# Sex cannot be determined through orbital margin anthropometry: A radiologic study of the aditus orbitae of adult Igbos of Nigeria


## Abstract

**Introduction:** The study of the skull is one of the most useful ways of sex determination. **Aim:** This study was designed to investigate the reliability of the anthropometry of the adult orbital rim in determination of sex. **Materials and Methods:** A total number of 286 radiographic films of subjects (183 males and 103 females) aged between 18 years and 79 years were analyzed. The orbital height and orbital width were measured from which orbital index was calculated. Differences in the percentage frequencies between males and females were compared using Chi-square test. **Result:** The results showed that there was no statistically significant difference ($P > 0.05$) in the percentage frequency of any range of all the parameters studied between males and females. **Conclusion:** In conclusion, this study had shown that sex cannot be determined through orbital margin anthropometry.



**Key words:** Igbos, orbital margin, radiologic study, sex determination



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## INTRODUCTION

Sex of an individual is one of the initial factors to determine when identifying a set of human remains in forensic science.[1] The study of the skull has been noted as one of the most useful ways in the establishment of sex.[1] The orbital cavity within the skull is defined as being shaped like a pyramid, with the apex posteriorly directed as the optic canal and the base anteriorly directed as the orbital margin.[2] As with many skeletal parts of the body, the males were established to have greater orbital height and orbital width as well as orbit index when compared with their female counterparts.[3-5] As a result of this, many authors had claimed that sex could be determined through the anthropometry of the orbital margin.[3]

However, a closer observation of these studies showed that these authors made a very sensitive inference using the Students' *t*-test as their statistical tool.[3] This statistical tool, though useful when analyzing the differences between two contemporary groups in a sample size, becomes useless when an anthropologist is confronted with a single specimen.

Thus, concluding that an individual skull belongs to a particular sex based on orbital margin anthropometry remains a debate. This is because there could be an overlap in these measurements between males and females. However, the good news is that despite this overlap, it is possible that a particular range of measurements could predominate in a particular sex. Based on these premises, this study was designed to investigate the reliability of anthropometry of the adult orbital rim in the determination of sex from a radiologic point of view among the Igbo ethnic group of Nigeria.

## MATERIALS AND METHODS

This was a retrospective study carried out at the National Orthopaedic Hospital, Enugu, Enugu State Nigeria using plain X-rays of the Water's (frontal) view of the


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skull [Figure 1]. A total of 286 radiographic films of subjects (183 males and 103 females) aged between 18 years and 79 years were analyzed.

Measurements were taken only on skull radiographs that were evidently healthy or, if pathology was present, from those that did not affect the dimensions of the orbital margin. Information on the ethnicity, age, and gender were gathered from the hospital cards. All cases of raised intracranial or intraorbital pressures as reported by the radiologists were excluded from the study. More so, the films that were selected for the study were strictly those of the Igbos while the non-Igbos were excluded from the study. The Igbo ethnicity was determined when both parents and both maternal and paternal grandparents were Igbos. In addition to the radiographs employed in this research, other materials that were helpful in the measurements include an X-ray illuminator, a meter rule calibrated in millimeters, and a pair of dividers.

The orbital height was measured from the frontal film as the maximal distance between the superior and inferior orbital margins. The orbital width was also measured from the same frontal film as the maximal distance between the medial and lateral orbital margins [Figure 1]. The orbital indices were calculated from the data gathered using the following formula:

Orbital index = [height of orbit/width of orbit] × 100

For accuracy purposes and to reduce errors in measurements, all the measurements were taken twice by the same person using the same tools. While no statistically significant difference was found in both measurements, coefficient of variations between the sets of measurements was 1.1%, which indicated negligible error in the measurements. Thus, the average was taken for each measurement.

**Figure 1:** Plain film showing the orbital margin and measurement of orbital width and height[8]

The data were analyzed using Statistical Package for Social Sciences (SPSS, Chicago, Il, USA), version 16.0. The data gathered on orbital height, orbital width, and orbital index were split into eight ranges [As shown in Tables 1-3]. Comparisons were made between the means of the orbital parameters between males and females using the Students' *t*-test. Furthermore, because of the uneven distribution of male and females subjects in the study, the results were presented in percentage frequencies (nearest whole numbers) while the frequencies were shown alongside in parentheses. The differences in percentage frequencies between males and females were compared using Chi-square test on both sides and were considered to be statistically significant when the probability is less than 0.05 ($P < 0.05$).

