

■ **Original Article**

## Estimation of cranial capacity of coastal Andhra Pradesh of India

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### Abstract

**Background:** Analysis of cranial capacity exposes another aspect of growth and development and permits critical evaluation of unusually large, small or misshapen crania. The cranial capacity gives a reasonable estimate about the volume of brain. The usual capacity of modern man varies from 1200 cc to 1400 cc with an average of 1350 to 1400 cc. **Objective:** To estimate cranial capacity of coastal Andhra Pradesh, India. **Methods:** The present study was carried out with 320 (160 male & 160 female) medical students of Dr. Pinnamaneni Siddhartha Institute of Medical Sciences & Research Foundation and Dr. Sudha & Nageswara Rao Institute of Dental Sciences Chinnaoutpally, Krishna District (AP), India. **Results:** The mean cranial capacity was 1226.13±119.27 cc. The mean cranial capacity for male was 1322.78±61.88 cc and for female is 1129.49±76.88cc. The difference between male and female heads cranial capacity was significant (p< 0.001& difference 193.29 cc). **Conclusion:** We conclude that cranial capacity of the male is 10-15% higher than the female in costal Andhra Pradesh population. We can calculate cranial capacity for male and female heads by following formula: Cranial capacity (male) = 2.404495 x head circumference (OFC) in mm & Cranial capacity (male) = 2.130207 x head circumference (OFC) in mm [for OFC between 517 mm – 581mm for male & 509 mm – 556 mm for female]. This study will serve as basis of comparison for future studies on costal Andhra Pradesh population.

**Keywords:** Cranial capacity, head length, head breadth, head height, head circumference.

### Introduction

Knowledge of the capacity of cranial cavity of either a dry skull or of a living being may be important to the study and comparison of crania of population with various fundamental differences like racial, geographic, ethnic, dietary, environmental etc. The capacity of the cranium has in many studies been used to indirectly reflect the volume of the brain and to predict mental ability. Studies of cranial capacity can provide useful result in the field of forensic anthropology and paediatrics as an indicator of skull

development in both female and male individuals. This is an important study for anatomist and anthropologist. This information is useful in correlating cranial capacity with other cranial measurements and in studies of primate phylogeny.<sup>1, 2 & 3</sup>

The cranial capacity gives a reasonable estimate about the volume of brain. The usual cranial capacity of modern man varies from 1200cc to 1400 cc with an average of 1350 to 1400 cc.<sup>4</sup> Analysis of cranial capacity exposes another aspect of growth and development and permits critical evaluation of unusually large, small, misshapen crania.<sup>5</sup>

Based on cranial capacity, heads may be classified into following:

- 1) Microcephalic heads: - cranial capacity below 1350 cc.

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- 2) Mesocephalic heads: - cranial capacity varies between 1350 and 1450 cc.
- 3) Megacephalic heads: - cranial capacity over 1450 cc.

Few reports exist on the cranial capacity based on examination of living subjects of Coastal Andhra Pradesh of India and also Indian as well as South Asian Population. Hence an attempt has been made in this study to estimate cranial capacity of living subjects using linear dimensions of the heads of this region. We also made an attempt to find out sexual differences in cranial capacity of Coastal Andhra Pradesh of India. This study has also made an attempt to find out new formula for estimation of cranial capacity from head circumference (OFC) so that estimation of possible cranial capacity will be easy.

### Methods

The present study was carried out with 320 (160 male & 160 female) medical students of Dr. Pinnamaneni Siddhartha Institute of Medical Sciences & Research Foundation and Dr. Sudha & Nageswara Rao Institute of Dental Sciences Chinnaoutpally, Krishna District (AP), India. Medical students were selected because of the easy availability. Only students belonging to Andhra region were selected for present study. They belong to age group of 20-25 years. This study was carried out in the month of April and May 2010.

The anatomical landmarks, glabella (g), inion (I) and euryon (eu) were marked. The anatomical landmarks were defined as follows:

Glabella: A point above the nasal root between the eyebrows and intersected by mid-sagittal plane.

Inion: The distal most point placed on the external occipital protuberance in the mid-sagittal plane.

Euryon:-The lateral most point on the side of the head in the mid-sagittal plane.

Highest point of the vertex: - The highest point of the vertex in the mid-sagittal plane.

