Available online: www.notulaebiologicae.ro
Print ISSN 2067-3205; Electronic 2067-3264
Not Sci Biol, 2016, 8(4):396-400. DOI: 10.15835/nsb.8.4.9888

AcademicPres

Notulae Scientia Biologicae

Original Article

Relationship between Ratio of Second and Fourth Digit and Obesity Traits among Different Ethnic Groups in Ilorin, North Central Nigeria

Bolaji Fatai OYEYEMI[1,2]*, John Oluwafemi ADEBAYO[2], Abass Toba ANIFOWOSHE[3], Oluyinka Ajibola IYIOLA[3]

[1]*International Centre for Genetic Engineering and Biotechnology, Transcriptional Regulation Group, Integrative Biology Unit, New Delhi, India*
[2]*The Federal Polytechnic Ado-Ekiti, Department of Science Technology, Ekiti State Nigeria; bolaji@icgeb.res.in (*corresponding author)*
[3]*University of Ilorin, Department of Zoology, Cell Biology and Genetics unit, P.M.B. 1515, Ilorin Kwara State, Nigeria*

Abstract

Digit ratio (2D:4D) denotes the relative length of the second and fourth digits. There are contradicting reports on its relationship with ethnicity/race, whereas convincing studies show it is related to obesity. This cross-sectional study was undertaken to demystify ethnic difference in 2D:4D ratio and to analyze its relationship with obesity among adults in Ilorin Nigeria. The cross-sectional study included 701 individuals. Finger lengths were measured with electronic calipers and other anthropometric traits were measured with standard procedure. Student *t* test and one-way ANOVA were used to detect differences among groups and relationship was computed with Pearson correlation. The receiver operator characteristic curves were used to detect the diagnostic effect of 2D:4D for obesity. The obtained results showed sexual dimorphism in 2D:4D ratio and other anthropometrics at $p < 0.01$. Obesity was associated with significantly higher mean of 2D:4D in both genders (female 0.9814 ± 0.012:0.9700 ± 0.012; male 0.9700 ± 0.010:0.9592 ± 0.010 at $p < 0.001$). The area under the curve was 0.753 (95% CI 0.677-0.829, $p < 0.01$) and 0.798 (95% CI 0.756-0.804, $p < 0.01$) in female and male R2D:4D respectively for obesity, implying that 2D:4D might be a surrogate marker for obesity in future. No significant difference was found in 2D:4D among different ethnic groups studied ($p > 0.05$); this result proved that there was no ethnic specificity in 2D:4D ratio among study' participants. Thus, it can be reported that the digit ratio was related to high 2D:4D, but this cannot be said for different ethnic groups. The results imply that 2D:4D might be a good surrogate indicator for obesity, but not ethnicity.

Keywords: digit ratio, ethnic, obesity, sexual dimorphism, surrogate

Introduction

The ratio of second-to-fourth digit lengths (2D:4D) has been highlighted as a potentially useful phenotypic marker of steroid exposure inside utero in vertebrates (Berenbaum *et al*., 2009). The relationship between 2D:4D and some adult behavioral and physiological consequences had been reported by McIntyre (2006). Evidence for an association between 2D:4D and reproductive success (Auger and Eustache, 2011) and breast cancer risk and age at onset of breast cancer (Muller *et al*., 2012) had been also shown. Even more, 2D:4D had been implicated in identifying risk of cardiovascular diseases (Manning and Bundred, 2001; Fink *et al*., 2003; 2006). Many studies have shown a relationship between 2D:4D and obesity measure (Finks *et al*., 2003; 2006; Abba *et al*., 2012; Oyeyemi *et al*., 2014). Since 2D:4D was determined prenatally and relatively stable throughout the life span (Malas *et al*., 2006; Trivers *et al*., 2006), it can be assumed it could be used as a putative marker for obesity at any stage in life.

Ilorin is usually known as a city of peace and harmony; the capital of Kwara State, North Central Nigeria, it lies on longitude 4.15˚E and between latitudes 4.35˚N and 8.30˚N of the Equator. Apart from the indigenous people who are predominantly Yoruba and the Yoruba speaking Fulanis residing in the town, there are other people of various tribes and ethnic groups such as the Hausas, Igbos, Nupe, Barubas, Igbominas Okun-Yorubas among others, who are immigrants and settled in the town (Atomode, 2009). Thus, the city consists of divergent individuals from all parts of the country. The diversity of Nigerian population provides a unique opportunity to study the morphogenetic variations amongst the endogenous sub-populations and groups consisting of different tribes, languages and religious beliefs, living in different geographical and ecological

Received: 30 Aug 2016. Received in revised form: 11 Sep 2016. Accepted: 31 Oct 2016. Published online: 16 Dec 2016.

conditions. These sub-populations offer opportunities to study the anthropometric digit variations amongst these groups and tribes.

