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C.D. Orupabo¹ O. J. Odegba¹

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¹Clinton David Orupabo, ¹Department of Human Anatomy, Faculty of Basic Medical Sciences, College of Medical Sciences, Rivers State University. Clinton.orupabo@ust.edu.ng

¹Oghenetega Joseph Odegba¹, Department of Human Anatomy, Faculty of Basic Medical Sciences, College of Medical Sciences, Rivers State University. Email: Oghenetegaodegba@gmail.com

Corresponding author: ¹Clinton David Orupabo, ¹Department of Human Anatomy, Faculty of Basic Medical Sciences, College of Medical Sciences, Rivers State University. PMB 5080, Nkpolu-Oroworukwo, Port Harcourt, Nigeria. Email: Clinton.orupabo@ust.edu.ng

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C.D. Orupabo¹ O. J. Odegba¹

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ABSTRACT

Background: Metric assessment of skeletal remains and the use of the fingers has been useful in sex estimation especially when the index and ring fingers are carefully examined for its dimensions.

Aim: The aim of this study is to investigate the anthropometric variables of the index and ring finger in a Nigerian adult population and how it can serve as a predictive marker in sex estimation.

Materials & Methods: This is a cross-sectional study which employed random sampling method to obtain participants after an informed consent. Participants were drawn from Ijaw, Hausa and Igbo ethnic groups. A total of 353 participants were recruited for this study, with 104 individuals from Igbo tribe (54 males and 54 females), 144 individuals from Hausa (72 males and 72 females) and 101 individuals from Ijaw (52 males and 49 females).

Results: The hand and finger measurements was taken using a high precision stainless steel digital sliding Vernier caliper. The male index width and length were higher than those of the females. Index width was 19.36 ± 0.08 for males and 18.04 ± 0.11 for females. Also Index length was 75.35 ± 0.49 for males and 65.67 ± 0.46 for females. 2D:4D ratio was noted to be 0.99 for both male and female population. A wide margin of difference was seen for the 2D:4D ratio among Ijaw males and females. There was also a statistically significant difference ($P=0.00$) for the left index dimensions, right index width for males and females, whereas those of the right index length was statistically not significant ($P>0.05$). It is therefore imperative to admit that the left index width and length as well as the right index width dimensions are useful and could prove accurate when the issue of sex determination arises. The hand and finger indices can be useful as a predictive marker for sex estimation since sexual dimorphism do exist.

Keywords: Index finger, Ring finger, 2D:4D ratio, Sex estimation, Forensic anthropology, Nigerian

INTRODUCTION

The diversity of the Nigerian population provides the opportunity to study whether variations exist among these ethnic groups and consider how such variations could impact future forensic investigations. Again considering the fact that these sub-groups arise from diverse backgrounds of African ancestry, it becomes necessary to study subtle difference that may exist. Moreover these sub-groups provide great opportunity to study the anthropometric digit variations among the groups and tribes (Oladipo et. al., 2009). Metric assessment of skeletal remains and the use of the fingers has been useful in sex estimation since sexual dimorphism has been noted in some studies (Rillanathagar, 1984, Kanchan et al., 2008, Emam 2011, Ghada et. al., 2018).

The ring finger is known as the fourth digit of the human hand and the second most medial finger and is located between the middle finger and the little finger while the index finger also known as the forefinger, is the first finger and the second digit of a human hand. It is located between the thumb and the middle finger (Arthur et al., 1998; Fink et al., 2004a). Some studies have shown that males have relatively shorter index fingers than the ring fingers (Burriss et al., 2007; Brown et al., 2002; Neave et al., 2003).

Auger et al., 2013 demonstrated in their study that 2D:4D is influenced by androgens where they conducted an investigation using mice which revealed that those with higher testosterone and low estrogen levels had more male-like digits (low 2D:4D ratio), while mice with higher estrogen levels or low testosterone levels had more feminine digit ratios (high 2D:4D). Further work showed that a low 2D:4D ratio has been shown to correlate with high testosterone levels which is characteristic of males, while a high 2D:4D ratio is correlated with low testosterone level, a characteristic of females (Manning, 2002, Lutchmaya et al., 2004). In fact most research work and reviews of literatures have admitted to the fact that 2D:4D ratio demonstrates sexual dimorphism showing prenatal androgen exposure and the development of masculine traits (Manning et al., 1998, Fink et al., 2003, Lutchmaya et al., 2004, Mondal et al., 2023). We intend therefore to investigate the anthropometric variables of the index and ring finger in a Nigerian adult population and how it can serve as a predictive marker in sex estimation. Shokri et al., 2021 conducted a study on Index Finger Length to Ring Finger Length (2d:4d) ratio in Schizophrenic Men Living in Khorasan Razavi to find a link between brain violation and finger length. The index and ring finger lengths of both hands in 62 schizophrenic men and 72 healthy subjects who were aged 18 to 65