## RESULTS

The results showed that orbital height, orbital width, and orbital index are significantly higher in males as a group when compared to females as a group on both sides [Tables 1 and 2]. However, the subjects were grouped according to their age; orbital height was significantly higher in males than in females only in the age group of 18-27 years and in those who are older than 67 years but not in other age groups [Tables 1 and 2]. Furthermore, orbital width was significantly higher in males than in females only in the age group of 18-27 years but not in other age groups [Tables 1 and 2]. More so, orbital index was significantly higher in males than in females only in the age group of 58-67 years and in those who are older than 67 years but not in other age groups [Tables 1 and 2].

On the right side [Table 3], 10% (18/183) of the males had orbital height between 16 mm and 20 mm compared to 13% (13/103) of the females; 25% (45/183) of the males had orbital height between 21 mm and 25 mm compared to 31% (32/103) of the females; 23% (42/183) of the males had orbital height between 26 mm and 30 mm compared to 21% (22/103) of the females; 19% (35/183) of the males had orbital height between 31 mm and 35 mm compared to 20% (21/103) of the females; 11% (22/183) of the males had orbital height between 36 mm and 40 mm compared to 12% (12/103) of the females; 8% (15/183) of the males had orbital height between 41 mm and 45 mm compared to 2% (2/103) of the females; 3% (5/183) of the males had orbital height between 46 mm and 50 mm compared to 1% (1/103) of the females; 1% (1/183) of the males and no female had orbital height between 51 mm and 55 mm. On the left side [Table 3], 11% (20/183) of the males had orbital height between 16 mm and 20 mm compared to 13% (13/103) of the females; 26% (47/183) of the males had orbital height between 21 mm and 25 mm compared to 30% (31/103) of the females; 22% (41/183) of the males had orbital height between 26 mm and 30 mm compared to 23% (24/103) of the females; 16% (30/183) of the males had orbital height

**Table 1: Comparisons of means of orbital parameters between males and females among different age groups on the right side**

| Age range (years) | Height | | | Width | | | Index | | |
|---|---|---|---|---|---|---|---|---|---|
| | Males | Female | *P* | Males | Female | *P* | Males | Female | *P* |
| 18-27 | 30.0±0.8 | 26.7±1.2 | 0.03* | 41.4±0.5 | 37.0±0.7 | 0.00* | 72.2±1.6 | 72.0±2.6 | 0.95 |
| 28-37 | 31.4±1.2 | 29.1±1.1 | 0.19 | 40.8±0.7 | 40.5±0.6 | 0.80 | 76.0±2.0 | 71.8±2.5 | 0.20 |
| 38-47 | 32.3±1.6 | 32.0±1.4 | 0.92 | 41.6±0.9 | 41.9±0.7 | 0.67 | 76.9±2.6 | 76.3±3.1 | 0.90 |
| 48-57 | 28.8±2.1 | 30.1±2.7 | 0.65 | 38.5±0.8 | 40.7±1.6 | 0.30 | 74.0±4.5 | 72.7±4.4 | 0.97 |
| 58-67 | 29.8±1.3 | 26.0±1.7 | 0.10 | 39.5±1.1 | 39.7±0.7 | 0.83 | 75.1±2.1 | 65.5±3.6 | 0.04* |
| >67 | 29.1±0.9 | 23.1±1.5 | 0.00* | 38.5±1.0 | 36.5±0.9 | 0.16 | 76.0±2.6 | 62.9±3.0 | 0.00* |
| ALL | 30.6±0.5 | 28.0±0.7 | 0.00* | 40.7±0.3 | 39.1±0.4 | 0.00* | 74.6±1.0 | 71.2±1.3 | 0.04* |

*Statistically significant ($P<0.05$)

