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Study on Human Cranial Index with its Sex Difference from Central Kerala

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ABSTRACT

Background: Cranial index, primarily used as an indicator of race had been studied by various workers in view of its morphometric difference in sex predilection. Hence it would be useful to identify sex of an individual from skeletal remains. Similar studies from our geographic region, if at all present might be very few. **Aims and Objective:** Based on maximum breadth and length of skull the study aimed at whether there was any statistically significant difference in the cranial index of male and female. **Materials and Methods:** We used 96 dry,intact skulls preserved in the departments of Forensic Medicine and Anatomy of various Medical Colleges in Kottayam, Ernakulam, Alappuzha and Pathanamthitta districts of Kerala state, India. Skull typed as male or female by observation method was measured for its maximum breadth and length, cranial index derived and the data was entered against corresponding serial number. The data analysis was conducted using SPSS software. **Results:** The mean percentage values of cranial index for female and male were respectively 77.68 ± 4.53 and 73.71 ± 4.05 with the p-value noted as 0.0001from their ranks determined by Mann- Whitney U test which showed statistically significant difference in cranial index of the two sexes. Literature could reveal similar results in studies conducted by other authors. **Conclusion:** Hence this morphometric study proved that it is valuable to include the application of cranial index in the identification procedure of skeletal remains. Further metric studies in this field are needed with a wider usage of other indices.

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INTRODUCTION

Establishment of identity of unknown human bodies has got importance in forensic, anthropologic, archaeologic and anatomical studies. Human remains in skeletonized form are occasionally brought to forensic expert by police for identification and opinion. They would require conclusive evidence regarding sex of the retrieved skeleton. The expert examination of bones and the reliable assessment of sex would ease the load of proving identity to half. Sex is the most important single character in the identification process of an individual as it is unequivocal. It is defined as a biological character based upon reproductive attributes and roles in sexually reproducing species. Skull and pelvis, bones which individually display traits of sexual dimorphism play a major role in identification.[1]

Skull including mandible suitably exhibits traits which are unique for a particular sex. The appreciation of these morphological traits helps the experts to infer sex of the exhibit. There exists a probability that subjective variability could occur among examiners, which might end up in wrong conclusion. The facial difference between male and female subjects was attributable to the individual characteristics of the skeletal framework.[1] By virtue of this, there is, in general a difference in skeletal dimensions between the two sexes and therefore in the decisive indices too. Therefore past authours had subjected humam skull to various types of measurements and mathematical

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calculations based on the probable sexual variations in skeletal morphology.[2] Indices derived from various cranial dimensions including that of maximum breadth and length of the skull (cranial index) had been studied by different workers from this point of view with varying results[3,4,5] obtained. Cranial index, on the other hand was studied as a predictor of race too and some of such works were further subjected to evaluation.[6] It is learnt, hence that its value may vary with populations. Studies from our state on sex difference in the value of cranial index, if at all present may be very few and the present study is thus genuinely grounded.

MATERIALS AND METHODS

The study was conducted on the skulls preserved in museums attached to the departments of Forensic Medicine and Anatomy in various Medical Colleges of Central Kerala. It was commenced after securing clearance from the Institutional Review Board.

The method comprised two different procedures. Firstly, each skull was ascribed to a particular one of either sex based on morphological traits of predilection by an expert in Forensic Medicine with experience not less than eight years of regular service. For streamlining the examination and appreciation of characteristic morphologic traits, a questionnaire was designed for the features peculiar to male and female of a particular trait so that the examiner could choose an appropriate response. The questionnaire was about five salient traits related to the norma frontalis, lateralis and basalis. They included (1) sloping/bossing of frontal bone, (2) prominence/ inconspicuousness of supra orbital ridge, (3) distinctiveness/ smoothness of frontonasal angulation, (4) stoutness/ slendering of the mastoid process and (5) large/ small outline of the foramen magnum. When three or more of these traits were matching to a particular sex, the skull was typed of that sex. The response was serially numbered corresponding to the skull sample and kept aside unbiased.

Secondly, the maximum breadth and maximum length of each skull was measured in centimetres, the distances being correspondingly from euryon to euryon and from glabella to opisthocranion, after placing it in the Frankfurt Horizontal plane (Figure 1). The measurements were taken by the principal investigator (first author) using a spreading calipers and measuring scale and assisted by the first co- investigator (second author). Cranial index was calculated serially and tabulated for each skull using the formula:

$$\frac{\text{Maximum breadth} \times 100}{\text{Maximum length}}$$

Statistical Analysis

Maximum breadth and length were measured on 102 human skulls constituted by 28 females, 68 males and 6 sex undetermined. The undetermined group was not considered for data analysis. The data was analysed using SPSS software. Continuous variables were expressed as means and standard deviations and categorical variables stated as numbers and percentages. The maximum breadth and length were analysed separately, followed by the cranial index. The data on skull dimensions were checked for normality and the mean values and standard deviations for the two sexes were summarized in Table 1.

