Indian Journal of Forensic Odontology
Volume 3 Number 2,April-June, 2010

Use of Cranio –Facial Measurements in Determining Cranial Sex

Harneet Kaur
Surinder Nath

ABSTRACT

An attempt has been made in the present study to determine sex on the basis of metric observations pertaining to the cranio-facial region. A total of 150 adult completely dry crania (75 males and 75 females) were measured for eighteen measurements following standard craniometric technique, from various educational and medical institutes,

Results of the present study reveal that there exists a highly significant sex difference in all the measurements (at 0,01% level)except for Palatal breadth and orbital height. The study suggests that metric observations are relatively more reliable than the non-metric ones.

Key Words: metric observations, Cranio-facial dimensions, sex differences

INTRODUCTION

The study of Human remains can provide vital information about our past. Man has evinced interest in his own biological past, both from an evolutionary and a historical point of view. The study of human skeletons from archeological sites can provide information on health, demography, diet, activity patterns, physique and genetic aspects of earlier population. In a broad sense, the study of human remains includes early migration of people, ancient warfare, social inequality, human health and lifestyles.

Forensic Anthropology is the application of the science of Physical Anthropology and Human Osteology in a legal setting, most often in criminal cases where the victim's remains are more or less skeletonized. Forensic Anthropology borrows methods developed from the academic discipline of Physical Anthropology and applies them to cases of forensic importance. Forensic Anthropologists frequently work in conjunction with forensic pathologists, odontologists, and homicide investigators to identify a decedent. They may also testify in court as expert witness.

Identification of the recently dead person falls under the domain of forensic medicine, while that of the decomposed/mutilated bodies and skeletal remains comes under the canopy of forensic anthropology.

A Forensic Anthropologist may be called in when human remains are found during archaeological excavation, or when badly decomposed, burned, or skeletonized remains are found by law enforcement or members of the public. The identification of skeletal, badly decompose, or otherwise unidentified human remains is important for both legal and humanitarian reasons. The primary responsibility of a Forensic Anthropologists is to provide law enforcement with a biological profile of the deceased and for this he attempts to answer the following questions.

Author's Affilation: Department of Anthropology, University of Delhi, Delhi-110007.

Reprint's request: Prof Surinder Nath, 10-C, Pocket-A, Phase-3, Ashok Vihar, Delhi-110052, India, Email: snath31@rediffmail.com

(Received on 15.09.2010, accepted on 14.10.2010)

1. Whether the bones are of human?
2. Whether bones belong to one or more individuals?
3. What would be the sex?
4. What is the probable age?
5. How tall the person would be?
6. Cause of death?
7. Other characteristic features.

Sex Determination is one of the important components of biological profile. One of the common ways to determine sex is using the size of the bones; males tend to have larger bones than females. Males also tend to have larger areas for muscle attachment. The Pelvis is one of the most common bones to use if it is available. The sub pubic angle is much wider in females than in males, typically more that 90 degrees and less than 90 degrees, respectively. The greater sciatic notch is also wider in females, usually more than 68 degrees for females and less for males. The acetabulum, where the head of the femur meets the pubic bone, is typically larger and deeper in males than females. The sacrum is straighter in females and more curved in males. The space in the middle of the pelvic bone (the pelvic inlet) is larger in women to facilitate birthing.

