Original Study

A Cross Sectional Study of Cephalic Index using Various Measurement Techniques in Varanasi Region of North Indian Population

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Abstract

Background: Cephalic Index is defined as the ratio calculated by the occipitofrontal diameter (OFD) to the biparietal diameter (BPD).

It has been reported that factors like race, ethnicity, genetic interactions, traditions, nutrition, environment, and climate influences head types.

The multifariousness of our nation fascinates and raises the need for anthropometric studies in various regions and compare the outcomes.

The cross-sectional study was carried on three different groups/subjects of either sex.

Group 1 comprised of living subjects (Undergraduate students) belonging to this particular region.

Group 2 comprised of those that presented to the radio- diagnosis department of Sir Sunderlal Hospital, IMS, BHU, UP, India.

Group 3 comprised of dry skulls available in the departmental museum of department of Forensic medicine, IMS, BHU, UP, India.

The measurement of maximum cranial breadth and maximum cranial length, are taken manually/on DICOM CT records depending on the group and recorded for analysis.

The average CI in both the sexes and prevalence of the type is classified according to Martin and Saller classification. (1957)

Objectives: The objectives were to find out the prevalence of the type of skull in the study population. It would also show the sensitivity of radiology and its efficaciousness in anthropometric measurements. To ascertain the mean CI,range of maximum cranial breadth and maximum cranial length.

Result: A total of 70% amongst the study population shows dolichocephalisation.

The mean cephalic index in this particular study population was 73.92 ± 5.05.

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Maximum cranial breadth ranged from 10.4cms to 16.2cms with a mean breadth of 13.21±0.93.

Maximum cranial length ranged from 15.6 cms to 20.67cms with a mean length of 17.89 ± 0.86.

Conclusion: The observations and findings of the present study based on CT can be replicated in various communities, castes, and regions of India. The data can also be helpful in establishment of identity particularly race using skeletal remains.

Keywords: Anthropometry; Cephalic Index; Skeletal Remains; Race.

Introduction

The identification of skeletal remains is nothing less than a big challenge. It begins with what forensic anthropologists call "doing the big four"—identifying age, sex, race, and stature.

Later, there is corroboration with the available supplementary evidence and conclusions are drawn henceforth.

The skull offers the best evidence on racial origins; Krogman and Iscan claimed that ancestry can be determined in 90-95% percent of cases." [1]

Cephalic index is derived from Greek word "kephale" meaning "head," the Greek word "ikos" meaning "pertaining to," and the Latin word "index" meaning "that which points out".

It was described by Anders Retzius (1842) and first used in physical anthropology to classify ancient human remains found in Europe.[2]

Cephalometry continues to be the most versatile technique in the investigation of the craniofacial skeleton because of its validity and practicality. [3]

It is essential to have indigenous data of these constraints since these values reflect the possibly different shapes of craniofacial development subsequent from ethnic, racial, geographical and sexual differences.[4]

Anthropometric study of head is also useful in designing various head and face gadgets like helmets, headphones, goggles etc. by formulating standard sizes.[5]

The aim of the present study was to find out the dominant type of skull based on the Cephalic index in Varanasi region of North Indian population using physical anthropometry and computed tomography.

It also helped to explore the sensitivity and application of virtual scans in field of forensic anthropology and to find out the average occipitofrontal diameter and biparietal diameter in the study population.

The inferences drawn using the stated techniques also reflects on the efficacy of the it and concludes any variation in the results due to the method employed.

Material and Methods

The current cross sectional study was performed in Department of Forensic medicine, Institute of Medical Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh.

Study was carried out with departmental protocol presentation followed by institutional ethical committee clearance bearing No.Dean/2022/EC/4049 dated 15.04.2023. It was also presented midway through the data collection process at national conference organised by Indian Academy of Forensic medicine 2023 and feedback from the experienced panel members was considered thereafter.

In this study, the sample size considered was 275. Consent was obtained or waived by all participants in this study.

