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Original Research Article

ESTIMATION OF CRANIAL CAPACITY OF ADULT POPULATION IN FARIDKOT DISTRICT OF PUNJAB AND ITS CORRELATION WITH CRANIAL AND BODY DIMENSIONS

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ABSTRACT

Introduction: Estimation of cranial volume is an important investigation used for reconstruction of skull in forensic anthropological studies. Analysis of cranial capacity exposes another aspect of growth and development and permits critical evaluation of unusually large, small or misshapen crania.

Method: In the present study, an attempt was made to find out cranial capacity (cc) of 400 healthy adult (200 males and 200 females) individuals in Faridkot District of Punjab. Linear measurement of cranial length, width and height were measured and the cranial capacities were calculated.

Result: It has been observed that mean cranial capacity for male was 1421.62 ± 93.46cc and for female was 1276.78 ± 92.74cc. The difference between male and female cranial capacity was significant (P < 0.001). The study will also explore the correlation of cranial capacity with cranial length, cranial width, cranial height, body weight, body height and BMI, and we have also compared our findings with the previous studies.

Conclusion: In the present study, we have observed that mean values of all the observations are found to be higher in males than in females. Cranial capacity is also affected by racial factors as we have seen in present study that cranial capacity of males and females of punjab are different from the cranial capacity of different regions observed by different authors at different times. There is significant correlation between cranial capacity and cranial dimensions and body dimensions. The knowledge of cranial capacity is helpful in neurosurgical, anthropology and forensic practice.

KEY WORDS: Cranial capacity, head length, head breadth, head height, body height, body weight.

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INTRODUCTION

Craniometery is a branch of anthropometry through which cranial dimensions can be estimated [1]. Cranial capacity is a measure of the volume of the interior of the cranium (skull) of those vertebrates who have both a cranium and a brain [2]. The cranial capacity is used as a rough indicator of the brain size and this in turn is used as a rough indicator of the potential intelligence of the organism. However, larger cranial capacity is not always indicative of a more intelligent organism, since larger capacities are required for controlling a large body or in some cases an adaptive feature for

life in a colder environment [3]. According to Soames et al [4] cranial capacity is generally 11% larger in adult male cranium than adult female cranium because of adult males tend to be larger than females in a number of features due to combination of faster rate growth during puberty and longer period of growth. Based on cranial capacity heads may be classified into following three groups:

1. Microcephalic-cranial capacity below 1350cc.
2. Mesocephalic-cranial capacity varies between 1350 and 1450cc.
3. Megacephalic-cranial capacity over 1450cc.

Cranial capacity which is in correlation with brain volume reflects the racial characteristics and has been thought to be one of the commonest items in physical anthropological studies [5]. Knowledge of the cranial capacity of either dry skull or a living being may be important to study the comparison of the crania of populations with various fundamental differences like geographical racial, ethnic, dietary etc [6].

This information is useful in correlating the cranial capacity with other cranial measurements and in studies of Primate Phylogeny.

In the course of human evolution, the changes have occurred in the shape and size of cranium. The volume of the interior of the cranium, called cranial capacity increases as the capacity for culture grows. An adult male chimpanzee, our closest relative, has cranial capacity of about 350cc. whereas a twentieth-century male Homo sapiens has cranial capacity of about 1350cc. The cranium becomes more rounded, less football-shaped as its musculature decrease and brain inside grows larger [7].

Medically an analysis of cranial capacity exposes another aspect of growth and development and permits critical evaluation of unusually large, small, misshapen crania [8]. Although a few studies on the estimation of cranial volume do exist in the Indian literature, these studies are based on examination of macerated skull [6, 9, 10] and studies available in literature are below 30 years of age. But hardly any study of cranial capacity based on the examination of living subjects and above 30 years age. This motivated us to do such type of study in our state. Henceforth, in the present study an attempt has been made to estimate cranial capacity of living subjects using linear dimensions of head both in male and female in Faridkot District of Punjab. The study will also explore the correlation of cranial capacity with cranial length, cranial width, cranial height, body weight, body height and BMI and we have also compared our findings with the previous studies. In the present study we have also determined sexual differences in male and female cranial capacities, effect of racial factors on the cranial capacity. No such study has been reported in Punjabi males and females which can throw light on coefficient of correlation between cranial capacity and cranial dimensions and other body measurements.

