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Original Article

Sexual Dimorphism in the Foramen Magnum of Nigerian Adult

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ABSTRACT

Forensic study is very important in the identification of sex especially when the body of the deceased has been destroyed as a result of physical injury due to weapons, fire or strong chemicals. This becomes more difficult if only parts the skeletal are found or if the bones are compromised by physical insults such as explosive or violence. The aim of this study, therefore, is to determine the presence of sexual dimorphism in the foramen magnum of Nigerian skulls, construct a discriminant function and evaluate their practical performance in the sectioning point based on sex. The skulls used in the study were obtained from selected Nigerian universities. The sample comprised 100 skulls of Nigerian origin. Of these skulls, 90 were males and 10 females. The result obtained demonstrated that significant sexual dimorphism is present in the cranial base of the Nigerian crania. Using sectioning point derived by the discriminant function, a value higher than the sectioning point was deemed to be male and a value below it deemed to be female.

1. Introduction

The foramen magnum is a three dimensional aperture within the basal central region of the occipital bone. It is one of several oval or circular apertures in the base of the skull, through which medulla oblongata is transmitted. Apart from the transmission of the medulla oblongata and its membranes, the foramen magnum transmits the spinal accessory nerve, vertebral arteries, the anterior and posterior spinal arteries, the membrane tectoria and alar ligaments.

The anterior border of the foramen magnum is formed by basilar process of the occipital bone, the lateral border by the left and right ex-occipitalis and posterior border is formed by the supraoccipital part of the occipital bone [1]. Two convex kidney-shaped condylar facets are found on ether side of the foramen for articulation with the first cervical vertebra at the synovial atlanto-occipital joint [2].

In humans, the foramen magnum is farther underneath the head than in great Apes. Thus in humans, the neck muscles do not need to be as robust in order to hold the head upright. Comparisons of the position of the foramen magnum in early hominid species are useful to determine how comfortable particular specie was when walking on two limbs (bipedality) rather than four. The location of the foramen magnum plays a crucial role in our understanding of human evolution. Usually, the location of the foramen magnum is linked to bipedal behaviour or the lack thereof.

Due to the thickeness of the cranial base and its relatively protected anatomical position, this area of the skull tends to withstand both physical insults and inhumation somewhat more successful than many other areas of the cranium [3]. The skull and particularly the skull base, has been analyzed with varying results and levels of success. Measurements including the length of the foramen magnum achieved on accuracy of almost 85% correct prediction utilizing a cape "coloured" population[4]. In 1963, Giles and Elliot [5] examined sex determination of the skull by discriminant function analysis using Fisher's method [6]. Their accuracy of Negroid and Caucasoid material range between 82% ad 89%.

Again using discriminant function analysis, Kajaanoja [7] achieved correct determination of male sex in 79.4%. Interestingly, he also evaluated Giles and Elliots [5] reports which stated that their functions were independent of racial variations and found that this was not the case.

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Hence [8] claimed up to 100% accuracy in predicting sex from foramen magnum region whilst Holland [9] scored between 71 and 90% in the main sample and 70-80% in the control group. Catallina- Hercera [10] indicated that saggital and transverse dimensions of the foramen magnum were significantly higher in men's skull.

There is paucity of literature on sexual dimorphism in Nigeria skulls using the discriminant function analysis. In order to fill this observed gap and to add to the body of literature, this study was undertaken to determine the presence of sexual dimorphism among Nigerian skulls using the discriminant function analysis.

2. Materials and Methods

Skull samples were obtained from the following universities in south-south Nigeria: University of Port Harcourt, University of Calabar and Niger Delta University, Wilberforce Island. The skulls used in this study met the selection criteria which composed complete record of the sex and conservation conditions that permits measurements. The sample comprised 100, (90 male and 10 female), skulls accepted as those of individuals from the south-south of Nigeria, The skull samples with multilated foramen magnum and poorly preserved samples were not included in the study.

Digital Vernier caliper was used to measure the maximum transverse and maximum anterior-posterior dimensions of the foramen magnum.

Using the vernier, the following variables were recorded.

- Maximum length of the foramen magnum (LFM) measured in an anteroposterior direction along the principal axis of the foramen.
- Maximum width of the foramen magnum (WFM) measured approximately perpendicular to the LFM and recorded at the widest transverse diameter of the foramen.
- Circumference of the foramen magnum calculated using the formula below.

The LFM and WFM can be inserted into one of the two difference formula published by Rontal et al (1984) which is based on the length (h) and width (w) of the foramen magnum

Area = ¼x w x h

The second method used a formula derived by Teixeira [11] which also uses the width and the height of the foramen magnum. To get the circumference of the foramen magnum used in this study, the first method by Rontal et al [12] was imputed into formula suggested by Gapert et al [13] to estimate the radius (r) and the circumference of the foramen magnum.

Area = r2 C = 2 x x r.

2.1. Statistical Methods

Statistical descriptions were calculated from the measurements, the mean, standard deviation (SD) and differences were analyzed using t-test (Table 1) and a value of $P < 0.05$ was considered significant. Subsequently to determine the ability to discriminate between the males and female skulls from the measurements, univariate and multivariate discriminant function analysis was used to analyze sex differences within the skulls.

