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Morphometry of the Greater Sciatic Notch in Sex Determination in a Nigerian Population

[1]Amadi PN, [2]Oladipo GS and [3]Inibi M

[1]Department of Anatomy, Faculty of Basic Medical Sciences, Madonna University Elele Rivers State– Nigeria.
[2]Department of Anatomy, College of Health Sciences, University of Portharcourt, Port Harcourt – Nigeria.

Corresponding Author: Amadi PN

E-mail: paulicity101@gmail.com, +2348037395302

ABSTRACT
The greater sciatic notch as a landmark in sexual dimorphism was tested using various parameters of the sciatic notch. Examination of the male and female greater sciatic notches of the hip bone (oscoxae) was done using 200 radiographs of adult hip bones (one hundred and fifteen females and eighty – five males) from Nigeria. The maximal width (AB), maximal depth (OC), posterior width (AO) and total angle (<ACB) were measured and indices I and II calculated. All of the parameters identified a high percentage of the hip bones in both males and females (> 95%) with the lowest percentage identified being that of the posterior width in males (95.3%) while index II identified the highest percentage – (100%) in both males and females as did the total angle in males (100%). Maximal width, maximal depth, total angle and index I showed significant gender differences (p<0.05) while the gender differences observed in posterior width and index II were not significant (p>0.05), showing that the posterior segment of the width is not very useful in sex determination while the total angle was observed as the best parameter.

Key Words: Greater sciatic notch, sexual dimorphism, Nigeria.

INTRODUCTION
The greater sciatic notch is the larger of the two notches found on the ischium separated from each other by the spine. The notch is converted into a foramen by the sacrospinous ligament, to become the greater sciatic foramen, creating a large passageway from the pelvis to the gluteal region. This foramen provides passage for the piriformis muscle, the superior and inferior gluteal vessels and nerves, the sciatic and posterior femoral cutaneous nerves, the internal pudendal vessels and pudendal nerve, and the nerves to the obturatorinternus and quadratusfemoris muscles on their course from the pelvis to the inferior limb (Rahilly[1]).

The greater sciatic notch is one of the sexually dimorphic traits of the hip bone and commonly used to determine sex in unknown individuals (Ari[2]). Bruzek [3] stated that the precision of sex determination using the morphology of the greater sciatic notch to describe the shape of the greater sciatic notch corresponds directly to an estimation of the discriminatory power of this trait. Jovanovic et al. [4] tested the reliability of the greater sciatic notch in sex determination on deformed ossacoxae and concluded that pathological changes and abnormalities do not affect the greater sciatic notch in either sex and reported that this feature is still a reliable indicator in these conditions. Ari [2] carried out a study on adult male coxae of byzantine(13th century) skeletons from Nicea(Turkey) using a stainless steel caliper and found that no noticeable differences were found between the left and right coxae.

The greater sciatic notch attracted the attention of anthropologists as early as 1875, when Verneau noticed that it was narrower in males and shallower in females. According to Straus[5], the greater sciatic notch in man is better developed, and shows sex differences not observed in other primates. Palfrey [6] studied West African skeletons of known sex and found highly significant differences between the sexes regarding the width and the posterior segment width of the greater sciatic notch, except for the depth of the greater sciatic notch.

Kayalioglu et al. [7] analyzed the adult coxae of unknown sex from the skeletal collection of their department and found the maximal width was not a good parameter while posterior segment width and index II were found to be good parameters for sex determination.

Akpan et al. [8] used X-ray films of adult Nigerians to measure the width, depth, and posterior width of the greater sciatic notch. They reported that the width, depth and index I were insignificant criteria, but that index II was the most useful criteria for sex determination.

Patriquin et al. [9] reported that the width of the greater sciatic notch is wider in females but deeper in males and that there are significant differences between both South African males and females and whites and blacks. Steyn et al. [10] used geometric morphometric analysis of the greater sciatic notch and reported that this feature may not be so reliable, especially in South African White males. Nevertheless, they found that South African black males have a typical narrow shape and that both black and white females have typical wide notches.

Caldwell and Molly [11] emphasized the importance of the greater sciatic notch in parturition. Jovanovic et al. [4] pointed out that the upper part of the greater sciatic notch was a reliable marker in sex determination since it was not affected even in pathological conditions of the hip boes.

