

Estimation of the Cranial Capacity in Dry Human Skull Bones

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Abstract

Background: The Cranial capacity is a measure of the volume of the interior of the cranium, which is used as a rough indicator of the size of brain. Craniometric study is an important fractions of anthropometry that can be employed in the determination of cranial study of an individual. Cranial capacity like several bodily dimensions are affected by environmental, ecological, biological, geographical, racial, gender and age factors.

Methods: The study will constitute 60 dried human skulls belonging to both sexes in the department of Anatomy, at Indira Gandhi Institute of medical sciences, Patna. And help of other medical college patna city. The skull was placed on the rubber ring and the length of the skull was measured from glabella to inion, breadth by the distance between the two parietal eminences above zygomatic arch and the height from the basion [anterior margin of foramen magnum in the median plane) to bregma by spreading caliper and measuring tape respectively.

Conclusion: The mean, SD of cranial length, cranial breadth and cranial height of both male and female skulls are mentioned in the table: 6. The mean cranial capacity and SD in male and female skulls were 1275.33cc +/- 124.68cc and 1213cc +/- 138.66cc respectively by direct method and 1344cc +/- 106cc and 1276cc +/- 68cc respectively by calculated method. There was a significant difference between genders ($p < 0.001$). The mean, SD of cranial length, cranial breadth and cranial height of male skulls were more compared to female skulls. In the present study, the significant difference is found in the cranial capacities of male and female skulls.

Keywords: Skull, Cranial capacity.

Introduction

The Cranial capacity is a measure of the volume of the interior of the skull (also called the braincase or brainpan) of those vertebrates who have both a skull and a brain. Cranial volume is often used as a general estimate for the size of a vertebrate's brain. Cranial capacity is used as a rough indicator of the size of brain. Craniometric study is an important fractions of anthropometry that can be employed in the determination of cranial study of an individual. Cranial capacity

like several bodily dimensions are affected by environmental, ecological, biological, geographical, racial, gender and age factors. Determination of sex is an important criterion, for identification of an individual for the medico-legal purposes. Skull and pelvis assume great importance in establishing sex of an individual. A number of dimensions and indices have been reported to be of valuable indicator in the differentiation of male and female skulls. It is

well known that cranial capacity which is in correlation with brain volume which reflects the racial characteristics and has been thought to be one of the commonest factors in physical anthropological studies.

The human being has been studied physically; this science of man constitutes Anthropology. Anthropology is a science of man, devoted to comparative study of man and its divisions being Physical and Social anthropology. In Forensic science, anthropologists are often directly involved in the analysis of archeological and fossilized skeletal remains. Using skeletal remains, the anthropologists can also estimate a person's stature and general body proportion in life. In addition, skeletal remains helps in the determination of a person's racial background. Anthropometry is a system of techniques. It is a systematized art of measuring and taking observation on man, skeleton, brain, or other organs, by most reliable means and methods, for scientific purposes. Vertebrate skull is the most modified part of skeleton. It is a skeletal complex adapted to support brain and organs of special senses. This concentration of functions is linked with elaboration of cranial free end of nervous system into a brain whose size and dominance have increased throughout the vertebrate evolution. The size of human brain emphasizes skull's cerebral function. Cranium is not merely protective from external impacts, but also provides continuous isolation for cerebral circulation. The rate of skeletal maturity in males and females vary during the course of growth. The female skull has a capacity about one tenth less than that of the male skull of the same race. Cranial capacity has been measured by many workers without differentiating male and female skulls. Measurement of intracranial capacity was undertaken to determine if there is any significant parameter for gender differentiation. The most commonly used unit of measure is the 'cubic centimeter' or cc. The volume of the cranium is used as a rough indicator of the size of the brain,

and this in turn is used as a rough indicator of the potential intelligence of the organism. Neurological functions are determined more by the organization of the brain rather than the volume.

Objectives

Cranial capacity is an important predictor in the study of racial differences, sex and clinically the analysis of cranial capacity exposes another aspect of growth and development and permits critical evaluation of unusual large, small or mis-shaped crania.

