Testosterone and second-to-fourth digit ratio: Their relationships in adolescent males and females of Igbo Ethnic group in Nigeria

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ABSTRACT

Background: The ratio of the second-to-fourth finger lengths (2D:4D) demonstrates a reliable sexual dimorphism across human ethnic groups. It may be established *in utero* and is negatively correlated with sperm counts and testosterone in men and positively correlated with estrogen in men and women. In view of its clinical importance, this study was carried out to document values of the 2nd to 4th digit ratio in the Igbo ethnic group of Nigerian population and to investigate its relationship with testosterone. **Materials and Methods:** A sample of 412 subjects (209 boys and 203 girls) between ages 12 and 20 years were recruited randomly for this study. Finger lengths were measured twice, using an electronic Vernier calliper (precision 0.01 mm). Blood samples were collected and analyzed for testosterone. **Results:** Men had lower 2D:4D ratio (0.98 ± 0.01 for the right and left hand) than women (0.99 ± 0.01 for both hands). These differences in 2D:4D between sexes were statistically significant ($P < 0.001$ for both hands). The other digit ratios were also lower in men than women for both hands. These differences were statistically significant for all digit ratios except for the 3D:5D and 3D:4D ratio of the both hands. **Conclusion:** Testosterone had an inverse relationship with 2D: 4D of both hands in males, as well as females' left hands. This result confirms that digit ratios are sexually dimorphic and useful markers of disease predisposition.

Key words: Adolescent, 2D:4D, 4D:5D, digit ratio, serum testosterone, sexual dimorphism

INTRODUCTION

The ratio between relative length of the index finger (2nd digit) and ring finger (4th digit), that is the second-to-fourth digit ratio (2D:4D), is sexually dimorphic. Digit ratio has been reported by many workers to show sexual dimorphism with women having higher ratio than men.[1-5] Results from previous studies suggest that 2D:4D is influenced by prenatal oestrogen and testosterone levels in utero and it may predict disease predisposition.[3,6,7]

From finger length measurements, males have on average longer 4th digits in relation to their 2nd digits while females have relatively longer 2nd digits, although their 2nd digits are not necessarily longer than their 4th digits.[2,8] These sex differences in 2D:4D are reliably consistent across a number of ethnic groups and races.[2,9,10]

There is evidence that the 2D:4D ratio is a marker for testosterone and estrogen levels towards the end of the first trimester of pregnancy[2,3] and reflects the action of Hox genes on differentiation during early pregnancy.[11] Today digit ratios are related to a variety of variables such as fertility, human behavior,[2] body composition,[12] predictor of birth weight,[13] aggression and assertiveness,[4,8,14] personality disorders,[2] gender inequalities,[15] and congenital adrenal hyperplasia.[16]

Several studies have investigated the 2D:4D ratios in many ethnic groups but studies on the other digits ratios are rather limited. To our knowledge, there are few studies on 2D:4D and other digit ratios among the Igbo ethnic group in Nigeria. In view of the clinical interest that 2D:4D and other finger ratios may have as markers of disease predisposition, and as markers of genetic or

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environmental influence, we investigated the 2D:4D and other digit ratios in a sample of adolescents from the Igbo ethnic group in Nigeria.

MATERIALS AND METHODS

A sample of 412 adolescents from the Igbo ethnic group of Nigeria (females $n = 203$ and males $n = 209$) aged 12-20 years, selected by random procedures participated in this study. All participating persons gave their consent to the study following protocol which was approved by the ethical committee. Individuals with structural deformities that could hinder accurate anthropological assessment were excluded from the study.

Measurement of digits length

The lengths of the second (2D), third (3D), fourth (4D), and fifth (5D) fingers of both hands were measured with an electronic Vernier calliper (precision 0.01 mm, Neiko Corporation, USA).[2] The length of each finger was defined as the distance from the ventral proximal crease of the digit to the tip. If there was a band of creases at the base of the digit, measurements were made from the most proximal of these. Measurements were performed twice. Finger lengths were calculated as the mean values of the first and second measurement of the length of each digit.

Blood specimen collection and processing

Blood specimens (2 ml each) were also taken into plain tubes by venepuncture. Serum testosterone levels were measured by enzyme immunoassay using a commercially available testosterone EIA test kit (BioCheck Inc., Foster City, CA).

Data analyses

Data were expressed as mean ± standard deviation. The Student's t-test was used to test the difference in the mean of all variables between boys and girls from the Hausa and Igbo ethnic groups. Pearson's correlation coefficient was used to test the relationship between testosterone and all the measured anthropometric parameters. $P < 0.05$ was deemed statistically significant and SPSS version 16 (IBM Corp., New York) was used for the statistical analyses.