years old were measured by digital caliper. The findings revealed significant differences between the average index finger lengths (2d:4d) in men's right hand of healthy and schizophrenic subjects. In another study by Sharma, 2019, digit ratio was positively correlated with waist-hip-ratio and was therefore indicative for being overweight in women and suggest a predisposition toward cardiovascular disease. In a study on South Indian population by Jayanth, 2020, the mean stature, index finger length and ring finger length were significantly higher in males than females. Also statistically significant correlation was observed between stature, index finger length and ring finger length in the right and left hands. However the correlation coefficient was higher among males than females. The left ring finger length in males and the right index finger length in females, showed more correlation with stature.

Gheat et al., 2020 evaluated hand measurements as a potential tool for sex and stature estimation in an Egyptian and Malaysian population and documented that sex and stature can be predicted with reasonable accuracy. In a similar study by Mukherjee and Das 2021, males have longer mean 2D and 4D lengths than females. Akhlaghi et al., 2019 noted in their work that the average hand length was found to be greater in males than females. Also mean index and ring finger length were 73mm and 74mm in males and 68mm and 68mm in females. The accuracy of gender identification for these parameters was obtained to be 92%, 71%, 73% and 74.5% for stature, index finger length, ring finger length and as well the sum of the index and ring finger length respectively. Again Jeyaseelan et al., 2016 showed that the mean of right hand length (18.65) and left hand length (18.62) of male hand was higher than right hand length (16.93) and left hand length (16.94) of females respectively. The right hand index of males (44.03) was greater than the left hand index (43.15) and the right hand index of females (43.01) was greater than the left hand index (42.48). In same vein, the right and left hand index of males (44.03 and 43.15) were greater than those of the females (43.01 and 42.48). Meanwhile Varu et al., 2016 in their study showed no significant bilateral sex variation in Hand length ($P>0.05$) but Hand breadth ($P<0.05$).

MATERIALS AND METHOD

This is a cross-sectional study which employed random sampling method to obtain participants for this research. The study was carried out among persons from the Ijaw, Hausa and Igbo tribes living in Port Harcourt and its metropolis in Rivers State. The participants who volunteered in the study were healthy and without any obvious hand abnormalities. A total of 353 participants were

recruited for this study, with 104 individuals from Igbo tribe (54 males and 54 females), 144 individuals from Hausa (72 males and 72 females) and 101 individuals from Ijaw (52 males and 49 females). All participants were subjected to taking of demographic data and history of age, sex, nationality and history of any trauma, bone disease or surgery. The hand and finger measurements was taken using a high precision stainless steel digital sliding Vernier caliper 8" 200mm with 0.02 precision and was done as recommended by Weiner and Lourie in 1969. These measurements were taken in mm and were measured to two decimal places.

The finger measurements recorded were Index Finger Length (IFL) and Width of the Right hand (RIFL and RIFW), Index Finger Length and Width of Left hand (LIFL and LIFW), Ring Finger Length (RFL) and Width of Right hand (RRFL and RIFW) and Ring Finger Length and Width of Left hand (LRFL). The index and ring finger ratio (i.e. 2D:4D) was calculated for both hands by dividing IFL by RFL ($IFL \div RFL$). The IFL was measured as the linear distance between the palmar crease of the base and the tip of the distal phalanx along the midline of the palmer surface of the index finger while the IFW was measured as the linear distance running between the lateral and medial borders of the proximal inter-phalangeal joint of the index finger. Likewise the RFL was measured as the linear distance between the palmar crease of the base and the tip of the distal phalanx along the midline of the palmer surface of the ring finger while the RFW was measured as the linear distance between the palmar crease of the base and the tip of the distal phalanx along the midline of the palmer surface of the ring finger.

Finger measurements were taken using digital calipers with a 0-300 mm measurement capacity sensitive to ± 0.01 mm. During the measurement, attention was paid to avoid abduction and adduction of the wrist joint and measurements were recorded to nearest 0.01 cm. To prevent interpersonal error, all measurements were taken by the same person and each participant was measured twice, and an average of the two readings was recorded. Also the instruments were calibrated regularly to ensure accuracy and validity. Statistical analysis was done using SPSS version 22 for windows. Data values were expressed as mean \pm standard deviation.

RESULTS AND ANALYSIS

Table 1 shows the mean of the index width and index height and as well the ring finger width and length of the study population. The findings show that of the male, female and combined sexes.

