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Sexual Dimorphism in Human Crania by Craniometry

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ABSTRACT

Physical Anthropology plays a pivotal role in the knowledge of primate evolution & variations, especially those of humans. The tool used for the study is anthropometry, to be more specific- craniometry, the quest for skull. The purpose of the present study is to compare various craniometric parameters of significant bony landmarks on skull for sex determination. For the study 64 skull were considered (32 male & 32 female), devoid of deformities. The crania were studied from the department of Anthropology, Lucknow university and also from anatomy department, KGMU. Sexual dimorphism is significantly evident in occipital region (bi-occipital breadth, bi-mastoid breadth), bi- auricular region (bi- auricular breadth) for the two sexes. Least differences in the sexes is seen in foramen magnum length – breadth index, for the present study. This is further confirmed by the student's t tests and p values.

Thus, was deciphered, that sexual differences do exists between the two genders, for all the craniometric parameters, and all values are higher for male crania than female crania, except for the foramen magnum index, where differences are the least. Thus, index, although shows distinctions within the sexes, is a weaker parameter for sexual dimorphism. Therefore, it is true that the above parameters can be used to define the sexes of individuals.

The result is almost similar to those of previous researchers, except for the bi-mastoid breadth, foramen magnum length and bi- auricular breadth, as these compared parameters show much variability with the present study.

Key Words: - Cranium, Sexual dimorphism, Craniometry, Morphometry.

INTRODUCTION

Craniometry has been a very fascinating and interesting area in anthropometry. It is not only supportive in individual variations and racial classification, but also valuable in the study of evolution, archaeology and forensic anthropology. Cranium + mandible = skull, is the most studied element in physical anthropology, as most of the fossil finds comprises of cranium and mandible.

Apart from os innominate bone, cranium is only most suitable bone for age and sex findings for individuals, studied by morphological and anthropometric techniques.

The bi-occipital breadth, bi-auricular breadth and bi-mastoid breadth gives us transverse measurement of Norma occipitalis (back of cranium) and Norma basalis (base of cranium), while the length, breadth and index of foramen magnum indicate the normalcy or deformities and the pathophysiology of the region. Mastoid bone is also rather suitable for age and sex determination studies as it mostly stands even the body decomposition since it is rather resistant to traumas with its anatomic position and compact structure (Kanchan, et al. 2013).

Foramen magnum, the largest hole in human body, holds an important place in evolution as its position is directly associated with bipedalism in humans. Foramen magnum plays a very significant role as a transition zone between spine and skull, being in close proximity to brain and spinal cord (Sendemir et al., 1994).

Apart from the above dozens of studies have also been conducted on sexual dimorphism of cranial measurements in Indian as well as foreign populations. Some studies conducted by others include- Knight (1915), Hanihara (1958), Jack et al. (1967), Olivier (1975), Krogmann (1986), Deshmukh et al. (2006), Vidya et al. (2012), Talokar et al. (2015), Pasuk, et al. (2015), Naqshi et al. (2017), Rajkumar et al. (2017), Jain et al. (2017), Buran et al. (2018) etc. The study conducted by Talokar et al. (2015) on bi-occipital breadth, the p value is less than 0.05 and as such is significant and an indicator for sexual dimorphism. According to the study, on the foramen magnum by Naqshi et al. (2017)showed that the average anteroposterior diameter of foramen magnum was more than the transverse diameter. The study by Buran et al. (2018) indicates that there are no significant changes occurring in mastoid bone dimension with the advancing age, and many more, to name a few.

Aim of the study

The present study was undertaken in order to compare craniometric measurements of bony landmarks on Norma occipitalis and basalis between male and female crania, which will focus on the variability and sexual similarities between the two genders. It will further confirm, whether sexual dimorphism does exist between the two genders or not. The study will prove helpful in individual variations and racial classifications. The study also compares its work with the works of other researchers, done on different populations of India and aboard.

MATERIAL AND METHODS

The material consists of 64 well identified original human crania into male and female cranium (32 crania for each gender), completely ossified and devoid of deformities. The study has been conducted with the help of anatomy department KGMU, Uttar Pradesh and the department of anthropology Lucknow University.

The study was done on crania for six anthropometric parameters. The measurements were taken in millimetres. The six parameters and their landmarks are: -

- Bi -occipital Breadth = it is the straight distance measured from asterion to asterion,
- Bi-auricular Breadth = it is the straight distance measured from auricular to auricular.
- Bi-mastoid Breadth = it is the straight distance measured from mastoidale to mastoidale.
- Length of Foramen Magnum = it is the straight distance measured from basion to opisthion.
- Breadth of Foramen Magnum = it is usually measured at perpendicular distance to length of the foramen magnum
- Foramen Magnum Index (FMI) is calculated by the formula (Martin & Saller 1957)

$$FMI = \frac{\text{Breadth of Foramen Magnum x 100}}{\text{Length of Foramen Magnum}}$$

Definitions of landmarks used

- **Asterion: -** it is a fixed point where three sutures (lambdoid suture, parieto- mastoid and occipito- mastoid suture) intersect each other.