RESULTS

The mean digit lengths of all digits of the right and left hand in both sexes with the characteristics of their values (minimum and maximum) are represented in Table 1. The mean values of all the finger digits are lower in females than in males. All parameters are statistically significant at $P < 0.001$. The digit ratios of the right and left hands in both sexes are presented in Table 2. Females had higher 2D: 4D (0.99 ± 0.01) than males (0.98 ± 0.01) in both hands. This difference was statistically significant at $P < 0.001$. The result also revealed statistical significant difference ($P < 0.001$) in other digit ratios except 3D:5D and 3D:4D. Difference in digit ratio between the right and left fingers was observed in 3D:5D in both sexes, however, this difference was not statistically significant. The highest difference in digit ratios between sexes was observed in 2D:5D ratios of both hands, with P values lower than 0.001. Table 3 demonstrated that in males, serum testosterone had an inverse relationship with 2D: 4D in both hands, while in females it correlated inversely with 2D:4D of the left hand only. These relationships were statistically significant at $P < 0.05$ and $P < 0.01$.

DISCUSSION

Digit ratio (2D:4D) is a sexually dimorphic biometric marker that is determined genetically by the Hox genes.[9,11] 2D:4D is under the influence of prenatal oestrogen and testosterone levels *in utero*.[11,17] The 2D:4D ratio in the sample of the Igbo population that was studied was found to be significantly higher in women than in men, a finding that is consistent with other studies of 2D:4D in other ethnic groups in Nigeria

Table 1: Descriptive statistics showing the finger length of hands in both sexes

Variables	Males (n = 209)				Females (n = 203)					
	Mean ± S.D.	Maximum	Minimum	Range	Mean ± S.D.	Maximum	Minimum	Range	t	P
Right 1D	67.67±4.77	83.25	55.02	28.23	62.18±4.15	74.43	48.70	25.73	12.43	<0.001
Right 2D	75.08±5.02	91.32	59.13	32.19	70.18±3.91	80.41	59.23	21.18	11.04	<0.001
Right 3D	83.68 ± 5.24	98.77	67.04	31.73	77.12±4.49	88.85	66.63	22.22	13.62	<0.001
Right 4D	76.77±5.12	91.24	60.02	31.22	70.60±4.08	82.88	59.13	23.75	13.53	<0.001
Right 5D	60.50±4.58	75.43	45.28	30.15	55.55±4.47	68.26	35.30	32.96	11.10	<0.001
Left 1D	67.32±4.52	82.51	56.29	26.22	61.40±4.12	71.31	44.75	26.56	13.89	<0.001
Left 2D	75.08±5.10	91.12	58.83	32.29	70.18±3.09	80.72	59.08	13.46	10.96	<0.001
Left 3D	83.68±5.21	98.54	70.05	28.49	77.31±4.45	89.06	66.60	22.46	13.56	<0.001
Left 4D	76.78±5.22	91.02	60.01	31.01	70.60±4.11	83.11	58.99	24.34	13.29	<0.001
Left 5D	60.92±4.75	75.06	46.20	28.89	55.80±4.25	68.09	43.74	25.35	11.52	<0.001

n = Sample size, S.D. = Standard deviation, 2D = 2nd digit (index finger), 3D = 3rd digit (middle finger), 4D = 4th digit (ring finger), 5D = 5th digit (little finger). Length is expressed in mm

Table 2: Descriptive statistics showing the digit ratios of the hands in both sexes

Variables	Males (n = 209)				Females (n = 203)					
	Mean± S.D.	Maximum	Minimum	Range	Mean ± S.D.	Maximum	Minimum	Range	t	*P*
Right 2D:4D	0.98±0.01	1.04	0.92	0.12	0.99±0.01	1.01	0.97	0.04	15.29	<0.001
Left 2D:4D	0.98±0.01	1.02	0.97	0.05	0.99±0.01	1.02	0.97	0.05	16.17	<0.001
Right 2D:3D	0.90±0.02	0.97	0.77	0.20	0.91±0.03	1.01	0.81	0.20	5.18	<0.001
Left 2D:3D	0.90±0.02	0.97	0.82	0.15	0.91±0.03	1.03	0.82	0.81	4.67	<0.001
Right 2D:5D	1.24±0.05	1.42	1.11	0.31	1.27±0.08	1.93	1.12	0.81	3.71	<0.001
Left 2D:5D	1.24±0.05	1.42	1.10	0.32	1.26±0.07	1.48	1.11	0.37	4.43	<0.001
Right 3D:5D	1.39±0.07	1.63	1.20	0.43	1.39±0.09	2.04	1.13	0.91	0.94	0.35
Left 3D:5D	1.38±0.7	1.64	1.23	0.41	1.38±0.07	1.63	1.15	0.48	1.55	0.12
Right 3D:4D	1.09±0.03	1.27	1.02	0.25	1.09±0.03	1.24	0.97	0.27	0.72	0.47
Left 3D:4D	1.09±0.03	1.19	1.03	0.16	1.09±0.03	1.22	0.95	0.27	1.09	0.28