Table 1: Descriptive Statistics of Index and Ring Finger Length and Width of the Study Population

PARAMETERS	MALES		FEMALES		COMBINED SEXES	
	Index finger	Ring finger	Index finger	Ring finger	Index finger	Ring finger
Number of samples	178	178	178	178	356	356
Finger Width (mm)	19.36 ± 0.08	19.33 ± 0.09	18.04 ± 0.11	18.04 ± 0.11	18.70 ± 0.10	18.69 ± 0.10
Finger Length (mm)	75.35 ± 0.49	76.24 ± 0.58	65.67 ± 0.46	66.67 ± 0.46	69.51 ± 0.48	71.46 ± 0.52

Values for finger width and length were expressed as mean ± SEM

Table 2: Test of variation in the Index finger dimensions between Male and Female Sexes using Student's t test

Left Index Finger Width (LIFW)			Right Index Finger Width (RIFW)			Left Index Finger Length (LIFL)			Right Index Finger Length (RIFL)		
t stat	t crit	p value	t stat	t crit	p value	t stat	t crit	p value	t stat	t crit	p value
9.93	1.65	0.00 ^x	8.96	1.65	0.00 ^x	14.14	1.65	0.00 ^x	-0.73	1.65	0.23

^x Statistically significant (P<0.05)

Table 2 shows sex variation in the anthropometric parameters of the index finger. The t stat is seen to be greater than the t critical for the LIFW, LIFL and RIFW. Sex variation in these parameters is statistically significant at P=0.00.

Table 3: Test of variation in the Ring finger dimensions between Male and Female Sexes using Student's t test

Left Ring Finger Width (LRFW)			Right Ring Finger Width (RRFW)			Left Ring Finger Length (LRFL)			Right Ring Finger Length (RRFL)		
t stat	t crit	p value	t stat	t crit	p value	t stat	t crit	p value	t stat	t crit	p value
9.36	1.65	0.00 ^x	9.40	1.65	0.00 ^x	13.74	1.65	0.00 ^x	10.64	1.65	0.00 ^x

^x Statistically significant (P<0.05)

Table 3 shows sex variation in the anthropometric parameters of the ring finger. The t stat is seen to be greater than the t critical for the LRFW, LRFL, RRFW and RRFL. Sex variation in these parameters is statistically significant at $P=0.00$.

Table 4a: Index Width and Length of various Nigerian Ethnic Groups

PARAMETERS	HAUSA MALES	HAUSA FEMALES	IGBO MALES	IGBO FEMALES	IJAW MALES	IJAW FEMALES
Number	72	72	54	54	52	52
Index width(mm)	19.92 ± 0.12	17.32 ± 0.16	18.76 ± 0.12	18.47 ± 0.17	19.21 ± 0.13	18.60 ± 0.17
Index Length (mm)	78.78 ± 0.77	63.59 ± 0.72	70.79 ± 0.61	66.23 ± 0.74	75.35 ± 0.74	67.96 ± 0.81

Values for index width and index height were expressed as mean ± SEM.

Table 4a showed the mean data for the index width and height of the Hausa males as 19.92 ± 0.12 and 78.78 ± 0.77 respectively while for the Hausa females the mean data for the index width and height was 17.32 ± 0.16 and 63.59 ± 0.72 respectively. The Igbo and Ijaw ethnic groups are shown as well in the table.

Table 4b: Ring Width and Length of various Nigerian Ethnic Groups

PARAMETERS	HAUSA MALES	HAUSA FEMALES	IGBO MALES	IGBO FEMALES	IJAW MALES	IJAW FEMALES
Number	72	72	54	54	52	52
Ring width(mm)	19.94 ± 0.12	17.29 ± 0.14	18.72 ± 0.13	18.36 ± 0.19	19.12 ± 0.15	18.77 ± 0.15
Ring Length (mm)	80.80 ± 0.77	64.46 ± 0.77	71.51 ± 0.64	67.88 ± 0.71	74.84 ± 1.15	68.47 ± 0.75

Values for ring width and ring height were expressed as mean ± SEM.

Table 4b showed the mean data for the Ring width and height of the Hausa males as 19.94 ± 0.12 and 80.80 ± 0.77 respectively while for the Hausa females the mean data for the Ring width and height was 17.29 ± 0.14 and 64.46 ± 0.77 respectively. The Igbo and Ijaw ethnic groups are shown in the table.

Table 5: 2D:4D Ratio for Adult Males and Females for the Study Population

PARAMETERS	2D: 4D RATIO
MALES	0.99
FEMALES	0.99
HAUSA MALES	0.98

HAUSA FEMALES	0.99
IGBO MALES	0.99
IGBO FEMALES	0.98
IJAW MALES	0.81
IJAW FEMALES	0.99

Table 5 shows the 2D:4D ratio for the males and females of the study population and as well the various ethnic groups studied. A ratio of 0.99 appears dominant in our study population with few variations seen with Hausa males, Igbo females and Ijaw males. A larger margin of difference is observed for the Ijaw males and females and a slight difference for the Hausa and Igbo males and females.