MATERIALS AND METHODS

The study was carried out on 400 adult individuals aged 25 year & above, (200 males and 200 females) in Faridkot District of Punjab. All the measurements were taken with subjects sitting in chair, in relaxed condition and head in the anatomical position. Each measurement was taken to the nearest millimetre at least three times and average was considered for calculation. 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 Guru Gobind Singh Medical College & Hospital Faridkot District of Punjab, India.

Craniometric measurements: In each subject following linear dimensions of the head were measured. The material used for the study include: Spreading calliper, Anthropometric rod, weighing machine.

Cranial length: It is defined as the straight distance between the most prominent point on the frontal bone above the root of the nose (glabella) and opisthocranion (op) i.e., the most projecting point on the back surface of the head in the mid-saggital plane.

Cranial Width: It measures the straight distance between the two eurya (eu) i.e. the lateral most point of the vertex in the mid-saggital plane.

Cranial Height: It measures the projective distance between tragion and vertex. Tragion: It is the point on the upper margin of tragus where tangents drawn to the anterior and upper margin of this cartilage cut each other. This point lies 1-2mm below the helix spine. This point is taken at the ear opening.

Other Measurements:

Body Height: It is the vertical distance from vertex to floor in the exact anatomical position. The body height was recorded in centimetres.

Body Weight: For this measurement subject was in light clothing and without shoes. The machine was set to 0 levels before each measurement. The weight was recorded in kilograms.

Body Mass Index (BMI): The BMI was calculated by dividing the weight in kilograms by the square of height in meters.

Inclusion criteria: Healthy adults of both sexes were included in the study.

Exclusion criteria: Individuals with apparent physical deformities/growth and development defect were excluded from the study.

Cranial capacity was calculated using the following formula given by Standring et al [11] and Manjunath [9].

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 in mm, B is head breadth in mm and HT is head height in mm**.**

Data analysis: The data for each person was recorded in a designated data form and then analyzed by SPSS 16. For comparison of the means of anthropometric measurements Students t test (p>0.05) was used for sexes.

RESULTS

From the collected data, statics were analyzed and observation and results are presented in tabulated form (Table 1). It has been observed that mean cranial capacity for male was 1421.62±93.46cc and for female was 1276.78±92.74cc. (Fig.1) The difference between male and female cranial capacity was significant (P < 0.001). This investigation has shown that the cranial capacity is significantly higher in males than in females.

The mean cranial length in males was 186.88±9.43mm and in females was 176.87± 9.57mm (Fig.2), mean cranial width in males was 143.38±8.92mm and for females was 138.80±8.76mm (Fig.3) and mean cranial height in males was 140.50± 6.07mm and in females was 132.83±6.27mm (Fig.4).The difference between male and female cranial length, width and height was significant (P<0.001).

It has been observed in the present study that mean body height of males was 172.42±6.64 cm and of females was 159.32±6.54cm (Fig.5). The mean body weight of males was 70.68±12.03kg and of females was 60.66 ± 11.46kg (Fig.6). The difference between male and female body height and weight was significant (P<0.001). Mean body mass index for males was 23.77 ± 3.84 and for females was 23.87 ± 4.12 (Fig 7).

Correlation coefficient between cranial dimensions and the cranial capacity are depicted in Table 2, 3, 4. Correlation coefficient between cranial capacity and all measured cranial dimensions are found to be statistically significant and positive.

Out of the three cranial dimensions of cranial length, cranial width and cranial height, the cranial height is found to have the highest correlation with the cranial capacity. Scatter plots and regression lines demonstrating the relationship between cranial capacity and head dimensions are illustrated in Figs.8a, 8b, 9a, 9b, 10a, 10b for males and females.

Table 1: Statistical significance of metric measurements between male and female individuals.

	Male		Female		p-value	Significance
Measurements	Mean	SD	Mean	SD		
Cranial Length (mm)	186.88	9.43	176.87	9.57	0	HS
Cranial Width (mm)	143.38	8.92	138.8	8.76	0	HS
Cranial height (mm)	140.5	6.07	132.83	6.27	0	HS
Cranial Capacity (cc)	1421.62	93.46	1276.78	92.74	0	HS
Body Height (cm)	172.42	6.64	159.32	6.54	0	HS
Body Weight (kg)	70.68	12.03	60.66	11.46	0	HS
BMI (kg/m^2)	23.77	3.84	23.87	4.12	0.795	NS

Correlation coefficient between the cranial capacity and body weight, body height and BMI are depicted in Table 5, 6, 7. Out of these three body dimensions body weight is found to have

the highest correlation with cranial capacity. Scatter plots and regression lines demonstrating the relationship between cranial capacity and body dimensions are illustrated in Figs.11a, 11b, 12a, 12b, 13a, 13b for males and females.