Even though several earlier studies support the theory that the greater sciatic notch is wider in females and narrower in males, Davivongs [12] observed that female sciatic notches were deeper as well as wider in Australian aborigines. This deviation can be regarded as a racial characteristic. Furthermore, Walker [13] adds that the notch tends to be narrow and U- shaped in males but comparatively opens with a longer width to depth ratio.

Singh and Potturi [14] carried out a study on adult male and female hip bones of known sex from India using a triflanged stainless steel caliper and found that the total angle was significantly higher in females than in the male subjects and that the posterior angle of the greater sciatic notch was the best discriminating measurement for identification of male from female hip bones and that the greater sciatic notch is wider in females than in males, irrespective of the side.

Walker [13] observed that for both sexes, there is a strong relationship between age at death and sciatic notch score. He noted that people who die at a younger age tend to have wider, more feminine appearing sciatic notches than people of greater longevity. There are also significant population differences, he argues, as his work on the 18th-19th century English sample has a more feminine morphology than Americans of European or African ancestry. Environmental influences on skeletal development (vitamin D deficiency) appear to provide the most likely explanation for these population differences.

Ascadi and Nemeskeri [15] developed a scoring system for the greater sciatic notch for making skeletal sex determination. This scale was adopted in a slightly modified form by the Workshop of European Anthropologists (1980) as part of an attempt to standardize osteologial techniques. In this system, scores are assigned to sciatic notches from -2 to +2.The details are as follows: -2 = hyper feminine,-1 = feminine, 0 = androgenous,+1 = masculine and+2 = hyper masculine.

However, Walker [13] noted that this system had great limitations as it was developed specifically for sexing people of European ancestry. As a result, their anonymous score of zero (0) may not be optimal for discriminating between males and females from other populations. The greater sciatic notch has an advantage in the study of its morphometry in juveniles in that it is recognizable early in fetal development. Vlak et al. carried out a study on juveniles of known sex and age (0-12yrs for female subjects and 0-15yrs for males) on ilia samples from a collection in Portugal born between 1805 and 1872 using Schutkowski's method. They found that the application of Schutkowski's method to the juveniles did not reveal a statistically significant level of sexual dimorphism. Furthermore Vlak et al.[15] argued that Schutkowski's [16] morphological method does not predict sex accurately in all populations and recorded correlation of iliac features with age needs to further explore in the context of the ontogeny of sexual dimorphism. However, they found a strong correlation between pelvic morphology and age at death.

Reports on Nigerian population on the subject under discussion are scanty, thus the need for the present study.

MATERIALS AND METHODS

The sample size in this study consisted of a total of two hundred radiographs of adult hip bones (One hundred and fifteen Females and eighty five Males). The radiographs were obtained at random from the radiology department of the University of Port Harcourt Teaching Hospital (UPTH), Port Harcourt, Nigeria.

The radiographs were distinguished as either male or female based on the basis of the names of the subjects recorded on the radiographs and reinforced by the gender detail provided in the patient information card contained in the radiographs, especially for controversial names.

All radiographs were viewed with the aid of an X- Ray view box on which each radiograph was placed before any measurements whatsoever, were carried out.

Only radiographs that showed the greater sciatic notch of the hip bone as intact were studied as some were excluded from the study due to observed damage (i.e. wear and tear, fracture, or other pathology) either to the greater sciatic notch or even to the areas around it. All radiographs were scored twice with utmost caution and with two to three days between scoring sessions so as to access intra observer error.

The width, depth, and angle of the greater sciatic notch were scored using Schutkoski's descriptions and scoring procedures (Fig. 1).