The sample size of the present study was calculated with the help of Department of statistics, Institute of Medical Sciences, Banaras Hindu University based on the mean and standard deviation of the two relevant parameters namely Mean cranial length and Mean cranial breadth of previously published similar studies. Sample size formula for two independent variables was used. It has been calculated taking into consideration 5% level of significance and 80% power. The formula is as follows:

$$n = \frac{2(Z_{1-\alpha/2} + Z_{1-\beta}).\ S_p}{d^2}$$

Where, $Z_{1-\alpha/2}$ =1.96 at 5% level of significance.

$Z_{1-\beta}$ =0.842 at 80% power.

d = difference of means

S_p= pooled standard deviation.

The study sample was further categorised into three different groups namely:

Group 1 comprised of 100 living subjects (50 female, 50 male) who are undergraduate and postgraduate students of IMS, BHU selected belonging to this particular region who consented to participate in the study. Informed consent form was drafted in accordance with WHO Informed consent form template for research involving human participants. After obtaining their consent, the subjects were asked to sit on a chair in relaxed condition with their heads in anatomical position and the measurements were taken.

Group 2 (DICOM format CT scans) comprised of those that presented to the radio- diagnosis department of Sir Sunderlal Hospital, IMS, BHU, UP, India.

CT records of patients were collected from the database registered at Department of Radiology, IMS, BHU.

In this category-100 Head CT scan images (50 female, 50 male) were randomly selected falling in age group 18-75 years.

Inclusion criteria:

- Intact scans of human skulls (18-75 years) of both sexes, who had undergone computed tomography scan for various diagnostic medical or surgical indications.
- High quality CT scan images.

Exclusion criteria:

- Low quality blurred images or those with artifacts.
- Scans of subjects with evidence of head trauma, any other possible abnormalities that affected normal morphology.
- Incomplete scans due to software issues.

Imaging and interpretation:

Multislice Computed Tomography (MSCT) scans of the skull were obtained on a GE light speed VCT 128 slice CT scanner. The scanning parameters were kV=120, mA=300.The images were post processed using RadiAnt DICOM Viewer 2022.1.1(64-bit) software that allowed analysis of images in 2D and 3D view. The measurements were taken directly on primary cross-sectional images in 2-D view.(Refer image 1) The midventricular slice of the CT scan, which shows the most prominent frontal horns of the lateral ventricle, was selected for the estimation of cranial area since it reflects the maximum size of the cranium.[6] Also, the measurements were correlated in the 3-D view.(Refer image 2) In case of difference, measurements were repeated and mean was considered,

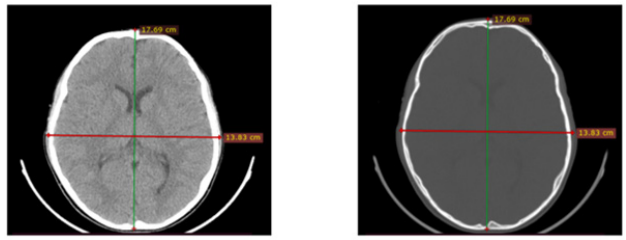


Image 1: 2-D images in DICOM format showing brain and bone window of midventricular slice.

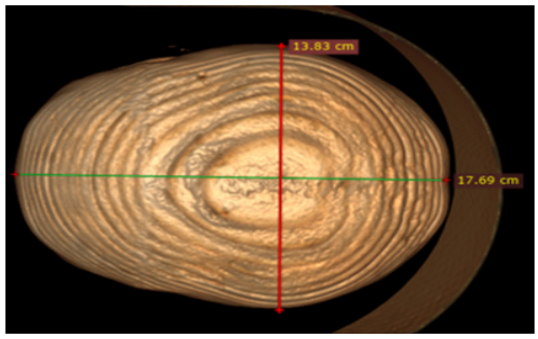


Image 2: 3-D image of the skull seen in the viewer.