**Table 2: Comparisons of means of orbital parameters between males and females among different age groups on the left side**

| Age range (years) | Height | | | Width | | | Index | | |
|---|---|---|---|---|---|---|---|---|---|
| | Males | Female | *P* | Males | Female | *P* | Males | Female | *P* |
| 18-27 | 30.2±0.9 | 26.5±1.3 | 0.02* | 41.4±0.5 | 36.8±0.7 | 0.00* | 72.6±1.7 | 71.5±2.6 | 0.72 |
| 28-37 | 31.4±1.2 | 29.1±1.1 | 0.19 | 40.9±0.7 | 40.5±0.6 | 0.73 | 76.1±2.0 | 71.7±2.3 | 0.17 |
| 38-47 | 32.2±1.6 | 32.3±1.4 | 0.95 | 41.8±0.9 | 42.6±0.6 | 0.58 | 76.4±2.7 | 75.9±3.0 | 0.92 |
| 48-57 | 28.8±2.1 | 30.3±2.7 | 0.70 | 38.7±0.8 | 40.1±1.5 | 0.26 | 73.6±4.3 | 74.2±4.5 | 0.89 |
| 58-67 | 29.7±1.3 | 26.1±1.7 | 0.10 | 39.7±1.1 | 39.3±0.7 | 0.96 | 74.5±2.1 | 66.3±3.6 | 0.04* |
| >67 | 29.2±0.9 | 23.4±1.5 | 0.00* | 38.8±1.0 | 37.2±1.0 | 0.25 | 75.4±2.1 | 62.5±3.0 | 0.00* |
| All | 30.6±0.5 | 28.0±0.7 | 0.00* | 40.8±0.3 | 39.3±0.4 | 0.01* | 74.5±1.0 | 70.7±1.3 | 0.02* |

*Statistically significant ($P<0.05$)

**Table 3: Comparisons of percentage frequencies of different ranges of orbital height between males and females**

| Orbital height (in mm) | Right; percentage frequency (frequency) | | | Left; percentage frequency (frequency) | | |
|---|---|---|---|---|---|---|
| | Males | Females | Probability | Males | Females | Probability |
| 16-20 | 10 (18/183) | 13 (13/103) | 0.109 | 11 (20/183) | 13 (13/103) | 0.071 |
| 21-25 | 25 (45/183) | 31 (32/103) | 0.423 | 26 (47/183) | 30 (31/103) | 0.593 |
| 26-30 | 23 (42/183) | 21 (22/103) | 0.763 | 22 (41/183) | 23 (24/103) | 0.881 |
| 31-35 | 19 (35/183) | 20 (21/103) | 0.873 | 16 (30/183) | 19 (20/103) | 0.612 |
| 36-40 | 11 (22/183) | 12 (12/103) | 0.835 | 13 (24/183) | 12 (12/103) | 0.841 |
| 41-45 | 8 (15/183) | 2 (2/103) | 0.058 | 8 (14/183) | 2 (2/103) | 0.058 |
| 46-50 | 3 (5/183) | 1 (1/103) | 0.625 | 3 (6/183) | 1 (1/103) | 0.625 |
| 51-55 | 1 (1/183) | 0 (0/103) | - | 1 (1/183) | 0 (0/103) | - |
| Total | 100 (183/183) | 100 (103/103) | | 100 (183/183) | 100 (103/103) | |

between 31 mm and 35 mm compared to 19% (20/103) of the females; 13% (24/183) of the males had orbital height between 36 mm and 40 mm compared to 12% (12/103) of the females; 8% (14/183) of the males had orbital height between 41 mm and 45 mm compared to 2% (2/103) of the females; 3% (5/183) of the males had orbital height between 46 mm and 50 mm compared to 1% (1/103) of the females; 1% (1/183) of the males and no female had orbital height between 51 mm and 55 mm. There was no statistically significant difference ($P>0.05$) in the percentage frequencies of all the ranges of orbital height between males and females on both sides [Table 3].