Table 1: Non- metric cranial traits used for sex determination

S.No.	CRANIAL TRAITS	MALE	FEMALE
2	**General size**	Large	Small
3	**Architecture**	Rugged and rough	Smooth and gracile
4	**Supra-orbital ridges**	Medium to large	Small to medium
5	**Mastoid processes**	Medium to massive in size	Small to medium in size
6	**Occipital area**	Muscle lines and protuberance well developed	Muscle lines and protuberance less developed
7	**Frontal eminences**	Less developed	Prominent and Projecting outwards
8	**Parietal eminences**	Less developed	Prominent and Projecting
9	**Orbits**	Squared, lower, relatively smaller in size with rounded margins	Less squared(rounded), higher, relatively larger in size with sharp margins
10	**Forehead**	Steeper, sloping and less rounder	More vertical, rounded
11	**Cheek bones**	Heavier, more laterally arched	Lighter and more compressed
12	**Mandible**	Larger with higher symphysis, broader ascending ramus	Smaller with lower symphysis, and less broader ascending ramus
13	**Palate**	Larger, broader tends more to u-shape	Smaller, tends more to parabolic shape
14	**Teeth**	Large in size, lower molars often 5 cusped	Smaller in size, lower molars often 4 cusped
15	**Foramen magnum**	Larger and broader in size	Small in size
16	**Occipital Condyles**	Larger	Relatively smaller

The cranium, or skull, is another useful bone for sex determination. Sex determination is only really possible with adolescent or adult skeletons because there is not much sexual dimorphism in preadolescent children. There is a little difference between the skulls of male and female until puberty. Sex is mainly influenced by the hormones whereby sexual differences manifest in many tissues, including bone. It is the tissue, which is responsible to dictate the basis of sex difference. It reflects in the development of male and female skeletons.

Sexing of the skull has been performed using non-metric observations in most forensic laboratories around the world, despite the fact that some forensic scientists have made use of cranial measurements for discriminating sex of skull. Visual assessment of character traits is commonly used in determination of sex from the skull for two reasons. First, the method is rapid. Second, male and female ranges of cranial morphometric characteristics are population-specific (VanVark and Schaafoma, 1992). However, because the visual assessment method is subjective, inter-observer variation can result in differences in indices of population sexual dimorphism and sex identification

Following are the Non-Metric observations used in the present study

Though non-metric measurements are used frequently (Walrath, 2004; M. Ðuriæ, 2005; Wood Jones, 1930-31; Walker, 2008, Rogers, 2005; Weinberg, 2005; Brasilli, 1999; Berry, 1975;) and the norms are available but there are few studies (Dayal, 2008; Ramsthaler, 2007; Brenda, 2006, Deshmukh and Devarshi, 2006; Williams and Rogers 2006; Kajanoja 2005; Iscan, 2005; Ublekar, 2002; Jeyasingh, 1988; Birkby, 1966; Giles & Elliot, 1963; Hanihara, 1959) where researchers have taken certain cranial measurements for this purpose. It is felt that on combining metric traits with the non-metric ones the authenticity in sex determination from skull would enhance.

OBJECTIVES

Following are the objectives of the present study:-

- To Observe the differences in different cranial measurements
- To identify measurements which could be used for Sex determination

METHODOLOGY

In the present study 150 (75 Male and 75 Female) completely dry adult human crania were measured for eighteen craniometric measurements. Utmost care was taken in perfect sampling and for taking the metric measurements as well as scoring the non-metric traits to initially determine the sex of all the crania. The skulls once measured were numbered to avoid repetition. All measurements were taken three times to ensure precision in the measured dimension.

For the present study the metric measurements and non-metric observations were taken from the internationally accepted literature. The 18 metric measurements were selected from A Laboratory Manual on Biological Anthropology, "Anthropometry" by Singh and Bhasin (1968). While for the inclusion of 16 non-metric cranial observations 38th edition of Gray's Anatomy.(1995) was consulted.

Following are the Non-Metric observations used in the present study:-

1. MAXIMUM CRANIAL LENGTH:- It measures the straight distance between glabella (g) and opisthocranion (op)

2. MAXIMUM CRANIAL BREADTH :- It is obtained as the transverse distance between two euryon (eu) points.

3. GREATEST OCCIPITAL BREADTH :- It measures the straight distance between two asterion.points.

4. BIMASTOID BREADTH :- It measures the straight distance between two mastoidiale points.

5. PALATAL LENGTH :-It measures the straight distance from the orale to the staphylion.

6. PALATAL BREADTH:-It measures the straight distance from one endomolare to another.

7. LENGTH OF FORAMEN MAGNUM:- It measures the straight distance from the basion to the opisthion.

8. BREADTH OF FORAMEN MAGNUM:- It is obtained as maximum breadth of the foramen magnum.

9. LENGTH OF OCCIPITAL CONDYLE:- It measures the maximum length of occipital condyle.

10. MINIMUM FRONTAL BREADTH: - It measures the straight distance between two frontal temporal points..

11. BIZYGOMATIC BREADTH:- It is the maximum distance between two zygion points.

12. **ORBITAL BREADTH:-** It is the distance between maxillofrontale and ectoconchion.