The discriminant function is constructed by assigning a discriminant score to each case. Depending on the variables for a function, the score changes from case to case.

The sectioning point (SP) was created by using the mean male and female discriminant scores, which are also known as the group centroids. Therefore, each function has a different sectioning point, which is based on the varieties entered in the function. Standardized discriminant coefficients are used for building the formula.

The discriminant function was built as follows:

P = a1 x X1 + a2 + X2 +……+ an x Xa + b: Here "a1" through "an" are discriminating coefficients. "X1" through "Xn" are the discriminating variables and "b" is constant.

To assign the case to either male or female sex, the product P is compared to the sectioning point derived by discriminant function. A value higher than the sectioning point was deemed to be male while a value below it deemed to be female.

From table 1 & II since Tcal(1.5) < T_{tab} (1.98), we accept null hypothesis. This shows there is a significant difference in the length of foramen magnum (LFM) of both sexes.

For the fact T_{cal} (1.5) < T_{tab} (1.95) which is significant at 0.05 level. So 1.5 < 0.05, P < 0.05.

3. Results

The results of the descriptive statistics for 100 crania (tables I and II) show that the differences between all the male and female variables investigated displayed statistically significant differences (P<0.05).

Table 1: Shows mean length, SD, t-test and P-values of male and female foramen magnum

Sex	Mean Length	SD	T	P-value
Male	36.26	2.39	1.51	0.05
Female	34.39	8.85		

Table 2: Shoes mean breadth, SD, t-test and P-values of male and female foramen magnum

Sex	Mean Length	SD	T	P-value
Male n=90	30.09	2.58	3.06	0.05
Female n=10	28.16	1.99		

Statistics of the foramen magnum size of male and female skulls from the population of south-south Nigerians using students t-tes. Using the function from Table III of Gapert et al [13] that incorporates foramen magnum width (WFM) and circumference (FMC) the sectioning point (SP) of the 100 crania is 0.036, the male centroid, 0.594 and female centroid is -0.522.

Decision Rule

Table III: t-test table showing the level of significance

Level of significance	0.10	0.05	0.01	0.005	0.002
Critical values of z fo r one tailed test	-1.28 or 1.28	-1.64 or 1.645	-2.33 or 2.33	-2.58 or 2.58	-2.88 or 2.88
Critical values of z fo r one tailed test	-1.645 or 1.645	-1.98 or 1.98	-2.58 or 2.58	-2.81 or 2.81	-3.08 or 3.08

If the calculated student-test value (T_{cal}) is greater than that of the table value (T_{tab}), we reject null hypothesis. Otherwise, we accept null hypothesis.

From tables II or II above, since T_{cal} (1.5) < (1.98), we accept the null hypothesis. This shows that there is significant difference in the length of the foramen magnum (LFM) of both sexes.

The t-test for the width of the foramen magnum (WFM) of the male and female crania shows that there is no significant difference between them since T_{cal} (3.06) > T_{tab} (1.98).

4. Discussion

There has been no previous documented evaluation of sexual dimorphism of the foramen magnum region within the area under study. Sex determination in the human cranium is generally based on size differences and robustiaty [14]. These differences are unique to each population and thought to be influenced by genetic, environments and socio-economic factors [15]. Sexual dimorphism is population specific and discrimiannt functions applied to cases other than the source population used to develop these functions have known incorrect classification percentages between 32% and 48% [7]. It is therefore necessary to study its expression as many geographically and temporarily diverse populations as possible utilizing measurements for sex identification rather than morphognostic observation permits the representation of results in an objective manner.

Past researchers used measurements of the whole cranium [5, 16], the mandible [17] as well as dentition [14] to determine sex by discrminant function analysis and regression equations. Past studies demonstrated that statistically significant differences exist between male and female skulls. These differences can be used to predict sex in an unknown skull.

However, the need for methods to identify sex from cranial fragments becomes apparent when considering the fragile nature of the splanchno-cranium (viscerocranium). The cranial base has been noted for its ability to remain intact in cases where the rest of the cranium has been compromised and researchers have made use of that fact by analyzing sexually significant dimorphic trait for this anatomic region [9, 3].

The results in this study demonstrated statistically significant differences between males and female skulls within the studied population. However, using the sectioning point (0.036) derived by the discriminant function, a value higher than the sectioning point is considered to be male (0.594) and value below it is considered to be female (-0.522).

The degree of sexual dimorphism within the foramen magnum may be explained by its development compared to many other skeletal elements. The foramen magnum reaches its adult size rather early in childhood [1] and is therefore unlikely to respond to significant secondary sexual changes. From a mechanical point of view, no muscles act upon the shape and size of the foramen magnum and its prime function is to accommodate the passage of structures into and out of the cranial base region and in particular, medulla oblongata which occupies the greatest portion of the foramen space. The nervous system is the most subconscious of all body systems. It reaches maturity at a very young age and therefore has no requirement to increase in size.

Population differences are also important in defining sexual differences in the cranium. Therefore sexual differences in the foramen magnum have been studied in various populations.

