; 10(2): 49-52.
4. Krogman, W.M. Iscan, M.Y. The Human Skeleton in Forensic Medicine. 2nd Edition, Charles C. Thomas, Springfield. 1986; p.551.
5. Mello-Gentil T, Souza-Mello V. Contributions of anatomy to forensic sex estimation: focus on head and neck bones. Forensic Sci Res. 2021 Jul 1;7(1):11-23.
6. Todd T, Russell Margaret. Cranial capacity and linear dimensions, in White and Negro. American Journal of Physical Anthropology 20 05; 6: 97 - 194.
7. Lee Alice, Pearson Karl. Data for the problem of evolution in man.VI. A first study of the correlation of the human skull Philosophical Transactions of the Royal Society of London. Series A, Containing Papers of a Mathematical or Physical Character 1901;196: 225–264
8. Shukla, A. P. A study of cranial capacity and cranial index of Indian skull. J. Anat. Soc. India. 1996; 15-31.
9. Thomas IM, Janaliram S, Rajangam S, Amar DS. Cranial capacity of crania from Karnataka. J. Anat. Soc. India, 1980; 29(3): 135-137.
10. Hwang YI, Lee KH, Choi BY, Lee KS, Lee HY, Sir WS, Kim HJ, Koh KS, Han SH, Chung MS, et al. Study on the Korean adult cranial capacity. J Korean Med Sci. 1995 Aug; 10(4):239-42.
11. Gohiya VK, Shrivastava S, Gohiya S. Estimation of Cranial Capacity in 20- 25-Year-Old Population of Madhya Pradesh, a State of India. Int. J. Morphl. 2010; 28(4):1211-14.
12. Manjunath KY. Estimation of cranial volume an overview of methodologies. J Anat. Soc. India, 2002;51(1):85-91.
13. Acer N, Usanmaz M, Tugay U, Ertekin T. Estimation of cranial capacity in 17-26-year-old university students. Int. J. Morphol., 2007; 25 (1):65-70.
14. MB Maina, YC Shapu, SH Garba, MA Muhammad, AM Garba, AU Yaro, ON Omoniyi. Assessments of Cranial Capacities in a North-Eastern Adult Nigerian Population. Journal of Applied Sciences. 2011;11: 2662-65.
15. Lalwani M, Yadav J, Arora A, Dubey BP. Study on Sex Identification from Cranial Capacity of Adult Human Skulls. J Indian Acad Forensic Med. 2012; 34:2-7.