13. ORBITAL HEIGHT: - It is obtained at right angle to the orbital breadth.

14. INTER ORBITAL BREADTH: - It is the straight distance between maxillofrontale to maxillofrontale.

15. BIORBITAL BREADTH:- It is the straight distance between ectoconchion and ectoconchion.

16. NASAL HEIGHT:- It is obtained as the distance between nasion and nasospinale.

17. NASAL BREADTH: - It measures the maximum breadth of the pyriform aperture.

18. FACIAL HEIGHT :- It measures the staright distance between nasion and prosthion

RESULT

In the present study an attempt has been made to obtain some absolute cranial and facial measurements The data has been analyzed statistically to accomplish the objectives of the present study.

Table 2 Presents the basic statistical constants for male crania. It is observed that the male crania are nearly 5.0 cm longer than the breadth..The average length of occipital condyle is nearly 0.5 cm less than the breadth of the foramen magnum..The Bizygomatic breadth is less by 0.4 cm than the cranial breadth and biorbital breadth is slightly greater than the minimum frontal breadth. The nasal height is over 2.0 cm greater than the nasal breadth among the male crania. The difference between the minimum and maximum values work out to be greatest for Bimastoid breadth ,followed by maximum cranial length and maximum cranial breadth, while the least difference is observed for nasal breadth

Table 3 Presents the basic statistical constants for female crania. It is observed that the frmale crania are nearly 4.5 cm longer that the breadth and this difference is found to be greater among the male crania than the female ones. The Bimastoid breadth is less by 0.33 cm than the greatest occipital breadth among females while among males the difference comes out to be slightly greater (0.39 cm) length of occipital condyle is less than breadth of foramen magnum by 0.42 cm, which is less than the difference observed among the males.The nasal height is 2.22 cm greater than the nasal breadth,this difference is only slightly less than the one observed among males.the minimum – maximum difference works out to be maximum for Bimastoid breadth and the least is observed in case of nasal breadth

Table 4: Table 3 presents the mean values and standard error of mean for all the 18 cranial measurements for male and female crania. It is observed that males exhibit greater dimensions for all the measurements than the females except for Palatal breadth where the females out grow males. .Orbital height shows the least difference between male and female dimensions (0.04 cm), while the maximum difference is observed in case of maximum cranial length (0.68cm) These apparent variations reveal highly significant sex differences (at 0.01 % level) in case of all the measurements except for palatal breadth and orbital height, when subjected to t-test (test of significance)..this is suggestive of the fact that these measurements could help in determining the variation between male and female crania when ever recovered in forensic situation and the sex is required to be established .The metric measurements would supplement the visual (non-metric)observations in deciding the sex of the unknown crania/skull.

Table 2:_Mean Standard error of mean, standard deviation and range of different cranial measurements of male crania