RESULTS

The student t- test was used to look for any significant difference in cranial breadth and length between the two sexes since their data followed normal distribution. The result was summarized in Table 2.

Cranial breadth was shown to be 12.91±0.58 for female and 13. 137±0.60 for male. The p- value was 0.095 and hence the null hypothesis was accepted indicating that there was no significant difference in cranial breadth at 5% level.

Cranial length was shown to be 16. 643±0.637 for female and 17.874±0.79 for male. The p- value was less than 0.001 and hence the null hypothesis was rejected indicating that there was significant difference in cranial length at 5% level.

The cranial index data was tested for normality and it was statistically confirmed that the data did not follow normal distribution. Hence a non- parametric test namely Mann-Whitney U test which employed a rank system for equality of means was used. The necessary statistics was given in Tables 3 and 4.

Table 1: Mean breadth and length with standard deviation

	Sex	N	Mean	Std. Deviation
Breadth	Female	28	12.911	0.5801
	Male	68	13.137	0.6030
Length	Female	28	16.643	0. 6374
	Male	68	17. 874	0. 7992

Table 2: Statistical test result of breadth and length

	Independent samples test				
	t-test for equality of means				
	t	df	p-value	95% confidential interval of the difference	
				Lower	Upper
Breadth	-1.688	94	0.095	-.4920	.0399
Length	-7.247	94	0.000	-1. 5678	-.8935

The mean percentage values for the cranial index data were 77.68 ± 4.53 for female, 73.71 ± 4.05 for male and an overall value of 74.63 ± 4.56.

A graphical representation of the data on breadth, length and cranial index of the two sexes is given below in Figure 2.

The mean rank values were 66.57 for female and 41.06 for male.

A graphical representation of the gender wise percentage value for breadth, length and cranial index is given below in Figure 3.

The values of the test statistics and p- value calculated for cranial index were given in Table 5.

The p-value was 0.0001 and hence the null hypothesis was rejected. By this it meant that cranial index was significantly different for the two sexes at 5% level.

DISCUSSION

Many indices have been used while testing the skull for sexual dimorphism.[7] Why we chose cranial index for our study was that because it reflected an overall proportion of the size of skull and hence it would be a better comparison between the two sexes. Indices were calculated applying the smaller value as numerator. The male skull was robust and of larger volume whereas the female one was gracile and of lesser volume. It could here be proposed that this basic difference in sex appreciation had been tested in different norms of the skull.[7] It was by virtue of this fact that an expert would type a skull as one particular sex after a subjective examination.

The results of our study showed significant difference in male and female skulls by Mann- Whitney U test which analyzed the data for a special rank system and then p- value calculated. Cranial index for female (mean rank =66.57) was significantly different from male (mean rank= 41.06) with p- value= 0.0001 at 5% level. Dhanwate et al[8] showed that the mean percentage value of cranial index for male and female skulls was 74.68 ± 4. 21 and 77.12 ± 4.92 respectively while the current study observed 73.71 ± 4.05 and 77.68 ± 4.53. It was interesting to note that the

Table 3: Mean % value of cranial index with std. deviation

	Cranial index	Std. Deviation
Female	77.68	4.53
Male	73.71	4.05
Overall	74.63	4.56

Table 4: Cranial Index with ranks

	Sex	N	Mean rank	Sum of ranks
Cranial Index	Female	28	66.57	1864.00
	Male	68	41.06	2792.00
	Total	96		