Review of Literature

Most studies carried out to determine the cranial capacity in a population are done with the aim of detecting the effect of various fundamental parameters such as racial, geographic, ethnic and dietary factors etc. Lee and Pearson⁸ formula stated by Todd 1923, the most consistent results are obtained only when the skulls of same race are used. Pearson 1899 also cautioned that formula may be affected by such characters as age, sex and amount of drying of skull. This formula cannot be used on fresh skull. Shukla 1966, had said that great amount of variations exists among Indian skulls. His series had mean capacity 1370 ml with S.D 5.16. Thomas et al 1980, studied the various methods of estimating cranial capacity. Measurement of cranial capacity of an individual is of both anthropological and clinical interest. Such measurements are necessary as they indicate indirectly the brain volume. There are so many methods [Hooton 1963] like: Youn-hawang et al, in 1995 conducted study on the Korean adult cranial capacity. The cavity was filled with rice seeds and the volume of the seeds was measured in a graduated cylinder. They found 1470cc and 1317cc respectively for male and female skulls. In 2002, Manjunath et al, has estimated the cranial capacity of both macerated skulls and living using anthropological and radiological techniques, by using the linear methods, packing/

filling methods, cephalometric and roentgenograms. He also used Lee-Pearson formula to find the cranial capacity on living humans and in infants by water displacement method. According to Golalipur. M. J etal In 2007, Cephalometry or measurement of head was done in the identification, forensic medicine, plastic surgery, orthodontics, archeology and to examine the differences between races and ethnicities. This descriptive investigation was undertaken on 198 young Turkman males to determine the cephalic index and head phenotype among them in Gorgan, North of Iran. In this study cephalic index was determined by classic cephalometric method. Obaje S.G etal, in 2015, study was undertaken due to lack of adequate cephalometry among Nigerians. Four hundred and twenty five subjects were used for the study of which 158 were Igede tribe and 267 were Idoma tribe with mean age of 22.5 and 23.0 year respectively. T, The plates of the membranous bones making up the calvarium of the skull are each derived from the primary ossification center, from which bone formation spreads outward. However, the individual plates do not fused with each other during prenatal development. The Mongoloid skull is generally described as round with a nasal aperture of medium width, well developed and high cheek

bones, moderate prognathism, a tented nasal root, short nasalspine and shovel shaped incisors.

Material and methods

The study will constitute 100 dried human skulls belonging to both sexes in the department of Anatomy, at Indira Gandhi Institute of medical sciences, Patna. And help of other medical college patna city. The skull was placed on the rubber ring and the length of the skull was measured from glabella to inion, breadth by the distance between the two parietal eminences above zygomatic arch and the height from the basion [anterior margin of foramen magnum in the median plane) to bregma by spreading caliper and measuring tape respectively. **Source of Data:** The study will constitute 60 dried male human skulls and 40 dried female human skulls belonging to both sexes in the department of Anatomy, IGIMS and Other medical college in Patna. Study duration of two and half years. The skulls were placed on the rubber ring and the length of the skulls were measured from glabella to inion, the breadth by the distance between the two parietal eminences above the zygomatic arch and the height from the basion [anterior margin of foramen magnum in the median plane) to bregma by spreading calipers. The average of the three recorded measurements were taken for each parameter studied.



Figure 1: Vernier Caliper



Figure 2: Measuring the cranial length

This method is widely used for determining the cranial volume of the skull, where the interior of the skull is packed with the filling materials and then measured. Packing materials used in our study is channa dal. First all the foramina of the skull are plugged with cotton. Then the skull is placed over the rubber ring with frontal end at a lower level. After all the foramina were packed by cotton wool, a large funnel is placed into the foramen magnum.

Inclusion criteria

Complete adult crania of both sexes

Exclusion criteria

Atrophied /decomposed/deformed crania, The most elderly skulls in which skull vault suture showing complete closure, Skulls with any injury, pathology or congenital anomaly are excluded.

Results

Table 1: Gender distribution of the skulls studied

Gender	No. of skulls	%
Male	60	60.0
Female	40	40.0
Total	100	100.0

Table 2: Length (mm) distribution of the skulls studied

Length(mm)	Gender		Total
	Male	Female	
<150	1(1.7%)	3(7.5%)	4(4%)
150-160	1(1.7%)	6(15%)	7(7%)
161-170	18(30%)	11(27.5%)	29(29%)
171-180	28(46.7%)	16(40%)	44(44%)
181-190	12(20%)	4(10%)	16(16%)
Total	60(100%)	40(100%)	100(100%)

Table 3: Direct cranial volume (ml) distribution of skulls studied

Direct cranial volume (ml)	Gender		Total
	Male	Female	
Microcephalic	38(63.3%)	37(92.5%)	75(75%)
Mesocephalic	19(31.7%)	2(5%)	21(21%)
Megacephalic	3(5%)	1(2.5%)	4(4%)
Total	60(100%)	40(100%)	100(100%)