Table 2: Correlation coefficient between cranial capacity and cranial length.

Subject	Parameter	'r' value	'p' value
Male	CC & Cranial length	0.439	0
Female	CC & Cranial length	0.515	0

Table 3: Correlation coefficient between cranial capacity and cranial width.

Subject	Parameter	'r' value	'p' value
Male	CC & Cranial width	0.468	0
Female	CC & Cranial width	0.541	0

Table 4: Correlation coefficient between cranial capacity and cranial height.

Subject	Parameter	'r' value	'p' value
Male	CC & Cranial height	0.794	0
Female	CC & Cranial height	0.813	0

Table 5: Correlation coefficient between cranial capacity and body height.

Gender	Parameter	'r' value	'p' value
Male	CC & Body height	0.354	0
Female	CC & Body height	0.421	0

Table 6: Correlation coefficient between cranial capacity and body weight.

Subject	Parameter	'r' value	'p' value
Male	CC & Body weight	0.489	0
Female	CC & Body weight	0.457	0

Table 7: Body mass index in male and female subjects.

Subject	N	BMI (kg/m^2)		Range		'P' value
		Mean	S.D.	Min.	Max.	
Male	200	23.77	3.84	15.55	36.88	0.795
Female	200	23.87	4.12	15.82	38.1	0.795

Fig. 1: Mean cranial capacity of male and female.

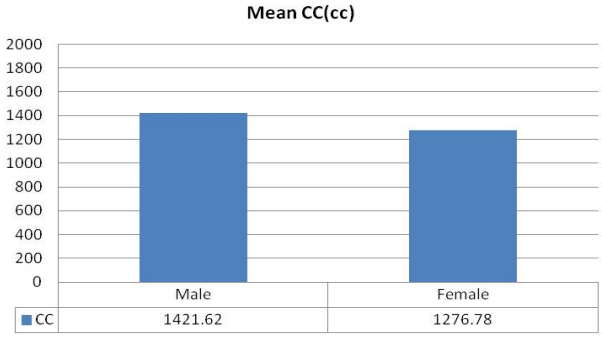


Fig. 2: Mean cranial length of male and female.

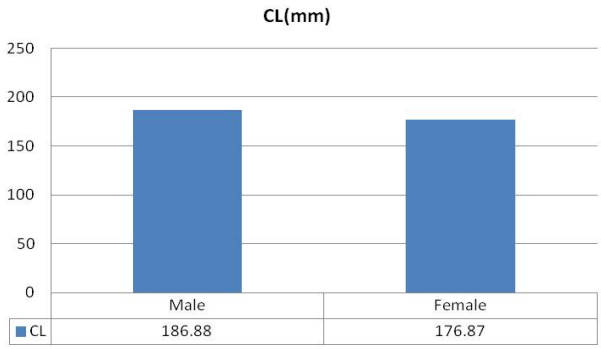


Fig. 3: Mean cranial width of male and female.

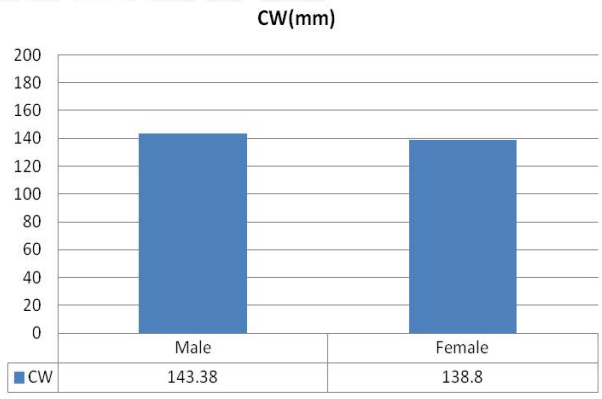
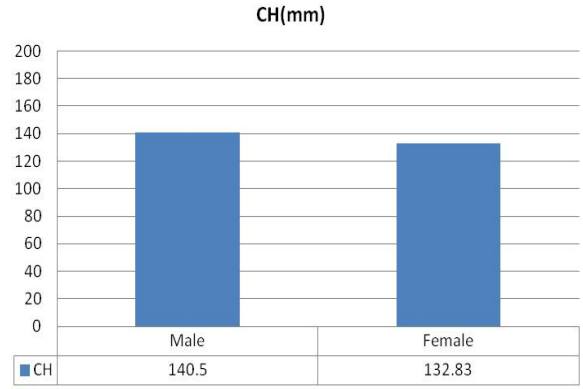


Fig. 4: Mean cranial height of male and female.