S. No	Measurement	Mean (cm)	Sex	SD	Range	
					Max	Min
1	Maximum Cranial Length	17.75	.091	0.79	19.20	16.0
2	Maximum Cranial Breadth	12.77	.064	0.56	14.50	11.30
3	Greatest Occipital Breadth	10.35	.059	0.51	11.60	9.20
4	Bimastoid Breadth	9.96	.064	0.55	12.20	8.80
5	Palatal Length	4.87	.047	0.40	5.80	3.60
6	Palatal Breadth	3.68	.029	0.25	4.70	3.20
7	Length of Foramen Magnum	3.47	.033	0.28	4.0	2.80
8	Breadth of Foramen Magnum	2.94	.031	0.27	4.40	2.50
9	Length of Occipital Condyle	2.38	029	0.25	3.60	1.90
10	Minimum Frontal Breadth	9.27	.053	0.46	10.90	8.40
11	Bi-zygomatic Breadth	12.42	052	0.45	13.50	11.60
12	Orbital Breadth	4.09	.031	0.26	4.70	3.00
13	Orbital Height	3.26	.029	0.25	4.00	2.70
14	Inter Orbital Breadth	1.84	.023	0.20	2.60	1.40
15	Biorbital Breadth	9.56	.043	0.37	10.60	8.70
16	Nasal Height	4.75	.039	0.34	5.60	3.90
17	Nasal Width	2.47	.027	0.23	3.00	1.90
18	Facial Height	6.35	.051	0.44	7.70	5.60

Though non-metric observations are used frequently to determine sex of the skeletal material and the norms are available but there are very few studies where researchers have taken certain cranial measurements for this purpose. It is felt that on combining metric traits with the non-metric ones, the authenticity in sex determination from skull would enhance.

Table 3: Mean Standard error of mean, Standard deviation and Range of different cranial measurements of female crania

S.No	Measurement	Mean (cm)	Sex	S.D	Range	
					Max	Min
1	Maximum Cranial Length	16.89	.070	0.60	17.90	15.0
2	Maximum Cranial Breadth	12.20	.151	1.30	13.80	12.20
3	Greatest Occipital Breadth	9.87	.048	0.41	11.20	9.10
4	Bimastoid Breadth	9.54	.053	0.46	11.20	8.50
5	Palatal Length	4.51	.045	0.39	5.50	3.40
6	Palatal Breadth	3.74	.023	0.20	4.50	3.30
7	Length of Foramen Magnum	3.30	.036	0.31	4.40	2.40
8	Breadth of Foramen Magnum	2.66	.029	0.25	3.20	2.10
9	Length of Occipital Condyle	2.24	.029	0.25	2.80	1.60
10	Minimum Frontal Breadth	8.93	.051	0.44	10.00	7.70
11	Bi-zygomatic Breadth	11.63	.073	0.64	12.80	9.10
12	Orbital Breadth	3.68	.026	0.23	4.20	3.10
13	Orbital Height	3.22	.027	0.23	3.80	2.50
14	Inter Orbital Breadth	1.72	.025	0.22	2.60	1.20
15	Bi-Orbital Breadth	8.98	.108	0.94	11.60	10.00
16	Nasal Height	4.52	.036	0.31	5.30	4.00
17	Nasal Width	2.30	.020	0.18	2.70	1.90
18	Facial Height	5.93	.051	0.44	7.50	5.10

Table 4: Sex Differences in Different Cranial Measurements

S. No	MEASUREMENTS	MALE		FEMALE		t- Value
		Mean	SEx	Mean	SEx	
1	Maximum Cranial Length	17.75	.091	16.89	.070	7.966*
2	Maximum Cranial Breadth	12.77	.064	12.20	.151	3.662*
3	Greatest occipital Breadth	10.35	.059	9.87	.048	6.549*
4	Bimastoidal Breadth	9.96	.064	9.54	.053	5.086*
5	Paalatal Length	4.87	.047	4.51	.045	5.014*
6	Palatal Breadth	3.68	.029	3.74	.023	1.515
7	Length of Foramen Magnum	3.47	.033	3.30	.036	3.527*
8	Breadth of Foramen Magnum	2.94	.031	2.66	.029	6.872*
9	Length of Occipital Condyle	2.38	.029	2.24	.029	3.388*
10	Minimum Frontal Breadth	9.27	.053	8.93	.051	4.380*
11	Bizygomatic Breadth	12.42	.052	11.63	.073	8.212*
12	Orbital Breadth	4.09	.031	3.68	.026	9.519*
13	Orbtal Height	3.26	.029	3.22	.027	1.038
14	Inter Orbital Breadth	1.84	.023	1.72	.025	2.991*
15	Biorbital Breadth	9.56	.043	8.98	.108	5.228*
16	Nasal Height	4.75	.039	4.52	.036	4.707*
17	Nasal Breadth	2.47	.027	2.30	.020	5.284*
18	Facial Height	6.35	.051	5.93	.051	6.022*