All the measurements were taken with subjects sitting on the chair; head in anatomical position. The each measurement was taken to the nearest 1 mm. The head length was measured with spreading caliper with scale from glabella to Inion. Head breadth was measured as the maximum transverse diameter between the two euryons using spreading caliper with scale. Auricular height (head height) was measured

from external acoustic meatus to the highest point of the vertex using an auricular head spanner. Occipito-frontal circumference (head circumference /OFC) was measured using a steel tape. The process of measurements was explained to each and every subject. Each measurement was taken to the nearest millimeter at least three times and average was considered for computation. The written consent was obtained from each and every subject before taking measurements. This study has got permission from the ethical and research committee of Dr. Pinnamaneni Siddhartha Institute of Medical Sciences & Research Foundation Chinnaoutpally, Krishna District (AP), INDIA.

Cranial capacity was calculated using the following formula given by Williams et al<sup>12</sup> and Manjunath.<sup>11</sup>  
Males:  $0.000337(L - 11)(B - 11)(HT - 11) + 406.01$   
Females:  $0.000400(L - 11)(B - 11)(HT - 11) + 206.60$

Where L is head length, B is head breadth and HT is head height in mm. The subjects were classified into microcephalic, mesocephalic and megacephalic.

Data analysis: The data of each person was recorded. Then data was entered into the computer and analyzed using NCSS statistical package. The differences in means of cephalic index, head length and head breadth were tested for statistical significance by independent sample "t" test.

### Results

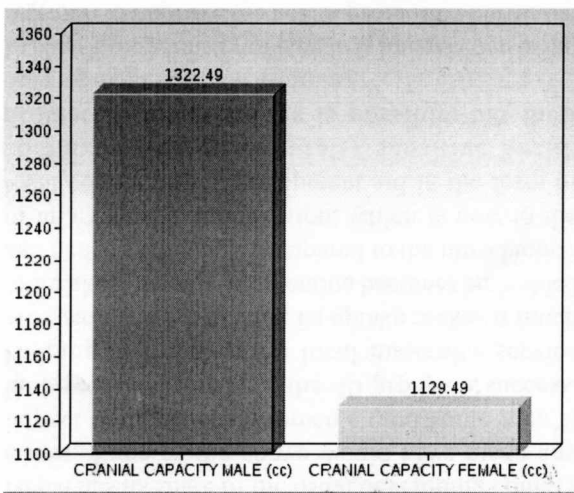
From the collected data, statistics were analyzed and observations and results are presented in tabulated form (Table 1, 2). The minimum cranial capacity was found to be 992.01 cc and maximum cranial capacity was found to be 1456.27 cc. The mean cranial capacity was  $1226.13 \pm 119.27$  cc. The mean cranial capacity for male was  $1322.78 \pm 61.88$  cc and for female was  $1129.49 \pm 76.88$  cc (Figure 1). The difference between male and female cranial capacity was significant ( $p < 0.001$  & difference 193.29 cc). The mean head length was  $177.75 \pm 7.32$  mm. In males the head length varies from 173 mm to 203 mm, the mean head length being  $182.83 \pm 6.04$  mm. In females the head length varies from 163 mm to 191 mm, the mean head length being  $172.68 \pm 4.40$  mm. The difference between male and female head length was significant ( $p < 0.001$  & difference 10.15 mm).

**Table 1: Showing statistics of various parameters of present study**

Variable	n	Min.	Max.	Mean	S.D.	S.E.	P Value
Cranial capacity (male) in cc	160	1163.64	1456.27	1322.78	61.88	4.892	< 0.001
Cranial capacity (female) in cc	160	992.01	1319.62	1129.49	76.88	6.078	< 0.001
Cranial capacity (male & female) in cc	320	992.01	1456.27	1226.13	119.27	6.667	-----
OFC(male) in mm	160	517	581	550.09	13.19	1.042	< 0.001
OFC(female) in mm	160	509	556	529.88	10.69	0.845	< 0.001
OFC(male & female) in mm	320	509	581	539.98	15.69	0.877	-----
Head length of male (mm)	160	173	203	182.83	6.04	0.477	< 0.001
Head length of female (mm)	160	163	191	172.68	4.40	0.348	< 0.001
Head length of male & female (mm)	320	163	203	177.75	7.32	0.409	-----
Head breadth of male (mm)	160	132	144	138.25	2.44	0.193	< 0.001
Head breadth of female (mm)	160	128	143	134.98	3.50	0.277	< 0.001
Head breadth of male & female (mm)	320	128	144	136.61	3.43	0.192	-----
Head height of male (mm)	160	117	142	136.33	4.83	0.382	< 0.001
Head height of female (mm)	160	115	140	126.04	7.37	0.582	< 0.001
Head height of male & female (mm)	320	115	142	130.68	7.77	0.434	-----

**Table 2: Showing classification of subjects based on cranial capacity.**

Sex	n	Microcephalic (cranial capacity below 1350 cc)	Mesocephalic (cranial capacity between 1350- 1450 cc)	Megacephalic (cranial capacity above 1450 cc)	Total
Male	160	112	43	05	160
Female	160	160	00	00	160
Total ( male & female)	320	272	43	05	320



*Figure 1: Showing comparison of cranial capacity of male and female*

The mean head breadth was  $136.61 \pm 3.43$  mm. In males the head breadth varies from 132 mm to 144 mm, the mean head breadth being  $138.25 \pm 2.44$  mm. In females the head breadth varies from 128 mm to 143 mm, the mean head breadth being  $134.98 \pm 3.50$  mm. The difference between male and female head breadth was significant ( $p < 0.001$  & difference 3.27 mm).