On the right side [Table 4], 2% (4/183) of the males had orbital width between 30 mm and 32 mm compared to 3% (3/103) of the females; 12% (22/183) of the males had orbital width between 33 mm and 35 mm compared to 16% (17/103) of the females; 21% (38/183) of the males had orbital width between 36 mm and 38 mm compared to 18% (19/103) of the females; 30% (54/183) of the males had orbital width between 39 mm and 41 mm compared to 38% (39/103) of the females; 21% (39/183) of the males had orbital width between 42 mm and 44 mm compared to 14% (14/103) of the females; 9% (16/183) of the males had orbital width between 45 mm and 47 mm compared to 7% (7/103) of the females; 4% (8/183) of the males had orbital width between 48 mm and 50 mm compared to 4% (4/103) of the females; 1% (2/183) of the males and no female had orbital width between 51 mm and 54 mm. On the left side [Table 2], 1% (2/183) of the males had orbital width between 30 mm and 32 mm compared to 4% (4/103) of the females; 14% (25/183) of the males had orbital width between 33 mm and 35 mm compared to 15% (15/103) of the females; 18% (33/183) of the males had orbital width between 36 mm and 38 mm compared to 19% (20/103) of the females; 32% (58/183) of the males had orbital width between 39 mm and 41 mm compared to 35% (36/103) of the females; 21% (40/183) of the males had orbital width between 42 mm and 44 mm compared to 18% (19/103) of the females; 7% (12/183) of the males had orbital width between 45 mm and 47 mm compared to 5% (5/103) of the females; 6% (11/183) of the males had orbital width between 48 mm and 50 mm compared to 3% (3/103) of the females; 1% (2/183) of the males had orbital width between 51 mm and 54 mm compared to 1% (1/103) of the females. There was no statistically significant difference ($P > 0.05$) in the percentage frequencies of all the ranges of orbital width between males and females on both sides [Table 4].

On the right side [Table 5], 1% (1/183) of the males had orbital index between 41 and 50 compared to 2% (2/103) of the females; 13% (24/183) of the males had orbital index between 51 and 60 compared to 22% (23/103) of the females; 27% (50/183) of the males had orbital index between 61 and 70 compared to 21% (22/103) of the females; 27% (50/183) of the males had orbital index between 71 and 80 compared to 32% (33/103) of the females; 19% (35/183) of the males had orbital index between 81 and 90 compared to 16% (16/103) of the females; 6% (11/183) of the males had orbital index between 91 and 100 compared to 4% (4/103) of the females; 5% (9/183) of the males had orbital index between 101 and 110 compared to 2% (2/103) of the females; 2% (3/183) of the males had orbital index between 111 mm and 120 compared to 1% (1/103) of the females. On the left side [Table 3], 1% (1/183) of the males had orbital index between 41 and 50 compared to 2% (2/103) of the females; 13% (23/183) of the males had orbital index between 51 and 60 compared to 23% (24/103) of the females; 28% (53/183) of the males had orbital index between 61 and 70 compared to 23% (24/103) of the females; 29% (53/183) of the males had orbital index between 71 and 80 compared to 31% (32/103) of the females; 15% (28/183) of the males had orbital index between 81 and 90 compared to 13% (13/103) of the females; 8% (14/183) of the males had orbital index between 91 and 100 compared to 5% (5/103) of the females; 6% (11/183) of the males had orbital index between 101 and 110 compared to 2% (2/103) of the females; no male had orbital index between 111 mm

**Table 4: Comparisons of percentage frequencies of different ranges of orbital width between males and females**

| Orbital width (in mm) | Right; percentage frequency (frequency) | | | Left; percentage frequency (frequency) | | |
|---|---|---|---|---|---|---|
| | Males | Females | Probability | Males | Females | Probability |
| 30-32 | 2 (4/183) | 3 (3/103) | 0.625 | 1 (2/183) | 4 (4/103) | 0.312 |
| 33-35 | 12 (22/183) | 16 (17/103) | 0.45 | 14 (25/183) | 15 (15/103) | 0.853 |
| 36-38 | 21 (38/183) | 18 (19/103) | 0.631 | 18 (33/183) | 19 (20/103) | 0.869 |
| 39-41 | 30 (54/183) | 38 (39/103) | 0.332 | 32 (58/183) | 35 (36/103) | 0.714 |
| 42-44 | 21 (39/183) | 14 (14/103) | 0.237 | 21 (40/183) | 18 (19/103) | 0.631 |
| 45-47 | 9 (16/183) | 7 (7/103) | 0.617 | 7 (12/183) | 5 (5/103) | 0.564 |
| 48-50 | 4 (8/183) | 4 (4/103) | 1 | 6 (11/183) | 3 (3/103) | 0.328 |
| 51-54 | 1 (2/183) | 0 (0/103) | - | 1 (2/183) | 1 (1/103) | 1 |
| Total | 100 (183/183) | 100 (103/103) | | 100 (183/183) | 100 (103/103) | |