Author	Year	Cranial Length		Cranial capacity		Correlation	
		Male	Female	Male	Female	Male	Female
Ilayperuma I [14]	2010	180	171.92	1421.12	1300.95	0.806	0.255
Nzotta ON and Ezejindu BN [16]	2014	196.69	193.16	1636.33	1632.59	0.507	0.675
Present study	2014	186	176	1421.62	1276.78	0.439	0.515

Table 8: Comparison of correlation of cranial length and cranial capacity.

Author	Year	Cranial Width		Cranial capacity		Correlation	
		Male	Female	Male	Female	Male	Female
Ilayperuma I [14]	2010	140.15	136.15	1421.12	1300.95	0.663	0.839
Nzotta ON and Ezejindu DN [16]	2014	159.97	159.32	1636.33	1632.59	0.495	0.681
Present study	2014	143.38	138.8	1421.62	1276.78	0.468	0.541

Table 9: Comparison of correlation of cranial width and cranial capacity.

Author	Year	Cranial Height		Cranial capacity		Correlation	
		Male	Female	Male	Female	Male	Female
Ilayperuma I [14]	2010	141.1	135.38	1421.12	1300.95	0.882	0.884
Nzotta ON and Ezejindu DN [16]	2014	142.97	142.81	1636.33	1632.59	0.719	0.573
Present study	2014	140.5	132.83	1421.62	1276.78	0.794	0.813

Table 10: Comparison of correlation of cranial height and cranial capacity.

Author	Total No	Year	Body Height	Cranial Capacity	Correlation
Acer N et al [13]	366	2007	174.21	1371.6	0.293
Present Study	400	2014	165.87	1349.2	0.65

Table 11: Comparison of correlation of body height and cranial capacity.

Author	Total No	Year	Body Weight	Cranial Capacity	Correlation
Acer N et al [13]	366	2007	65.34	1371.6	0.305
Present Study	400	2014	65.67	1349.2	0.585

Table 12: Comparison of correlation of body weight and cranial capacity.

Author	Total No	Year	BMI	Cranial Capacity	Correlation
Acer N et al [13]	366	2007	21.43	1371.6	0.111
Present Study	400	2014	23.82	1349.2	0.251

Table 13: Comparison of correlation of body mass index and cranial capacity.

Fig. 5: Mean Body height of male and female.

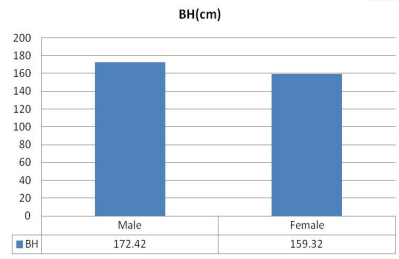


Fig. 6: Mean Body weight of male and female.

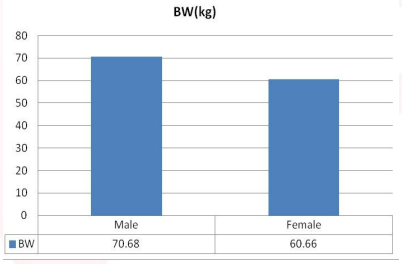


Fig. 7: Mean BMI of male and female.

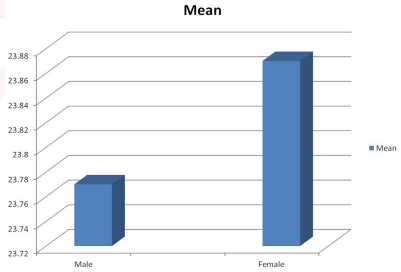


Fig. 8a: Scatter plots and regression line showing the relationship between cranial capacity and cranial length for males.

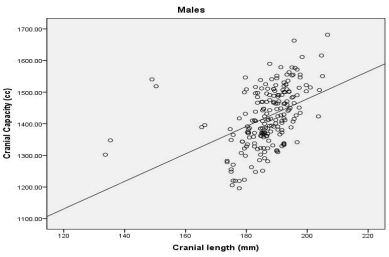


Fig. 8b: Scatter plots and regression line showing the relationship between cranial capacity and cranial length for females.