Group 3 comprised of 75 dry skulls available in the departmental museum of department of Forensic medicine, IMS, BHU, UP, India. Incomplete/ fragmented skulls that created hindrances in identifying the measuring points were excluded. Measurements were taken placing the skull on a steady platform at anthropology lab of the department using spreading callipers. (Refer image 3)

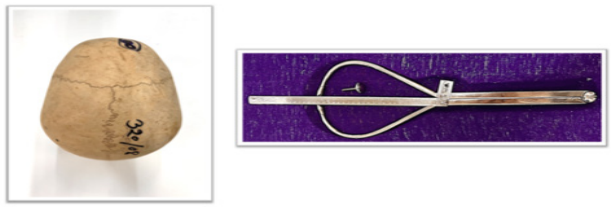


Image 3: Dry skull and spreading callipers for manual measurement.

Group 1 and Group 3 measurements were taken physically by two observers. In case of difference, mean value was considered. The method used for assessment was Hrdlicka's method.[7] The maximum cranial breadth was measured from euryon(eu) to euryon(eu). The maximum cranial length was measured from glabella(g) to inion(I).

These anatomical landmarks are defined as:

g = The point above the nasal root intersected by the mid sagittal plane.

I = The distalmost point placed on the external occipital protuberance in the mid sagittal plane.

eu = The lateralmost point placed on the either side of the parietal bone/sides of head.

Spreading callipers was used for the measurements.The measurements obtained were recorded on an excel spreadsheet and classified according to Martin and Saller classification (1957). (Table 1)[8]

Table 1: Classification of Head Types According to Martin and Saller (1957).

TYPE OF SKULL	MALE RANGE	FEMALE RANGE
Hyperdolichocephalic	66.0- 70.9	67.0- 71.9
Dolichocephalic	71.0- 75.9	72.0- 76.9
Mesocephalic	76.0- 80.9	77.0- 81.9
Brachycephalic	81.0- 85.4	82.0- 86.4
Hyperbrachycephalic	85.5- 90.9	86.5- 91.9

Findings:

Statistical analysis was done using Stata Corp Stata MP v16.0 program using pearson correlation with the help of Institute of Biostatistics, Institute of Medical Sciences, Banaras Hindu University. Data were expressed in the form of frequency and value in mean and standard deviation. A p-value of <0.05 was used as the criterion of statistical significance.

The data analysed was expressed in tabulated form as:

Findings Tabulation:

Table 2: Mean, Standard Deviation, P-Value of MCL, MCB, CI of Total Measured Skulls.

Variables	Mean(n=275)	Range		p-value
		Minimum	Maximum	
Maximum Cranial Breadth (in cms)	13.21 ± 0.93	10.4	16.2	<0.01
Maximum Cranial Length (in cms)	17.89 ± 0.86	15.6	20.67	<0.01
Cephalic Index	73.92 ± 5.05	61.20	90.06	<0.01

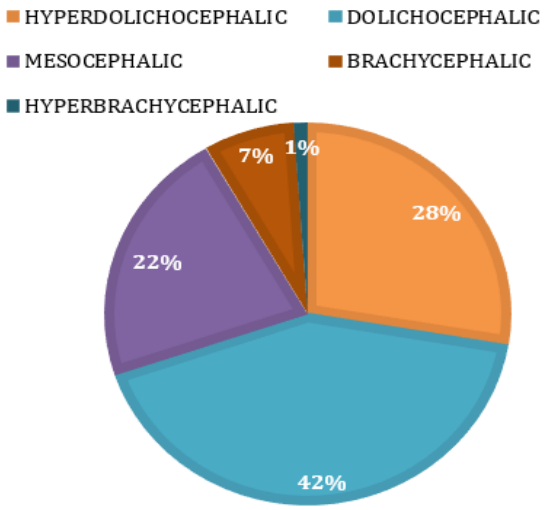


Diagram 1: Represents Percentage Distribution of Type of Skull

Table 3: Frequency and Percentage of Type of Skull

Type of skull (n=275)	Frequency	Percentage
Hyperdolichocephalic	76	27.64%
Dolichocephalic	116	42.18%
Mesocephalic	60	21.82%
Brachycephalic	20	7.27%
Hyperbrachycephalic	3	1.09%