- **Auriculare: -** it is the point at the centre of external auditory meatus, just above the porion, at the root of zygoma.
- **Basion: -** it is the point on the anterior margin of the foramen magnum in the mid sagittal plane.
- **Mastoidale: -**it is the inferior and lateral most point on the mastoid process
- **Opisthion: -** it is the point on the posterior margin of the foramen magnum in the mid sagittal plane.

The technique used for taking measurements for the present study have been referred from Wilder (1920). Sliding and spreading calipers were used to measure the distances between two defined bony landmarks.

All the taken measurements were statistically analysed. Mean (x), standard error of mean (S.E. of x), standard deviation (S.D.), standard error of standard deviation (S.E. of S.D.) and coefficient of variation (C.V.) were calculated for each measurement. For a more meaningful interpretation Student's t- test was calculated, and probability values were found. These statistical variables are depicted in table no. 1.

RESULTS

32 male and 32 female crania were differentiated and studied, for six craniometric parameters. These six dimensions were measured between pre-determined landmarks on the skulls.

Table no. 1 depicts the five measurements and foramen magnum index, whose landmarks can be located on Norma occipitalis and Norma basalis. Significant sexual dimorphism can be seen in **bi-occipital breadth** (Mean value for males is 103.0mm ± 4.89 and for females it is 94.0mm ±6.11 & $p \leq .001$ with confidence level of 99.9%) and **bi-auricular breadth** (Mean value for males is 116.75mm ± 5.11 and for females it is 104.02mm ± 8.04 & $p \leq .001$ with confidence level of 99.9%). Differences in sexes can also be seen in **bi-mastoid breadth** (Mean value for males is 113.64mm ± 5.05 and for females it is 110.5mm ± 5.61 & $p \leq .02$ with confidence level of 98%) followed by **foramen magnum length** (Mean value for males is 35.0 mm ± 3.21 and for females it is 33.0mm ± 2.85 & $p \leq .01$ with confidence level of 99%) and **foramen magnum breadth** (Mean value for males is 30.4mm ± 2.50 and for females it is 28.9

mm ± 2.81 & p ≤ .02 with confidence level of 98%). **Foramen magnum index** for the two sexes, where male and female crania belong to narrow (range is below 82 for males, according to Martin & Saller 1957) & medium (range is between 82- 85.9 for females, according to Martin & Saller 1957) category respectively in general, and further this parameter shows least differences between them. The mean for males is 81.74 ± 9.48 and for females it is 84.0 ± 11.03 with p ≥ 40 with confidence level of 60 %.

Table 1. Sexual dimorphism in cranial measurements and foramen magnum index

Name of Measurement≤	Gender	Mean (x) (mm)	Standard Error of Mean (S.E. of x)	Coefficient of Variation (C.V.)	Standard Deviation (S.D.)	S.E. of S.D.	t- test and p value
Bi- Occipital Breadth	M	103.0	±0.87	4.75	±4.89	±0.61	6.5051 P ≤ .001
	F	94.0	±1.09	6.5	±6.11	±0.77	
Length of Foramen Magnum	M	35.0	±0.57	9.17	±3.21	±0.20	2.6356 P ≤ .01
	F	33.0	±0.50	8.63	±2.85	±0.35	
Breadth of Foramen Magnum	M	30.4	±0.44	8.22	±2.50	±0.31	2.256 P ≤ .02
	F	28.9	±0.50	10.0	±2.81	±0.35	
Bi-mastoid Breadth	M	113.64	±0.90	4.44	±5.05	±0.63	2.3532 p ≤ .02
	F	110.5	±1.00	5.08	±5.61	±0.90	
Bi- auricular Breadth	M	116.75	±0.91	4.36	±5.11	±0.63	7.5591 p ≤.001
	F	104.02	±1.43	7.73	±8.04	±1.00	
Foramen magnum index	M	81.74	±1.69	11.60	±9.48	±1.18	0.7779 p ≥ 40
	F	84.0	±1.96	13.09	±11.03	±1.37	

Thus, it can be deciphered from the above that sexual differences do exists between the two genders, for all the craniometric parameters, and all values are higher for male crania than female crania, except for the foramen magnum index, where differences are the least. Thus, index, although shows distinctions within the sexes, is a weaker parameter for sexual dimorphism. Therefore, it is true that the above parameters can be used to define the sexes of individuals.