**Significant at .01 level*

REFERENCES

1. Berry, A.C. Factors affecting the incidence of non-metrical skeletal variants. Journal of Anatomy. 1975; 120:519-535.
2. Birbky,W.H. An evaluation of race and sex identification from cranial measurements. Am.J.Phys.Anthrop. 1966; 24(1): 21-27.
3. Brasilli, P., Zaccagni, L., and Gualdi-Russo, E. Scoring of non-metric cranial traits: a methodological approach. J. Anat. 1999; 195: 551-562.
4. Dayal, M.R., Spoctera, M.A. and Bidmosa, M.A. An assessment of sex using the skull of black South Africans by discriminant function analysis. HOMO J.Comp.Hum.Biol. 2008; 59(3): 209-221.
5. Deshmukh, A.G. and Devershi, D.B. Comparison of cranial sex determination by univariate and multivariate analysis. J.Anat.Soc. India. 2006; 55 (2): 48-51.
6. Duric, M., Rakocevicb, Z. and Donica, D. The reliability of sex determination of skeletons from forensic context in the Balkans. Forensic.Sci.Int. 2005; 147(2): 159-164.
7. Giles, E. and Elliot, O. Sex determination by discriminant function analysis of crania. Am J. Phys Anthropol. 1963; 21: 53.
8. Hanihara, K. Sex Diagnosis of Japanese skulls and scapulae by means of Discriminant function. J.Anthro.Soc. Nippon. 1959; 67(4): 191-197.
9. Iscan, M.Y. Forensic Anthropology of body and sex size. For.sci.Int. 2005; 147(2-3): 107-112.
10. Jeyasingh, P., Aggarwal. A.K., Gupta, S.C., Arora, A.K. and Gupta, C.D. A study of cranio-facial indices in Uttar Pradesh Crania. Journal of Anatomy. 1988; 165: 345-349.
11. Kajanoja, P. Sex determination of finish crania by discriminant function analysis. Am. J.Phys. Anthrop. 1966; 24(1): 29-33.
12. Nath, S., Sehgal, V.N. and Bhasin, M.K. Studies in Forensic Science No. 1: Forensic -Anthropology, Science and Medicine. 2005.
13. Rogers, T.L. Determining the sex of human remains through cranial morphology. J.Forensic.Sci. 2005; 50(3): 493-500.
14. Singh, I.P.and Bhasin, M.K. Anthropometry. Kamla Raj Enterprises. 1985.
15. Ubelakar, D.H., Ross, A.H. and Graver, S.M. Application of forensic discriminant functions to a spanish cranial sample. Forensic.Sci.comm. 2002; 4(3).
16. VanVark, G. and Schaafoma, W. Advances in the quantitative analysis of skeletal morphology. In: Sanders S, Katzenberg M, editors. Skeletal biology of past peoples: research methods. New York: Wiley and Liss. 1992; 225–257
17. Walker, P.L., Johnson, J.R., and Lambert, P.M. Age and sex biases in the preservation of human skeletal remains. Am. J. Phy. Anthropol. 1988; 76: 183–188.
18. Walrath, D.E., Turner, P. and Bruzek, J. Reliability test of the visual assessment of cranial traits for sex determination. Am.J.Phys.Anthropol. 2004; 125: 132-137
19. Weinberg, S.M., Putz, D.A., Mooney, M.P. and Siegel, M.I. Evaluation of non-metric variation in the crania of black and white perinates. Forensic Sci International. 2005; 151(2–3): 177–85.
20. William, A.B. and [1]Department of Anthropology, University of Toronto, Toronto, ON, Canada. Rogers, T.L. Evaluating the Accuracy and Precision of Cranial Morphological Traits for Sex Determination. J. Forensic Sci. 2006; 51(4): 729-735.