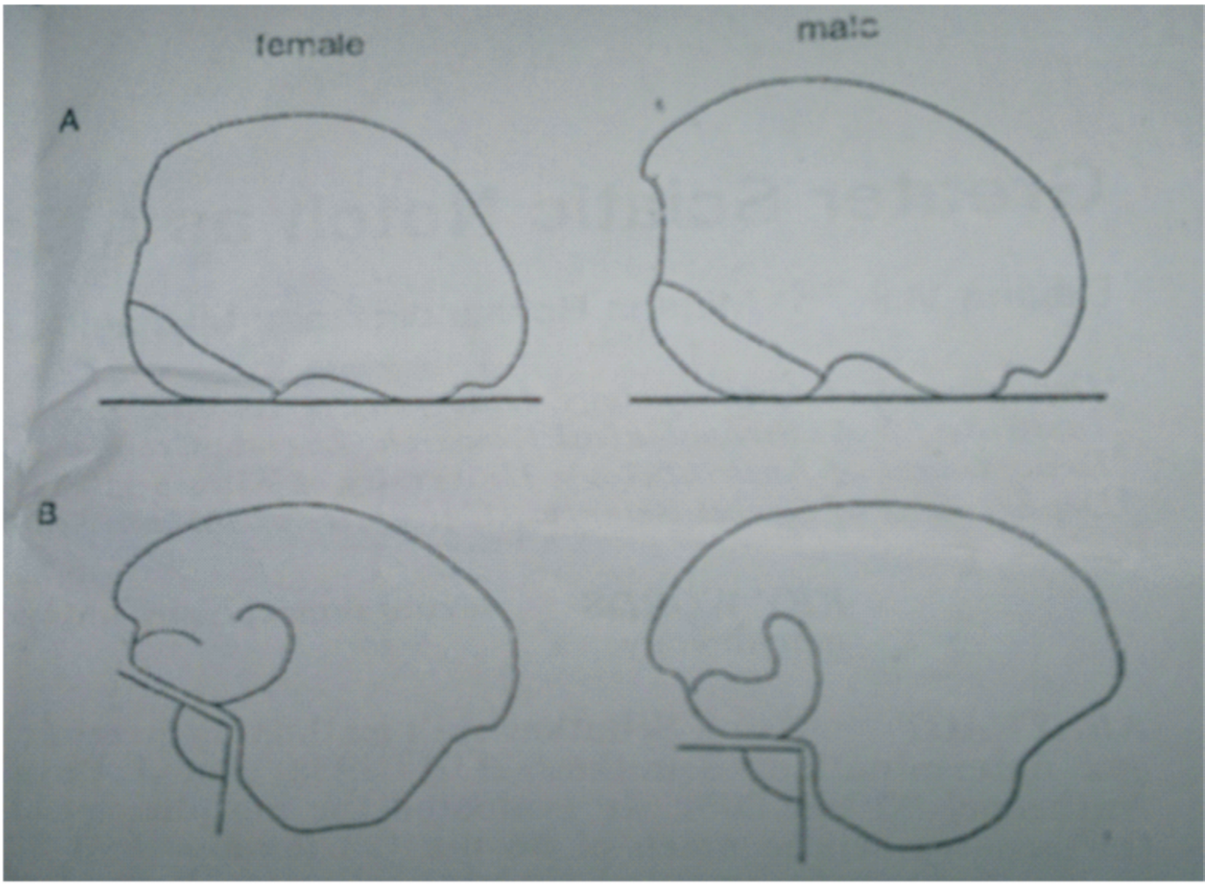

Figure1: Diagram of the greater sciatic notch and width, depth and angle

The Piriform tubercule was taken as the posterior point (A) and the tip of the Ischial spine was taken as the anterior point (B), of the width (AB). Maximum depth (OC) was determined between the baseline (AB) and the deepest point (C), of the greater sciatic notch. Also, (AO) was designated as the posterior segment (Fig. 2).

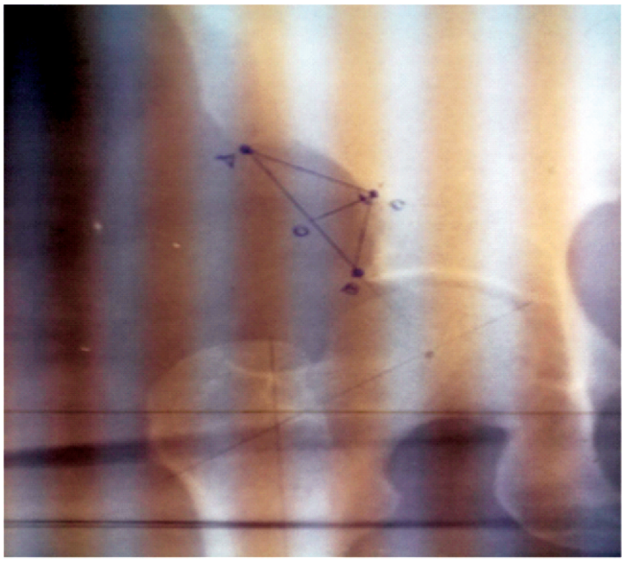

Figure 2: A radiograph used, showing the parameters studied. (A): piriform tubercule, (B): tip of ischial spine, (C): deepest point of the notch, line (AB): Maximal width, (OC): Maximal depth, (AO): Posterior segment, <ACB: Total angle