DISCUSSION

Index and ring finger measurements have been widely conducted across various tribes and populations. We intend therefore by this study to investigate whether these parameters can be applied to sex estimation as a predictive marker in forensic case investigation. Our findings however show that the male index width and length were higher than those of the females. Index width was 19.36 ± 0.08 for males and 18.04 ± 0.11 for females. Also Index length was 75.35 ± 0.49 for males and 65.67 ± 0.46 for females (Table 1). In same vein, the Ring finger dimensions were higher in males than the females. Ring width was 19.33 ± 0.09 and 18.04 ± 0.11 for males and females respectively while Ring length was 76.24 ± 0.58 for males and 66.67 ± 0.46 for females (Table 1). Further analysis was done to investigate both left and right sides of the hand dimensions and it was observed that sex variation for the left index width and length was statistically significant ($P < 0.05$) (Table 2). There was also a statistically significant difference ($P = 0.00$) for the right index width for males and females, whereas those of the right index length was statistically not significant ($P > 0.05$) (Table 2). It is therefore imperative to admit that the left index width and length as well as the right index width dimensions are useful and could prove accurate when the issue of sex determination arises. These parameters could support forensic case diagnosis for sex in a Nigerian population. Again when test of variation was conducted for the Ring finger parameters using Student t test, we observed from our findings that the left and right sides of the Ring finger width and length, all proved statistically significant ($P < 0.05$) between

males and females (Table 3). The Ring finger dimensions are therefore accurate in sex determination since sexual differences are marked and statistically significant.

Our findings are in consent with the study by Ibrahim et al., 2018 and Oladipo et al., 2015 who documented higher values in Index width and length for males compared to their female counterparts. Krishan et al., 2012 also documented that males have higher values than the females. In fact both authors obtained 75mm and 65mm for the male Index length. The Index length of this present study was 75.35mm, a value much closer to that obtained by Ibrahim et al., 2018, whose study population were those of Saudi Arabians while Krishan et al., 2012 studied on an Indian population. Our study also agrees with some other authors who documented Ring length and width to be greater in their male population when compared to the female population (Danborno et al., 2009, Bardale et al., 2013, Jee et al., 2015).

Furthermore, our study showed that Hausa males had the highest mean index Length and width of 78.78 mm and 19.92 mm respectively (Table 4a). The Igbo males had the lowest mean index length and width of 70.79 mm and 18.76 mm respectively (Table 4a). We also observed that Hausa females had the lowest mean Index length and width of 63.59 mm and 17.32 mm respectively. The Ijaw females had the highest mean Index length and width of 67.96 mm and 18.60 mm respectively (Table 4a). Again, our findings for the Ring finger dimensions showed that Hausa males had the highest mean Ring length and width of 78.78 mm and 19.92 mm respectively (Table 4b). The Igbo males had the lowest mean Ring length and width of 70.79 mm and 18.76 mm respectively. The female counterparts showed that Hausa females had the lowest mean Ring length and width of 63.59 mm and 17.32 mm respectively while the Ijaw females had the highest mean Ring length and width of 67.96 mm and 18.60 mm (Table 4b). The findings for the Index and Ring finger dimensions for the various Nigerian ethnic groups appears to mirror each other for both male and female populations. It is therefore important to note that these hand dimensions could vary across ethnic groups as we have observed in this present study. What seems to hold firmly in our study is that even among the ethnic groups sex variation was observed.

We went further to look at the 2D:4D ratio for our study population and we observed that males and females have a similar 2D:4D ratio of 0.99 (Table 5). This is a slight variation from the study by Mukherjee et al., 2021, who obtained a 2D:4D ratio of 0.98 for both males and females. Both studies have however demonstrated that there is no variation in the 2D:4D ratio between males and females. The 2D:4D ratio therefore may pose difficulty when used for sex estimation of our

study population. It is however important to note that 2D:4D ratio could appear different for various populations as seen in these studies. We also saw that there was a slight variation in the 2D:4D ratio for the males and females of the Hausa tribe at 0.98 and 0.99 respectively (Table 5). The Igbo tribe also had slight variation in the 2D:4D ratio of the males and females at 0.99 and 0.98 respectively. The Ijaw tribe had the widest margin of difference in the 2D:4D ratio of males and females at 0.81 and 0.99 respectively. The reason for this wide margin of difference could not be established by this work.

Conclusion

Anthropometric variables of the index and ring fingers have proved useful in showing sexual dimorphism. The ring and index length and width dimensions have shown that these parameters can be used as predictive marker for sex estimation. The 2D:4D ratio shows sexual variation in the ethnic groups studied and with a wide margin of difference in the Ijaw ethnic group. These parameters however reveal distinctive features in various populations as shown in our study.

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