**Table 5: Comparisons of percentage frequencies of different ranges of orbital index between males and females**

| Orbital index (in %) | Right; percentage frequency (frequency) | | | Left; percentage frequency (frequency) | | |
|---|---|---|---|---|---|---|
| | Males | Females | Probability | Males | Females | Probability |
| 41-50 | 1 (1/183) | 2 (2/103) | 0.75 | 1 (1/183) | 2 (2/103) | 0.75 |
| 51-60 | 13 (24/183) | 22 (23/103) | 0.128 | 13 (23/183) | 23 (24/103) | 0.096 |
| 61-70 | 27 (50/183) | 21 (22/103) | 0.386 | 28 (53/183) | 23 (24/103) | 0.484 |
| 71-80 | 27 (50/183) | 32 (33/103) | 0.515 | 29 (53/183) | 31 (32/103) | 0.896 |
| 81-90 | 19 (35/183) | 16 (16/103) | 0.612 | 15 (28/183) | 13 (13/103) | 0.705 |
| 91-100 | 6 (11/183) | 4 (4/103) | 0.527 | 8 (14/183) | 5 (5/103) | 0.405 |
| 101-110 | 5 (9/183) | 2 (2/103) | 0.328 | 6 (11/183) | 2 (2/103) | 0.219 |
| 111-120 | 2 (3/183) | 1 (1/103) | 0.75 | 0 (0/183) | 1 (1/103) | - |
| Total | 100 (183/183) | 100 (103/103) | | 100 (183/183) | 100 (103/103) | |

and 120 compared to 1% (1/103) of the females. There was no statistically significant difference ($P > 0.05$) in the percentage frequencies of all ranges of orbital index between males and females on both sides [Table 5].

## DISCUSSION

Forensic science remains relevant when considering variations in anthropometric features among different populations. Craniometric parameters had been applied by several investigators in the determination of sex of individuals in different populations.[6] Among these parameters are the dimensions of the orbital margin; several anthropometrics claimed that this orbital margin is higher in males than in females,[3-5,7] which had led to their erroneous conclusion that these could be used as a tool for sex determination.[3] However, a deeper reflection of this assertion would leave one to debate its truism. First, does the fact that a particular sex has an average of an orbital parameter that is significantly different from the opposite sex statistically, based on perhaps the Student's *t*-test, automatically mean that the opposite sex would have no individual with similar measurements? Second, and related to the first, does a similarity in these measurements between an individual of a particular sex and his or her counterpart from the opposite sex make him or her less of his or her sex? We argue that it is preferable to determine the ranges of orbital parameters that are more predominant in a particular sex than the opposite sex. This would, to a greater extent, give a clearer picture of the sex of an individual from anthropometric point of view than the simple Student's *t*-test.

The choice of a particular ethnic group for this study was a result of racial and ethnic variations in anthropometric attributes of the human subjects. This study showed that all the orbital parameters are significantly higher in males than females when compared with the Student's *t*-test. This is at variance with the study by Igbigbi and Ebite[8] with adult Malawians, which found higher orbital index among the females than the males. These findings support the need for population-based studies on craniometry. The present study, however, showed that when the subjects were grouped according to age groups, the orbital parameters were only significantly higher in males than in females only in a few age groups but not in others, evidently hinting weakness in the use of orbital anthropometry in sex determination.

However, instead of concluding that sex can be determined in this population based on these sex differences determined by a mere *t*-test, this study went further to investigate the reliability of the orbital rim anthropometry in sex identification by grouping the subjects according to their orbital margin measurements. It could be seen from the results that there were no statistically significant differences in the percentage frequency of any range of all the parameters studied between males and females. In other words, no particular sex had a statistically significant predominant orbital measurement than the other sex. Munguti *et al*.[6] agreed that there was no statistical significant difference between male and female orbital indices to warrant its use in sexing the crania from a black Kenyan population. Even though they were right, their conclusion was again based on the simple Student's *t*-test. The present study presents a new, and perhaps more reliable, approach to sex determination from anthropometric features, which could be applied in different aspects of measurements other than that of orbit.

## CONCLUSION

In conclusion, this study had shown, whereas there are sex variations in the orbital margin anthropometry, sex cannot be determined through orbital margin anthropometry. Further studies are recommended in other populations to corroborate this finding.

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### Conflicts of interest
There are no conflicts of interest.

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