4. DiscussionTable IV showing comparism with other previous studies

Variables	Routeal et al (1984)-INDIA	Murshed et al (2003)- TURKEY	Catalina (1987) - SPAIN	Gapert et al, (2008) - BRITAIN	Suazo et al (2009)- BRAZIL (UNIFESP)	Present Study (2011) - Nigeria
FML MALES (mean±SD)	35.5±2.8	37.2±3.2	36.2±2.60	35.91±2.41	36.5±2.6	36.26±2.3
FML FEMALE (mean±SD)	32.0±2.8	34.6±3.16	34.30±2.04	34.71±1.91	35.6±2.50	34.39±3.88
FMW MALES (mean±SD	29.6±1.9	31.6±2.99	31.1±2.60	30.51±2.60	30.6±2.5	30.09±2.5
FMW FEMALES (mean±SD)	27.1±1.6	29.3±2.99	29.6±1.53	29.6±1.53	29.5±1.9	28.16±1.9
FMA (MALES)	819.0	931.7	888.4	783.82	-	857.30
FMA (FEMALES)	771.0	795.0	801.0	730.28	-	760.94

Table IV below shows the mean length of the foramen magnum of females in the British [13], Turkish [18] as well as Spanish [10] population. The lengths of the mean foramen magnum of the males in Sao Paulo 36.5mm [19] as well as the Spanish, 36.2mm [10] are comparable to values obtained in the present study, 36.3mm

Therefore, it is necessary to know the source population of any unidentified skull and adopt a method based data from that population or a population with similar expression of sexual dimorphism. The area of foramen magnum of Nigerians (cranial sample) is a useful indicator of sex, and comparison to values from other populations demonstrates similar results among some of the populations. It can be argued that due to the limit of expression of methods, involving this anatomical landmark should not be recommended in a situation of complete cranium.

5. References

[1] Scheuer L, Black S. The Juvenile Skeleton. Elsevier, London.

[2] Rene G, Sue B, Jason L. Sex determination from the foramen magnum: discriminant function analysis in an eighteen and nineteenth century, British Sample ,Int J Legal med. 2008; 123:25-33.

[3] Graw M. Morphometrische and Morphognostische. Geschlecthsdiagnostik an der menschlichen Schadelbasis. In: Oehmicen M, Geserick G (eds) Osteologische Identifikation and Altersschatzung Schmidt-Romhild, Lubeck, 2001 Pp. 103- 121.

[4] Keen J A. A Study of the differences between male and female skulls. Am J Phys. Anthropol. 1950; 8:65-78.

[5] Giles E, Elliot O. Sex Determination by discriminant functional analysis of crania. Am J. Phys Anthropol .1963; 21:53-68.

[6] Fisher RA. The Use of multiple measurements in Taxonomic problems. Ann. Eugen. 1936; 7:179-188.

[7] Kajanoja P. Sex determination of Finnish Crania by discriminant function analysis. Am. J. Phys. Anthropol .1989;24:29-30.

[8] Hence W. The method of discriminant function analysis for sexual determination of the skull. J. Hum Evol .1977;6:95-100.

[9] Holland TD. Sex determination of fragmentary crania by analysis of crania base. Am J Phys. Anthropol. 1986; 70:203-208.

[10] Catalina-Hercera CJ. Study of the Anatomical matrix values of the foramen magnum and its relationship with sex. Acta Anat (Basel) 1987;130(4):344-347.

[11] Routal RR, Pal GP, Bhagwat SS, Tamankar BP. Metrical Studies with sexual dimorphism in foramen magnum of human crania. J Anat Soc India .1984; 2(33):85-89.

[12] Tedeschi, Eckert, Tedeschi. Forensic Medicine Vol 11. Physical trauma. Pp 1106-1108.

[13] Tappert R, Black S, Last J. Sex determination from foramen magnum: discriminant function analysis in an eighteenth and nineteenth century in British sample. Int J. Legal Med .2009;123(1):25-33.

[14] Rosing FW, Graw M, Marre B, Ritz-Timme S, Rothschild MA, Rotzcsher K, Schmeling A, Schroder I, Geserick G. Recommendations for forensic diagnosis of sex and age from skeletons. Homo. 2007; 58:75-89.

[15] Hamilton ME. Sexual dimorphism in skeletal samples. In: Hall RL (ed) Sexual dimorphism in homo sapiens- a question of size. Praeger Publishers, New York. 1982; Pp 107-163.

[16] Franklin D, Freedman L, Milne N. Sexual dimorphism and discriminant function sexing in indigenous south African Crania. Homo. 2005; 55:213-228.

[17] Giles E, Elliot O. Sex determination by discriminant function analysis of crania. Am. J. Phys Anthropol. 1963;21:53-68.

[18] Murshed KA, Cicekcibasi AE, Tuncer I. Morphometric Evaluation of the foramen magnum and variations in its shapes: A study on computerized tomograhic images of normal adults. Turk J Med Sci. 2003; 301-306.

[19] Suazo GIC, Russo PP, Zavando MDA, Smith RL. Sexual dimorphism in foramen magnum dimensios. Int J. Morphol. 2009;27(1):21-23.