Table 5: Statistical test result of cranial index

	Cranial Index
Mann- Whitney U	446.000
p- value	0.0001

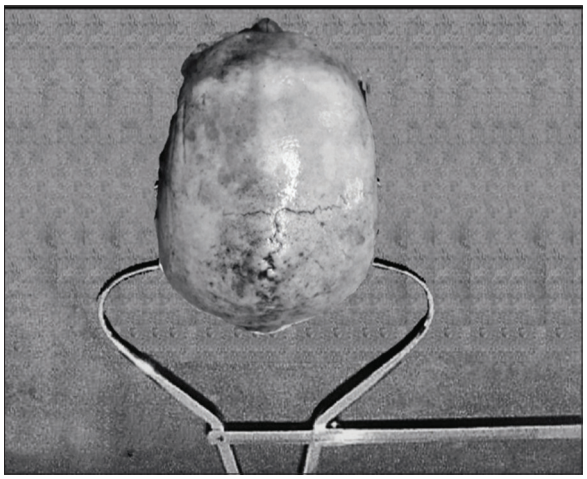

Figure 1: Measuring maximum cranial breadth with spreading calipers

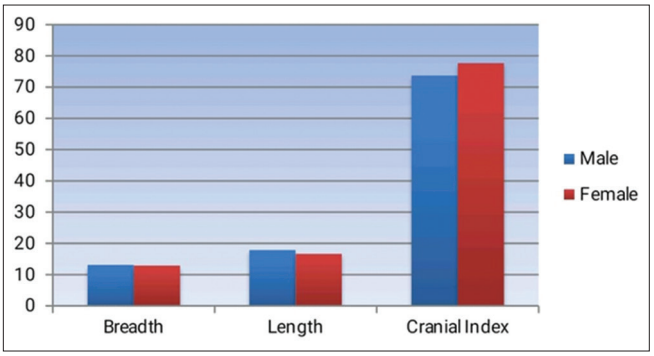

Figure 2: Genderwise comparison of breadth, length and cranial index

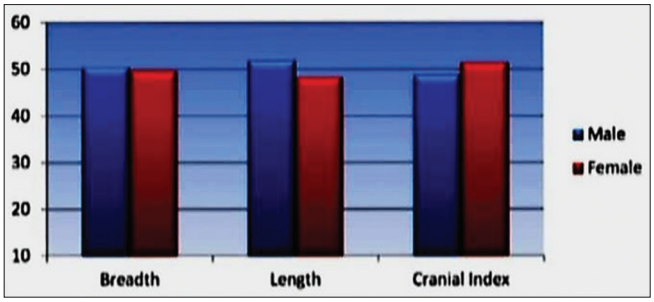

Figure 3: Percentage of breadth, length and cranial index

two studies showed similar results on cranial index. Their sample size was also similar. However in the former study the test of significance for cranial index was student t- test. Shanthi CH et al. found that mean percentage value of cranial index in male and female was respectively 69.75 ± 4.02 and 71.48 ± 5.81 with p- value ≤ 0.01.

Studies conducted on cranial index by workers in different parts of India and other countries showed results which were either significant or insignificant. A south Indian study conducted by Vidya et al with 80 skulls showed markedly narrow difference between mean value of cranial index among male and female and hence showed an insignificant result[9] on this matter of reference. A similar study on north Indian skulls by Kumar and Nagar showed statistically significant difference of cranial index in male and female.[10] Jeremiah et al. in Kenya studied cranial index with a comparatively larger sample size of 150 skulls having an almost equal number of male and female.[11] However their study did not show sex difference for cranial index with statistical significance.

In a term paper review by Orish C N on works by various authors, both abroad and Indian, higher values were cited for male parameters compared to female ones in an Indian study; the paper revealed that cranial index and dimensions would tend to vary with sexes.[12] In Setiya et al. study, females showed a higher mean cranial index compared to males, with somewhat similar results as shown in our study. They got their mean cranial index for male and female as respectively 77.65 ± 3.34 and 78.13 ± 3.76 with a higher sample size of 140 dry human skulls.[13] The current study could however record a more definite margin between the mean cranial index of male and female when compared with the results reported elsewhere. From our experience with the present study sample, we could perceive that accuracy of measurement and selection of points had a crucial role in the overall results. The result of the test of significance and gap in percentage mean value of cranial index in the two sexes were notable despite the occurrence of overlap in certain amount of values we obtained.

The sex undetermined skulls were disregarded because of their poorly defined morphological traits unfitting for either sex. The characteristic differences worked out for male and female features of skull might perhaps be affected by hormonal, nutritional and environmental factors during the process of evolution.[14] The large number of skulls examined could help to lessen subjective errors to a great extent during sex typing by the expert.

CONCLUSION

1. Cranial index differed significantly in male and female skulls as proven by statistical tests of relevance. The difference could be attributed to the characteristics of sex predilection with our study focused on vault of skull. This information stands valuable when skeletal remains are examined for purpose of identification in forensic, anthropologic and anatomical studies.
2. Cranial index can be assessed as an adjuvant measure after appropriate observation of the sex type during the process of identification of dead remains. This may become especially applicable in forensic practice when one encounters cases with controversial nature.
3. Multivariate morphometric studies with wider usage of indices are needed in this field for further refinement.

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Author's Contribution:
JBK-Concept and design of the study; literature review; data collection, analysis and interpretation of results; preparation of the manuscript; **AG-** Collection of part of specimens; data analysis; revision of manuscript; **RR-** Morphologic identification of sex; review of manuscript.

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