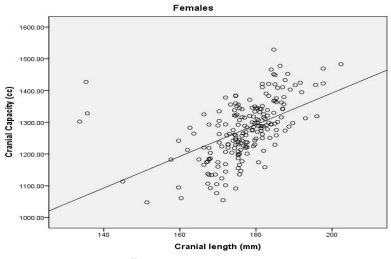
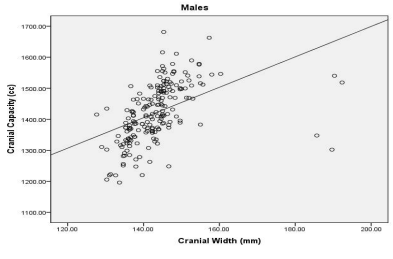


Fig. 9a: Scatter plots and regression line showing the relationship between cranial capacity and cranial width for males.



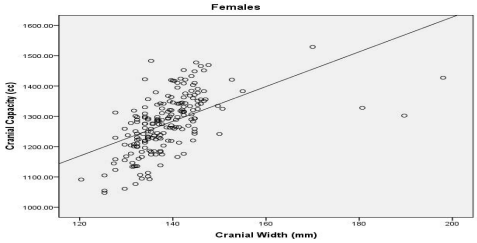


Fig. 9b: Scatter plots and regression line showing the relationship between cranial capacity and cranial width for females.

Fig. 10a: Scatter plots and regression line showing the relationship between cranial capacity and cranial height for males.

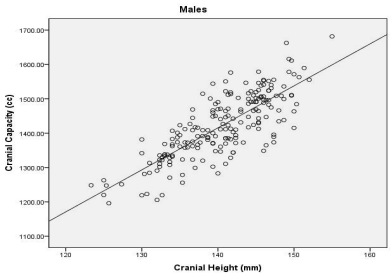


Fig. 10b: Scatter plots and regression line showing the relationship between cranial capacity and cranial height for females.

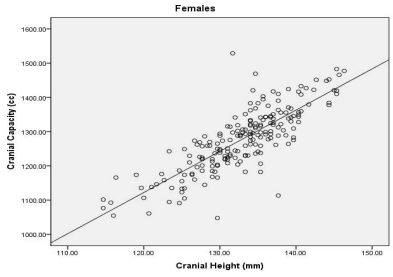


Fig. 11a: Scatter plots and regression line showing the relationship between cranial capacity and body height for males.

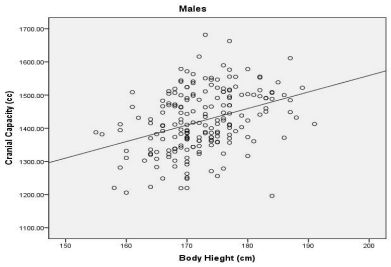


Fig. 11b: Scatter plots and regression line showing the relationship between cranial capacity and body height for females.

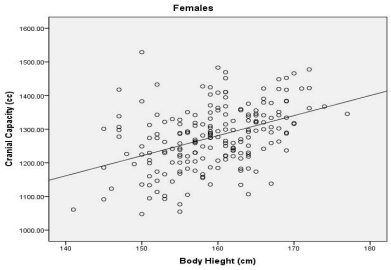


Fig. 12a: Scatter plots and regression line showing the relationship between cranial capacity and body weight for males.

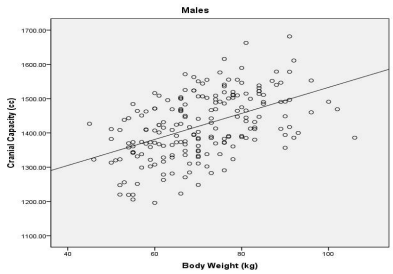


Fig. 12b: Scatter plots and regression line showing the relationship between cranial capacity and body weight for females.

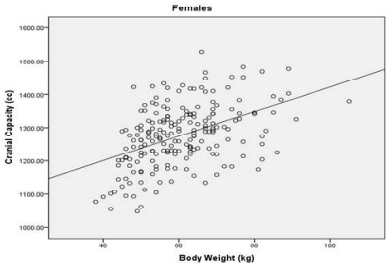


Fig. 13a: Scatter plots and regression line showing the relationship between cranial capacity and body mass index for males.