n = Sample size, S.D. = Standard deviation, 2D = 2nd digit (index finger), 3D = 3rd digit (middle finger), 4D = 4th digit (ring finger), 5D = 5th digit (little finger). Length is expressed in mm

Table 3: Correlation matrix of serum testosterone level and anthropometric variables in female (black font) and male (red font) participants

Parameters	T	Age	WT	HT	BMI	Right 2D4D	Left 2D4D
T	–	0.13	0.16[a]	0.16[a]	0.07	−0.31[b]	−0.37[b]
Age	0.08	—	0.27[b]	0.31[b]	0.09	−0.01	−0.02
WT	0.31[b]	0.05	—	0.73[b]	0.76[b]	−0.06	−0.01
HT	0.04	0.04	0.34[b]	—	0.07	0.03	0.00
BMI	0.31[b]	0.03	0.89[b]	−0.12	—	−0.11	−0.13
Right 2D4D	0.46[b]	0.02	−0.15[b]	−0.16[a]	−0.08	—	0.87[b]
Left 2D4D	−0.50[b]	0.03	−0.26[b]	−1.18[a]	−0.13	0.90[b]	–

T = Testosterone, WT = Weight, HT = Height, BMI = Body mass index, [ab]Statistical significant correlation at $P < 0.01$ and $P < 0.05$ respectively

and other countries.[8-10,18] In our study we found that the mean 2D:4D ratio was 0.98 ± 0.01 in males and 0.99 ± 0.01 in females, these values are higher than reported in previous studies carried out in Europe (the mean 2D:4D ratio in males and females were found respectively to be 0.98 and 1.00 in U.K., 0.95 and 0.98 in Austria, 0.93 and 0.94, in Greece, 0.93 and 0.95, in Finland, 0.96 and 0.97 in USA, 0.95 and 0.97 in Canada.[9,15]

In the Zulu and Sardinian ethnic groups, 2D:4D (0.95) and (0.98) respectively were found to be equal in men and women.[9] This did not present sexual dimorphism and thus are contrary to the findings in our study and other studies on other ethnic groups, in which the 2D:4D ratio was found to be sexually dimorphic.[15,18,19] Digit ratio is a biometric marker that turns to become very useful for the prevention and prognosis of diseases that are dependent on sex hormones.[2,7]

Although many studies on 2D:4D have been carried out during the last decade, studies on the other digit ratios are very limited.[9,20,21] In our study we found that the other digit ratios are also sexually dimorphic: They are lower in men than women. The difference in digits ratio between sexes was statistically significant for all digit ratios of both hands except for the 3D:5D and 3D:4D ratio of the both hands.

The study of 2D:4D and other digit ratios, as well as their variation among population groups and among individuals may serve as a useful tool for establishing their values as biomarkers.[9,20,21] 2D:4D and other digit ratios appear to be attractive anthropometric traits that probably deserve attention by anthropologists, scientists, and clinicians since these digit ratios have continued to show promise as biomarkers of health and diseases.[7,22,23]

Our results support the sexual dimorphism of digit ratios but not the lateralized character of digit ratios found in other studies.[13,15,24,25] Our study found an equal digit ratio in both hands except in 3D:5D in both sexes and 2D:5D in females (right = 1.27 ± 0.08 and left = 1.26 ± 0.07). The differences in the results among population groups could be attributed to different digit pattern expression, which may reflect differences in the influence of genetic or environmental parameters.[26] Previous studies have shown that testosterone is related negatively to 2D:4D whereas estrogen correlates positively with 2D:4D.[11,17,27] Lutchmaya *et al*.[28] also showed a relationship between 2D:4D measured in children and testosterone concentration measured in samples of amniotic fluid and cord blood collected during their gestation.[11,23] This work showed a significant negative relationship between 2D:4D and serum testosterone, further establishing the organizational effect of testosterone on digit ratio.

CONCLUSION

In conclusion, the result of this study has shown that the 2D:4D digit ratio is sexually dimorphic and it is a biometric marker that can be useful in the prognosis and prevention of diseases that are dependent on sex hormones, thus deserving further probing in different directions for possible discovery of associations with other traits by scientists and clinicians.

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