The following parameters of the greater sciatic notch were considered:1.Maximal width (AB): The distance between the piriform tubercule and the tip of the ischial spine2.Maximal depth (OC): Perpendicular to the width 3.Posterior segment of the width (AO) 4.Total angle: After construction (on paper) of the triangle ACB, and the depth OC from the above measurements, <ACB denoted the total angle 5.Index I: Maximal depth (OC) X100/ Maximal width (AB)6.Index II: posterior segment (AO) X100/Maximal width (AB).

All linear measurements were made in millimeters for every parameter and angles in degrees.
The materials used to carry out this study included: 200 radiographs (85 male and 115 females), X- ray view box (for viewing radiographs) digital steel Calliper (for linear measurements), meter rule (for constructing triangle and for linear measurements), HB pencil (for marking points on radiographs and for constructing triangle), protractor (for measuring angles) and previously columned ledger (for recording measurements)

RESULTS

The results obtained from the study of the 200 radiographs of hip bones of adult Nigerians were analyzed statistically and the female hip bones gave 39.6mm as the mean value for the maximal width length with 70mm as the maximum value and 8mm as the minimum value (Table 1). The maximal depth had 10.34mm, 20mm, and 5mm as mean, maximum value and minimum values respectively (Table 1). The posterior width's values were 17.45mm as mean, 35mm as the maximum value and 3mm as the minimum value (Table 1). Also, 121.67°, 155°, and 74° were the respective mean, maximum value and minimum values of the total angle (Table 1). Indices I and II were also calculated with their mean values as 26.98 and 44.39 respectively (Table 1). Their respective maximum and minimum values were67 and 5 for index I and 81 and 10 for index II (Table 1).

For males, the mean of the maximal width length was 34.55mm with 56mm as the maximum value and 18mm as the minimum value (Table 2). The maximal depth had 17.65mm, 32mm, and 6mm as mean, maximum value and minimum values respectively (Table 2). The posterior width's values were 17.62mm as mean, 42mm as the maximum value and 5mm as the minimum value (Table 2). Also, 86.54°, 118°, and 53° were the respective mean, maximum value and minimum values of the total angle (Table 2). Indices I and II were also calculated with their mean values as 50.45 and 50.34 respectively (Table 2). Their respective maximum and minimum values were100 and 16 for index I and 85 and 18 for index II (Table 2).

Table 1: Parameters of the female greater sciatic notches showing their mean, maximum and minimum values, variance, standard deviation and standard error.

	Maximal width (mm)	Maximal depth (mm)	Posterior width (mm)	Total angle (°)	Index I	Index II
Mean	39.6	I0.34	17.45	121.67	26.98	44.39
Max. value	70	20	35	155	67	81
Min. value	8	5	3	74	5	10
Variance	78.74	12.42	49.21	269.31	92.46	228.35
Standard deviation(S.D)	8.87	3.52	7.02	16.41	9.62	15.41
Standard error (S.E)	0.83	0.33	0.65	1.53	0.90	1.41

Table 2: Parameters of the male greater sciatic notches showing their mean, maximum and minimum values, variance, standard deviation and standard error.

	Maximal width (mm)	Maximal depth (mm)	Posterior width (mm)	Total angle (°)	Index I	Index II
Mean	34.55	17.65	17.62	86.54	50.45	50.34
Max. value	56	32	42	118	100	85
Min. value	18	6	5	53	16	18
Variance	52.75	19.16	50.36	192.08	259.25	200.58
Standard deviation(S.D)	7.26	4.38	7.10	13.86	16.10	14.16
Standard error (S.E)	0.79	0.48	0.77	1.50	1.75	1.54

In dealing with normal distributions which is the case in most biological variables (as well as this study), maximum and minimum limits can be calculated on the basis of standard deviation[16] thus;

Mean ± 1 S. D will give the range that covers 68.3% of the area or zone.
Mean ± 2 S. D will give the range that covers 95.4% of the area or zone.
Mean ± 1 S. D will give the range that covers 99.75% of the area or zone.