Previous studies suggested Body Mass Index (BMI), Waist-Height-ratio (WHtR) and Neck Circumference (NC) as simple screening measures for identifying overweight and metabolic syndrome (MetS) (Onat *et al.*, 2009; Ashwell *et al.*, 2012). Studies reported a significant relationship between 2D:4D and obesity measures (Fink *et al.,* 2003; 2006; Kyriakidis *et al.*, 2010), which implies that 2D:4D could be a proxy for obesity and MetS.

Earlier reports showed that 2D:4D might be affected by ethnicity (Manning *et al.*, 2004; 2007) and latitude of the study area (Loehlin *et al.*, 2006). Studies in this country reported no significant difference in 2D:4D among Yoruba and Igbo (Oladipo *et al.*, 2009) and Igbos and Urhobos (Oladipo *et al.*, 2006). But Gwunireama and Ihemelandu. (2010) had a contradictory result by reporting ethnic differences in 2D:4D in Andoni and Ikwerre ethnic groups within same geographical location in Niger delta and a recent report stating no significant difference in 2D:4D among men in Italy (Ancona) and Romania (Oradea) (Tomulescu and Nicoraș, 2015). Also, a study in China reported no significant differences in the 2D:4D between Han and ethnic minorities (Xu and Zheng, 2015).

Since there are contradicting results, it was sought to highlight the difference in 2D:4D among different ethnic groups residing in Ilorin and analyze its relationship with WHtR and BMI.

Materials and Methods

Subjects

A descriptive cross-sectional study design was used in this study. Multi-stage sampling technique was used in view of the large size of the study area to recruit 450 males (18-67 years old) and 251 females (18-55 years old) into the study. The study was carried out between February and August 2012 in Ilorin. Anthropometric variables and digit lengths were measured and data on socio-demographic characteristics were recorded into a structured questionnaire. All participants gave and signed a consent form before the study and the research was performed in accordance with the principle of Helsinki Declaration.

Finger length measurements

Digit length was measured as described by Manning *et al.* (1998). Briefly, participants were asked to keep their hands supine on the table surface with the palm facing up, the digits straight in the same plane and fingers opened in a posture of ease (not kept together tight under artificial pressure). Care was taken to ensure that details of major creases could be seen on the hands by removing finger ornaments. The length of each digit was measured on the ventral aspect of hand from the proximal crease to the tip of the second and fourth fingers. In cases where there were two creases at the base of ring finger, the most proximal crease was chosen for the measurement. The length of both left and right hands were measured using an electronic digital caliper (Fh, China) measuring to 0.01 mm with the pointers on the caliper just touching the middle point of proximal crease and tip of second and fourth fingers. All measurements of digit length were made twice with digits completely protracted. The average of the two measurements was taken. The digit ratio (2D:4D) was calculated by dividing the length of the 2nd digit by that of the 4th.

Anthropometric measurements

Body weight was measured to nearest 0.1 kg using a well-calibrated, mechanical personal scale (Camry scale, model BR-9011). The subjects were weighed barefoot, wearing minimal clothing (T-shirt and trousers or blouse and skirt, and underwear), with the feet together in the centre of the weighing scales and the head looking forward. The scales were checked before each measurement for zero adjustment and standardized.

Body height was measured to the nearest 0.1 cm using a portable stadiometer (Seca 213), which consisted of an anthropometer with a simple headboard. During height measurements, the subjects were made to stand upright without shoes and head held erect such that the external auditory meatus and the lower border of the eye were in one horizontal plane (Frankfurt plane). Back of the subjects were positioned against the instrument and heels touching the floor plate of the stadiometer with knees and legs together, and arms hanging naturally by the side. A movable headboard was brought against the crown of the head and the height measurement read off at maximum inspiration.

Body mass index (BMI) was calculated as weight (kg) divided by height (m) squared (kg/m^2).

Waist circumference (WC) was measured midway between the lowest rib and the iliac crest after exhaling, with the person standing without suppressing the skin, using an inextensible tape (measured to the nearest 0.1cm). The measurement of WC was performed one time for each subject.

The ratio of weight-height (WHtR) was calculated as WC (cm) divided by height (cm).

Neck circumference (NC) was measured in the midway of the neck, between the mid-cervical spine and mid-anterior neck to 0.5 cm, if palpable, just below the laryngeal prominence (Onat *et al.*, 2009).