Table 4: Frequency and Percentage of Type of Skull by Group

Type of skull	Group			Total
	Live skulls	CT scan films	Dry skulls	
Hyperdolichocephalic	17 22.37%	26 34.21%	33 43.42%	76 100%
Dolichocephalic	35 30.17%	50 43.10%	31 26.72%	116 100%
Mesocephalic	30 50 %	20 33.33%	10 16.67%	60 100%
Brachycephalic	15 75%	4 20%	1 5%	20 100%
Hyperbrachycephalic	3 100%	0 0	0 0	3 100%
Total	100 36.36%	100 36.36%	75 27.27%	275 100%

Table 5: Mean, Standard Deviation, P-Value of MCL, MCB, CI of Female Measured Skulls.

Variables	Mean(n=100)	Range		p-value
		Minimum	Maximum	
Maximum Cranial Breadth (in cms)	13.28±0.70	11	15.5	<0.01
Maximum Cranial Length (in cms)	17.57±0.70	16	19.14	<0.01
Cephalic Index	75.68±4.94	62.14	90.06	<0.01

Table 6: Mean, Standard Deviation, P-Value of MCL, MCB, CI of Male Measured Skulls.

Variables	Mean (n=100)	Range		p-value
		Minimum	Maximum	
Maximum Cranial Breadth (in cms)	13.83±0.82	12.19	16.20	<0.01
Maximum Cranial Length (in cms)	18.52±0.71	16.32	20.67	<0.01
Cephalic Index	74.74±4.72	62.67	87.22	<0.01

Table 7: Mean, Standard Deviation, P-Value of MCL, MCB, CI of Dry Skulls.

Variables	Mean(n=75)	Range		p-value
		Minimum	Maximum	
Maximum Cranial Breadth (in cms)	12.30±0.56	10.40	13.80	<0.01
Maximum Cranial Length (in cms)	17.48±0.74	15.60	19.40	<0.01
Cephalic Index	70.49±3.84	61.20	80.86	<0.01

Discussion

We encounter numerous cases of skeletonized remains especially in the tropical zones due to high rate of decomposition and deduction of identification features including race becomes of much importance. A standard uniform data is required to make conclusions especially when it comes to measurements and indices. Also, in cases of disasters identifying individuals becomes a challenging task .

It becomes necessary to accurately identify the victims not only from a legal aspect but also for humanitarian and religious reasons. The usual remains found in mass disasters are skull and the long bones.

Anthropometry pertaining to the human body needs to be standardised and improvements need to be done in the techniques and reference charts made available for our Indian population that contributes to a major part of the globe.

Research into these specific topics shall only be able to yield such metrics and since globalisation has an influence on numerous factors like geographical influences including temperature, dietary habits, interracial mixing, change and variation over a period of time is inevitable and therefore we must look into it.

In this particular study, the maximum skulls fell into category of dolichocephalic i.e. 116/275 skulls that constituted 42% followed by 72/275 skulls that fell into hyperdolichocephalic constituting 28%. (Refer Table 3)

A total of 70% amongst the study population shows dolichocephalisation.(Refer diagram 1)

The mean cephalic index in this particular study population was 73.92 ± 5.05.(Refer Table 2)

Maximum cranial breadth ranged from 10.4 cms to 16.2cms with a mean breadth of 13.21±0.93.

Maximum cranial length ranged from 15.6 cms to 20.67cms with a mean length of 17.89 ± 0.86.

Table 4 represents frequency and percentage of type of skull in particular categories of the study population.

Table 5 represents mean, standard deviation, p-value of MCB, MCL, CI of female measured skulls.

Table 6 represents mean, standard deviation, p-value of MCB, MCL, CI of male measured skulls.

Table 7 represents mean, standard deviation, p-value of MCB, MCL, CI of dry skulls.