In Medicolegal cases where 100% accuracy is demanded, the range for the maximum and minimum limits has to be calculated by adding and subtracting 3 S.D to and from the measurement. Such fudicial points based on calculated ranges have been named 'demarking points' by Jit and Singh[18].

The highest level of accuracy attainable (3 S. D – actually given as 2.57xS.D) was used in this study to identify the demarking points (dp) of each parameter and are recorded in table 3.

Maximal width and maximal depth both identified 98.3% of the hip bones in females and 98.8% of the bones in males (Table 3). Posterior width identified 98.3% of the hip bones in females and 95.3% of the hip bones in males (Table 3). Total angle identified 98.3% of the bones in females and 100% of the bones in males (Table 3). Index I identified 98.3% of the hip bones in females and 97.6% of the bones in males (Table 3). Index II identified the highest bones as both male and female identified 100% (Table 3) showing that with index II, all of the bones are identified either as males or females without any bones overlapping.

Table 3: Demarking points of the parameters of the greater sciatic notch with the percentages identified.

Parameters	Sex	Actual Range	Mean	3 S.D	Demarking points (dp)(to nearest whole no)	Percentage (%) identified
Maximal width	Female	8mm-70mm	39.6	±22.80	17mm-62mm	98.3%
	Male	18mm -56mm	34.55	±18.66	16mm-53mm	98.8%
Maximal depth	Female	5mm-20mm	10.34	±9.05	1mm-19mm	98.3%
	Male	6mm-32mm	17.65	±11.26	6mm-29mm	98.8%
Posterior width	Female	3mm-35mm	17.45	±18.04	0mm-34mm	98.3%
	Male	5mm-42mm	17.62	±18.24	0mm-36mm	95.3%
Total angle	Female	74^o-155^o	121.67	±42.17	80^o-164^o	98.3%
	Male	53^o - 118^0	86.54	±35.62	51^o-122^o	100%
Index I	Female	5-67	26.98	±24.72	3 – 52	98.3%
	Male	16-100	50.45	±41.38	9 – 92	97.6%
Index II	Female	10 – 81	44.39	±38.83	6 – 83	100%
	Male	18 – 85	50.34	±37.55	13 – 88	100%

Furthermore, the Z – test was used to compare between male and female greater sciatic notches for each of the parameters.
Results for the female sciatic notch was taken as population 1 while
Results for the male sciatic notch was taken as population 2.
Significant differences or gender differences were observed in maximal width, maximal depth, total angle and index I ($p<0.05$) while the gender differences observed in posterior width and index II were not significant ($p>0.05$) (Table 4)

Table 4: Z – test for the parameters of the greater sciatic notch between female and male populations

Parameter	Calculated Z – score	Critical Z – score	Inference
Maximal width	5.85	1.96	Significant
Maximal depth	9.22	1.96	Significant
Posterior width	0.17	1.96	Insignificant
Total angle	16.38	1.96	Significant
Index I	6.09	1.96	Significant
Index II	1.37	1.96	Insignificant

DISCUSSION

Maximal width of the greater sciatic notch was found to be significantly higher in females than in males, though the difference between the mean the values of both sexes is not so large.

The fact that the greater sciatic notch is significantly deeper in males than it is in females as observed in this study supports earlier findings[19, 20, 21] but negates Davivongs[12] findings in Australian aborigine samples which is generally regarded as a deviation that is due to racial characteristic.

Posterior width and Index II shows insignificant differences between males and females and the mean values of the posterior width also reveal that the posterior segment of the width is not a very useful parameter in sex determination amongst Nigerians as the findings of Singh and Potturi[14]. However, index I which depends on the depth and width of the notch serves as a better parameter.

The results obtained in this study negates the findings of Akpan et al.[8] on Nigerians. This can be as a result of the differences in sample size and the fact that the parameters used in the two studies are not totally the same.

In all, the total angle of the greater sciatic notch was found to be of the most importance in sex determination judging both by the high percentages of the bones identified in both females and males (98.3% and 100% respectively), the great disparity between the calculated Z – score and critical Z – score, and the disparity between the means of females and males.

CONCLUSION

The results obtained suggest that metric assessments of the features of the greater sciatic notch should be used cautiously in sex determination. However, morphometric analysis of the notch provides valuable information about the population studied as well other different populations, thereby, providing useful parameters for comparison between these populations.

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