The mean head height was  $130.68 \pm 7.77$  mm. In males the head height varies from 117 mm to 142 mm, the mean head height being  $136.33 \pm 4.8$  mm. In females the head height varies from 115 mm to 140 mm, the mean head height being  $126.04 \pm 7.37$  mm. The difference between male and female head height was significant ( $p < 0.001$  & difference 10.29 mm).

The mean head circumference (OFC) was  $539.98 \pm 15.69$  mm. In males the head circumference varies from 517 mm to 581 mm, the mean head

circumference being  $550.09 \pm 13.19$  mm. In females the head circumference varies from 509 mm to 556 mm, the mean head circumference being  $529.88 \pm 10.69$  mm. The difference between male and female head circumference (OFC) was significant ( $p < 0.001$  & difference 20.21 mm).

We classified subjects into microcephalic, mesocephalic and megacephalic based on their cranial capacity. Out of 160 male subjects 112 were microcephalic; 43 were mesocephalic and 05 were megacephalic. All female subjects were microcephalic.

We divided cranial capacity by head circumference (OFC). The mean values of this division were 2.404495 for male and 2.130207 for female (Figure 2).

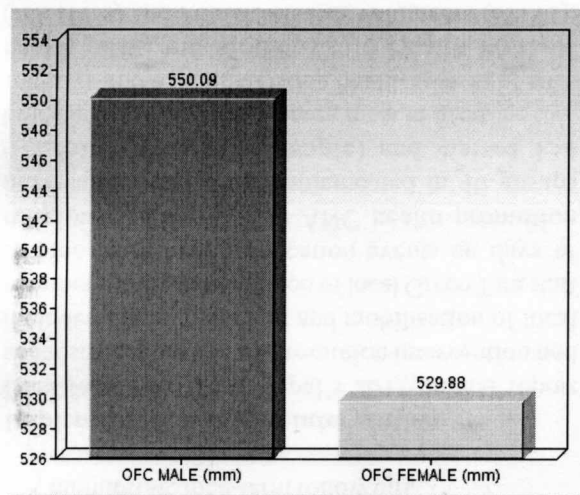


Figure 2: Showing comparison of OFC of male and female

## Discussions

In this study, the measured cranial capacity was  $1322.78 \pm 61.88$  cc in male and  $1129.49 \pm 76.88$  cc in females. The finding of this study is little higher than Indian heads of Manjunath<sup>6</sup> and lower than Gohiya et al,<sup>10</sup> Gopalipour et al<sup>4</sup> and Hwang et al.<sup>3</sup> This difference in cranial capacities is due to population difference as India is vast country and it has different groups of people.

Gopalipour et al<sup>4</sup> studied normal 17-20 year old in Turkman (male 198, female 203) and native Fars (male 200, female 207) group in South east of Caspian Sea border (North of Iran). In his study the cranial capacity of Turkman was  $1420.60 \pm 85$  cc in males and  $1227.40 \pm 120$  cc in female. In his study

the cranial capacity of native Fars was  $1369.60 \pm 142$  cc in males and  $1215.40 \pm 125$  cc in female.<sup>5</sup>

According Hwang et al, the cranial capacity was  $1470 \pm 120$  cc in male and  $1317 \pm 117$  cc in females.<sup>3</sup> In Manjunath (2002a) reports, the cranial capacity was  $1152.813 \pm 279.16$  cc for male and  $1117.82 \pm 99.09$  cc for females. He conclude that the technique of estimating the cranial capacity needs to be refined and modified as it may be of potential application in estimating brain atrophy or reconstruction of the cranium in anthropological studies.<sup>6</sup> In Acer N. report's, the cranial capacity was  $1411.64 \pm 118.9$  cc for male (Range: 1137.33-1798.92 cc) and  $1306.95 \pm 162.97$  cc (Range: 991.59-1930.5 cc) for female.<sup>7</sup>