Other similar studies in our country have yielded the following results:

- Shah & Jadhav[9]:2004 (Gujarat) 80.81 Brachycephalic
- Mahajan et al[10.] :2009 (Punjab) 85.53 Hyperbrachycephalic
- Kumar & Gopichand[11]: 2013 (Haryanvi) M-66.67 F-72.25 Both:Dolichocephalic
- Patro et al.[12] :2014 (Southern Odisha)M-77.28 F-78.38 Both: Mesocephalic

Further studies should be conducted in different regions to see the variations and draw inferences. Additional data like cranial volume and cephalometric measurements if available, the entire face and the skull can be constructed and will be very useful in forensic medicine to identify the individuals.[13]

Conclusion

In the total study sample(n=275); the frequency of dolichocephalic was maximum i.e 42% followed by hyperdolic hocephalic i.e 28%, mesocephalic 22%, brachycephalic 7%, hyperbrachycephalic 1%. 70% are in dolichocephalic category.

In group 1 i.e skulls of living subjects; dolichocephalic skulls were maximum in number, followed by mesocephalic and hyperdolichocephalic. In this group too dolichocephalisation was evident.

In group 2 i.e CT scan skulls;dolichocephalic skulls were maximum in number, followed by hyperdolichocephalic and mesocephalic.In this group too dolichocephalisation was evident.

In group 3 i.e dry skulls;hyperdolichocephalic skulls were maximum in number,followed by dolichocephalic and mesocephalic.In this group too dolichocephalisation was evident.

Hence,overall dolichocephalic or long headed skulls were the maximum in the studied sample and tendency towards dolichocephalisation was seen in Varanasi region.

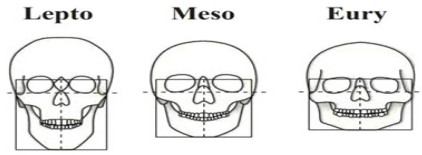
Another interesting finding was that 14/275 skulls showed a CI<66.According to the classification hyperdolichocephalic skulls range from CI of 66.

Such finding shows definite dolichocephalisation and there may be a need to reclassify the Martin Saller according to our population. References can be deduced after a metanalysis of similar studies conducted at various regions and states of our country.

Nonetheless, in practical use we must be very careful to opinionate as our population will have variable data due to the diversity of our country, in terms of environmental conditions and nutrition that have a very strong influence.

Gender does not show a particular deviation.

Individuals with a dolichocephalic head shape have a brain that is long in the anteroposterior direction and narrow in the transverse direction, which results in a longer, latter skull base, i.e., the angle formed by the floor of the skull is wider. As a result, the entire nasomaxillary complex assumes a lower, more protrusive position, inducing an inferior and posterior rotation of the mandible. Thus, a dolichocephalic head would favor the development of a predominantly long morphology of the face, with a tendency toward a retrognathic mandible and a Class II molar relationship compatible with a leptoprosopic facial type. The same reasoning may be applied to patients with a brachycephalic head shape. Their brains would be wider and more rounded, with a shorter, more angular cranial base, causing a relative retrusion of the nasomaxillary complex and anterior rotation of the mandible. Therefore, these individuals would exhibit features that are closer to a euryprosopic facial pattern.[14]



Further studies can be done to prove/disprove these associations of the facial symmetry with shape of skull. It would be helpful in orthodontics and facial reconstruction surgeries for both cosmetic and non-cosmetic uses.

Also, timing of fusion of skull bones may be different in various racial groups and influenced by environmental factors including nutrition and climate. Hence, this results in the different type of skull shapes for adaptation to a particular climatic condition.

There is a need for assessing timing of sutural fusion in our population as we deduce an important parameter i.e age in reference to the same.

Sutural fusion may be influenced by multiple parameters in the same fashion as it contributes to determine the shape of skull as seen in craniosynostosis and other abnormal head shapes like plagiocephaly, brachycephaly, schaphocephaly, and dolichocephaly seen in paediatric age group.

However, this particular inference and inferences drawn from other anthropometric studies should be utilised as a supplementary finding with various other measures and not a primary indicator to draw conclusions.

Further, more anthropometric studies should be done at different regions and for different parameters of the cranium and other accessible parts. Available radiographic data and use of software's would ease the work and accelerate the results.

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Ethical Clearance: Ethical clearance was obtained from Institutional Ethics Committee. The ethical clearance number is bearing No. Dean/2022/EC/4049 dated 15.04.2023.

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