DISCUSSION

The data of this study were compared with the data of Jain et al, 2017 (sample size 25 of unknown sex), Rajkumar et al., 2017(sample size 298 unknown sex) and Naqshi et al.,2017 (sample size 100 of unknown sex) for foramen magnum parameters, in table no. 2. While, data for bi-occipital breadth has been compared with that of Deshmukh et al. (2006) and Talokar et al. (2015). For bi-mastoid breadth, with the data of Knight (1915), Jack et al. (1967)

and Buran et al. (2018), with the data of Pasuk et al. (2015) for bi-auricular breadth. The compared data for which are represented in table no. 3.

Table no. 2. Comparative measurements of populations for unknown sex.

Name of measurement	Rajkumar et al. (2017)	Naqshi et al. (2017)	Jain et al. (2017)	Gender	Present study (mm)
Foramen magnum length	34.1 ± 02.4 (mm)	31.6 ± 02.1 (mm)	33.5 (mm)	M	35.0 ±3.21
				F	33.0± 2.85
Foramen magnum breadth	28.3 ± 2.0 (mm)	26.5 ± 2.1 (mm)	26.1 (mm)	M	30.45±2.50
				F	28.93±2.81
Foramen magnum index	83.14	83.64	---	M	81.74 ±9.48
				F	84.0± 11.0

Table No. 2, represents comparative data on foramen magnum of the present study with that of other researchers. The data of Naqshi et al. (2017) and Rajkumar et al. (2017) suggest some differences with the present study. The mean for this index is 83.64 for crania studied by Naqshi et al. (2017) whereas for crania studied by Rajkumar et al. (2017) the mean value lies at 83.14. These two sets of crania belong to unknown sexes and the shape are of medium category, whereas the crania for the present study show that the average shape of foramen magnum in males is narrow, while the female crania exhibit medium shape of foramen magnum. The length of foramen magnum does not show much variation amongst themselves for the populations compared, except for the foramen magnum breadth of males between the compared populations.

Table no. 3 depicts craniometric parameters for known sex, for the skull bones, in the form of bi-occipital breadth, bi-mastoid breadth and bi -auricular breadth. Sexual dimorphism is most evident between the two sexes in the present study. The comparative study for bi-occipital breadth suggests that males of all the three studies show less differences between themselves, and the differences are also less in the female counterparts as well.

For comparative chart of bi-mastoid breadth among various populations, it is seen that the crania of present study (mean value for males is 113.64±5.05, while for females it is 110.5±5.61) clearly stand apart from the other two populations i.e., Bushman (males= 99.8mm, females=91.7mm) and Indians from South New England (males=105.5mm, while females= 99.4mm). The values show marked differences between the populations and also between the two sexes.

Table no. 3 Comparative measurements of cranium of populations of known sex

Name of measurement	Gender	N	Bi - occipital breadth (mm)	Bi-mastoid breadth (mm)	Bi- auricular breadth (mm)
Present study	M	32	103.0 ± 4.89	113.64± 5.05	116.75±5.11
	F	32	94.0 ±6.11	110.5±5.61	104.02±8.04
Knight (1915)	M	93	--	105.5	--
	F		--	99.4	--
Talokar et al (2015)	M	89	103.61± 4.74	--	--
	F	61	97.11± 3.72	--	--
Pasuk, et al. (2015)	M	99	--	--	126.9 ±4.25
	F	100	--	--	120.1 ± 4.78
Jack, et al. (1967)	M	8	--	99.8	--
	F	6	--	91.7	--
Deshmukh, et al. (2006)	M	--	101.98	--	--
	F	--	98.0	--	--
Buran, et al (2018)	M	300	--	108.5±4.38	--
	F	300	--	100.8± 4.19	--

The bi-auricular breadth depicts significant variations between the sexes and also between the populations under study. The values for present study for males are 116.75±5.11mm, while for females is 104.02±8.04mm. The Thai population studied by Pasuk et al. (2015) indicate a much broader bi-auricular breadth than the Uttar Pradesh crania for both the sexes of the present study.

In all the compared populations and the population of the present study it is found that males have higher values for all the craniometric measurements than their female counterparts.

Conclusion

From the above study, following conclusions can be drawn

- Mean values for all the measurements are almost on higher side for males than females.
- Sex differences will be helpful in studies of populations, medico-legal applications and forensic anthropology.
- Parameters which are statistically significant for t test and p values, are bi-occipital breadth, biauricular breadth, bi-mastoid breadth, foramen magnum length, foramen

magnum breadth. Parameter like foramen magnum index shows least difference for the two sexes in the present study, that is statistically insignificant for p values.

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