The mean cranial capacity of Caucasians as computed by Dekaben (1977) shows higher values than ours (males- 1548 cc, female 1425 cc) because the skull vault/soft thickness was measured radiologically in living subjects in his series. His subjects belong to a homogenous group where as subjects used in present study is likely to be heterogeneous and socioeconomically poor.<sup>8</sup>

Acer N et al carried out study on 30 normal subjects whose ages ranged between 19 and 77 years old (males, 18; females, 12). Three different methods were used to assess the cranial capacity. The mean estimated cranial capacity using linear dimensions method in males and females were  $1416.8 \pm 64$  cc and  $1291.9 \pm 152$  cc, respectively. The mean estimated cranial capacity using point counting method in males and females was  $1474 \pm 93$  cc and  $1252 \pm 72$  cc, respectively. By using the planimetric method the mean cranial capacity, male and females were  $1492.1 \pm 74$  cc and  $1319.6 \pm 100$  cc, respectively. Cranial capacity between males and females was statistically significant ( $P < 0.001$ ). This study showed that there are minor differences among the given 3 distinct methods.<sup>9</sup>

Gohiya et al studied 400 healthy 20-25 year old (200 males and 200 females) individuals of Madhya Pradesh, India, during 2005. The mean estimated cranial capacity using linear dimensions method in males and females were  $1380.52 \pm 94.63$  cc and  $1188.75 \pm 91.16$  cc, respectively.<sup>10</sup>

Buda, Reed and Rabe (1975) have demonstrated that there is a positive correlation between head circumference (OFC) and the cranial capacity in infants with normally shaped skulls.<sup>11</sup> In this study

we divided cranial capacity by head circumference (OFC). There is a positive correlation between head circumference (OFC) and the cranial capacity. In general, the adult male cranium has 11% larger cranial capacity than adult female cranium. Adult males tend to be larger than females in a number of features due to a combination of faster rate of growth during puberty and longer period of growth.<sup>12</sup> In the present study cranial capacity of male is 15.72 % (192.76 cc) more than cranial capacity of females. According to classification based on cranial capacity,

112 male and 160 female subjects belong to microcephalic type, 43 male and no female subjects belong to mesocephalic type and 05 male and no female subjects belong to megacephalic type. Most of the anatomists and anthropologists while studying heads or crania of various races on the basis of morphological and metical features concluded that the population of a country is no more formed by one homogenous element but instead constituted by heterogeneous elements. This explains how there can be a wide range of variation of cranial capacity within a population group.<sup>6</sup>

**Table 3: Showing comparison of cranial capacity of various workers.**

Sr. no.	Name of workers	Place & country of work	Year of work	Sample size of study	Cranial capacity of male in cc	Cranial capacity of female in cc
1	Manjunath K Y	Bangalore, India	2001	33 males & 17 females	1152.81	1117.82
2	Golalipour M J	North Iran (Native Fars)	2002	198 males & 203 females	1369.60	1215.40
3	Golalipour M J	North Iran (Turkman)	2002	200 males & 207 females	1420.60	1227.40
4	Gohiya V K	Madhya Pradesh, India	2005	200 males & 200 females	1380.52	1188.75
5	Mania M B	Maiduguri, Nigeria	2009	150 males & 150 females	1424.4	1331.3
6	Present study	Andhra region, India	2010	160 males & 160 females	1322.78	1129.49

**Conclusion**

The result of present study shows that majority of male of Andhra region are microcephalic (112 out 160) and almost all female are microcephalic (160 out 160). There was a significant difference (p< 0.001& difference 192.76 cc) between cranial capacity of male and female heads of costal Andhra Pradesh. Thus we can conclude that cranial capacity of the male is 10-15% higher than the female in costal Andhra Pradesh population. The mean head circumference (OFC) for male was 550.09 mm and for female was 529.88 mm. There was a significant difference (p< 0.001& difference 20.21 mm) between head circumference of male and female heads of costal Andhra Pradesh. We found a positive correlation between head circumference (OFC). Thus we can calculate cranial capacity for male and female heads by following formula:  
 Cranial capacity (male) = 2.404495 x head circumference (OFC) in mm (for OFC between 517 mm – 581mm).

Cranial capacity (male) = 2.130207 x head circumference (OFC) in mm (for OFC between 509 mm – 556 mm).

Though this formula is useful for easy estimation of cranial capacity of Andhra region; but in broad perspective it is useful for whole South Asian population.

This data can be useful for forensic medicine experts, plastic surgeons, anatomist, neurologist, physiologist, psychiatrist, anthropologist, oral surgeons and for clinical and research purpose. This study will serve as basis of comparison for future studies on costal Andhra Pradesh and South Asian population.

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