Table 4: Calculated cranial volume (ml) distribution of the skulls studied

Calculated cranial volume (ml)	Gender		Total
	Male	Female	
Microcephalic	32(53.3%)	37(92.5%)	69(69%)
Mesocephalic	24(40%)	2(5%)	26(26%)
Megacephalic	4(6.7%)	1(2.5%)	5(5%)
Total	60(100%)	40(100%)	100(100%)

Classification of skull according to calculated cranial volume show higher percentage of microcephalic in female compared to more mesocephalic type in male skulls

Discussion

The sexual dimorphism in the cranial capacity of male and female skulls found are highly significant with 'p' value 0.001. In the present study, it is observed that, on the basis of overall mean of the cranial capacity of both sexes by direct method, the skulls could be classified as 63.3% of male and 92.5% of female skulls are microcephalic. However, 31.7% of male and 5% of female skulls are mesocephalic, while 5% of male and 2.5% of female skulls are megacephalic. Thus, based on calculated cranial capacity, the skulls can be classified as, 53.3% of male and 92.5% of female skulls are microcephalic. However, 40% of male and 5% of female skulls are mesocephalic and while 6.7% of male and 2.5% of female skulls are megacephalic. The mean cranial capacity(cc) by using direct method is 1275.33cc \pm 124.68cc in males and 1213.00cc \pm 138.66cc in female skulls, with significant difference in the cranial capacity between two genders with 'p' value 0.021. The

mean cranial capacity (cc) using Lee- Pearson formula is 1344.10cc \pm 106.62cc in males and 1276.26cc \pm 68.72cc in female skulls. However, this difference is also highly significant between two genders with 'p' value 0.001. In the present study, the sexual dimorphism in cranial capacity of male and female skulls (table 1) found to be highly significant as 'p' value is 0.001. The studies were carried out on the dry skulls using linear dimensions, packing methods and radiological methods. In our present study CC is estimated by filling method and by Lee-Pearson's method. It is natural that there exists some relationship between the head size and the size of the brain. Several investigators have estimated the cranial volume in the past which indirectly reflects the brain volume. Most of these studies have been made on the dry skulls using linear dimensions, packing methods or occasionally radiological methods. Following the removal of the calvaria the cranial volume was again estimated using spheroid formula after

subtracting the linear dimensions from scalp/softtissue thickness. The estimated mean cranial volume was as follows: by Lee- Pearson's formula: Males : 1152.813 ± 279.16 cc; Females: 1117.82 ± 99.09 cc.; by spheroid formula:Males-mean: 1169.68 ± 239.98 ; Females-mean 1081 ± 111.6 . The length, breadth and height is also similar to our Results. In 2007 Acer. N. Usanmaz estimated CC in 17-22years old from university students of Turkey. They studied 226 males and 140 female health students and found that CC is 1411 and 1306 respectively. There was significant difference between genders. Their study showed CC is larger in males which is similar to our study. In 2010 Gohiya etal, estimated CC in the 20-25 years old population of Madhya Pradesh. They studied 200 males and female by using linear dimensions of the head. The mean CC inmales and females 1380cc and 1189cc respectively. This study has shown significance difference between male and female population, male being heigher than in female. These results are also similar to our study The skulls used in the present study has a rounded to long shape (dolicocephalic), with a narrow nasal aperture, moderately developed supraorbital ridging, prominent nasal spine, a steeple shaped nasal root, little prognathism and a narrow inter-orbital distance. The forehead is steep, the chin is prominent, the palate is long and narrow, the cheek bones are not overly prominent and there is a tendency to maxillary protrusion or mandibular retrusion which belongs to the Caucasoid racial group.

Conclusion

The mean of head length, head breadth and head height of both males and female are mentioned in Table: 6. The mean cranial capacity and SD in males and females were 1275.33 cc +/- 124.68 cc and 1213 cc +/- 138.66 cc respectively by the direct cranial volume were 1344 cc +/- 106 cc and 1276 cc +/- 68 cc respectively by calculated method. Most of the anatomists and anthropologists while studying crania of various

races on the basis of morphological metrical features concluded that the population of a country is no more formed by one homogenous element but instead constituted by heterogenous elements. This explains how there can be s wide range of variation of cranial capacity within a group of population.

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