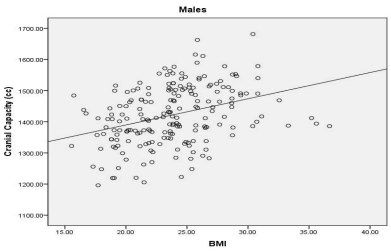
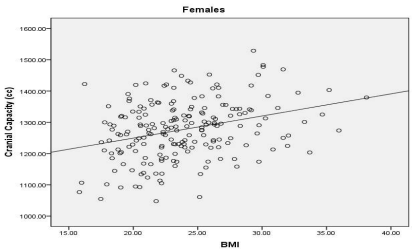


Fig. 13b: Scatter plots and regression line showing the relationship between cranial capacity and body mass index for females.



DISCUSSION

The mean cranial capacity observed in present study was 1421.62 ± 93.46cc in males and 1276.78 ± 92.74cc in females. Thus the mean cranial capacity in males was significantly higher than in females. This difference may be due to the fact that adult males tend to be larger than females in a number of features due to a combination of faster rate growth during puberty and long period of growth. This finding is in agreement with that of the previous studies done by different authors [12-18].

Nzotta and Ejezindu [16] studied the cranial capacity in age group of 18-30 years of student of Nnewi Campus, Anambra State, Nigeria and they found the cranial capacity for males and females were 1636.33 ± 109.94 and 1632.59 ± 149.44 respectively, nearly same in males and females, with very little difference, so the finding is different from the previous studies and our study.

Ilayperuma [14] studied the cranial capacity in the age group of 20-23 years in adult Sri Lankan population and he found the cranial capacity for males and females was 1421.12 ± 171.69 and 1300.95 ± 158.18.

The difference of cranial capacities in males & females in these studies and in our study may be due to age and racial factors.

If we compare the correlation of cranial capacity with cranial dimensions by Nzotta and Ezejindu [16] in the age group of 18-30 years and by

Ilaperuma [14] in the age group of 20-23 years (Table 8, 9, 10)

a) As far as the correlation of cranial capacity with cranial length is concerned, study of Nzotta and Ezejindu [16] showed that correlation is better in females than in males and study by Ilaperuma [14] has shown that this correlation is much better in males than in females. The findings of the present study are in line with Nzotta and Ezejindu [16] which shows that this correlation is slightly better in females than in males.

b) Correlation coefficient between cranial capacity and cranial width in the present study is also much better in females than in males, and these findings are in line with the studies of Nzotta and Ezejindu [16] and Ilayperuma [14].

c) Correlation coefficient between cranial capacity and cranial height in the present study is also much better in females than in males, and in line with the study of Ilayperuma [14] which also showed a strong correlation between the two parameters and shows a better correlation than the study of Nzotta and Ezejindu [16].

Out of the three cranial dimensions of cranial length, cranial width and cranial height, the cranial height is found to have the highest correlation with the cranial capacity, same findings was also observed by Ilaperuma [14] and also by Nzotta and Ezejindu [16] in males.

A correlation is found between cranial capacity and body weight, body height and BMI. The findings of our present study are in line with those of Acer et al [13] who observed the same findings in age group of 17-26 years (Table 11, 12, 13).

The cranium probably ranks foremost as the classical, most studied and informative subject of examination in physical anthropology [19]. Most of the anatomist and anthropologists while studying heads or crania of various races on the basis of morphological and metric features, concluded that population of a country is no more formed by one homogeneous 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 [20].

Many of studies showed that the CC accompanies increasing age from birth throughout childhoods. Most growth is achieved in the first 5 years [21, 22]. At the age of 16-20 the CC reaches its peak size and it is thought that the CC does not change its size during the rest of the life [23, 24].

Age-related decrease in the weight of adult brains has often been noted in cross-sectional studies. Some investigators have questioned whether such decreases are due to aging, because it is known that the stature of humans, as well as the size of the head and brain, has increased during the last century. The most likely explanation is that the head size of humans, and consequently the intracranial volume, increases with age and those changes mask the long term trend that affects the population as a whole [25].

According to Acer et al [13] an increase of CC resulted in increase of the body height, body weight and BMI. It may be perhaps helpful in medico legal and anthropological examination to find the relations between cranial capacity and age, height, body weight, BMI which could also be applied for the dementia, brain atrophy and other neurodegenerative diseases in living subjects.

CONCLUSION

We can conclude that in the present study, mean values of all the observations are found to be higher in males than in females. Cranial capacity is also affected by racial factors as we have seen in present study that cranial capacity of males and females of Punjab are different from the cranial capacity of different regions observed by different authors at different times. There is correlation between cranial capacity and cranial dimensions and body dimensions. We have also observed that cranial capacity is affected by the gender, race, ethnic, geographical, biological and ecological factors.

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Conflicts of Interests: None

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