The study was explained to potential participants and they were informed that the survey was completely voluntary. Their consents were sought before they were allowed to participate in the study. Subjects with injuries or deformities in any of the digits and those that cannot stand upright were left out of the study. Individuals that are not living in Ilorin were also left out of the study.

Statistical analyses

Continuous variables were expressed as mean ± standard deviation (SD) and discrete variables as numbers and percentages. Differences were assessed by student *t*-test and one-way ANOVA, while Cohen's d was used to calculate effect sizes of group differences. One-tailed Pearson correlation coefficients were used for assessing the relationship between 2D:4D, as well as body weight, BMI, NC and WHtR, and partial correlations were calculated in order to remove confounding effects of body weight. ROCs mode was used to detect predicting 2D:4D cutoff for obesity. Statistical significance was accepted at P values less than 0.01 and 0.05. All statistical analyses were conducted using IBM SPSS (Statistical Package for Social Sciences, release 24.0) for Mac.

Results

Re-measurement reliability of 2D:4D

There was a strong significant correlation between 2D:4D calculated at first and second measurement of digit lengths (correlation coefficient: $p < 0.01$; right hand $r_1 = 0.945$; left hand $r = 0.931$) and intra class correlation coefficients (ICC) (95% CI) was 0.901 (0.799-0.942) and 0.892 (0.766-0.902) for right and left hand respectively at $p < 0.01$. Also, the differences in 2D:4D between-individuals were much greater than the difference within-individual. The results of the current study showed that 2D:4D reflected real differences between individuals and there was a high re-measurement reliability. All the 2D:4D ratios used in the analyses were mean values of the first and second measurements. Means of right and left 2D:4D recorded in the hereby study were significantly correlated ($r = 0.816$, $p < 0.01$).

Basic characteristics of the study subjects

The basic characteristics of the study population, anthropometric traits and digit ratio, stratified by gender are shown in Table 1. All anthropometric parameters measured were significantly higher in male than female respondents, except WHtR, but 2D:4D in both hands was higher in female. Since the analysed parameters were different based on gender, the analyses were stratified based on gender criteria.

As shown in Table 2, there was statistically significant higher anthropometrics within the obesity group when compared with normal in female and male at $p < 0.01$; this implied that obesity might be related to these traits in the hereby study' individuals.

Pearson's correlation coefficients, as measured by the anthropometric indices and MetS surrogate marker tested showed a positive correlation with both hands 2D:4D ratio in both female and male respondents (Table 3). For male, the highest (0.616) and the lowest (0.370) correlation coefficients were recorded for BMI and weight respectively, while correlation coefficients for BMI and NC for female were noted between 0.497 and 0.283 respectively. A significant positive partial correlation between 2D:4D and all anthropometrics was also observed after age groupinig.

Lastly, as shown in Table 4, there was no significant difference in 2D:4D and other anthropometrics among different studied tribes in Ilorin, thus no tribe difference in 2D:4D was reported within the current study.

It was determined 2D:4D optimal cutoff points for obesity using ROCs with varying area under the curve, sensitivity and specificity of 2D:4D in female and male, as shown in Table 5. The optimal cutoff point of digit ratio for obesity categorization was 0.976 with sensitivity and specificity of 67.3% in female R2D:4D and 0.963; 67% and 67.4% sensitivity and specificity respectively in male R2D:4D.

Discussion

The hereby study showed sexual dimorphism in 2D:4D ratio, with female having higher ratio than male; this result is incongruent with earlier studies from Nigeria and other parts of the world (Fink *et al.*, 2006; Manning *et al.*, 2007;

Table 1. Characteristics of the study population

	Female (251)	Male (450)	p
Age (years)	25.90 (6.50)	29.19 (10.00)	<0.01
R2D:4D	0.9724 (0.0129)	0.9618 (0.0111)	<0.01
L2D:4D	0.9650 (0.0139)	0.9509 (0.0114)	<0.01
BMI (kg/m^2)	22.601 (3.084)	23.269 (2.59)	0.02
Weight (kg)	59.49 (10.11)	67.81 (11.21)	<0.01
NC (cm)	30.29 (4.98)	32.64 (5.05)	<0.01
WHtR	0.4106 (0.061)	0.4180 (0.052)	0.09

Data are presented as mean (SD). Student T-test was used to compare geometric mean levels across obesity category.
BMI; Body mass index, NC; Neck circumference, WHtR; Waist to height ratio, CES; Cohen's effect size, R2D:4D, Ratio of right hand second to fourth digit and L2D:4D, Ratio of left hand second to fourth digit

Table 3. The coefficient of correlation in anthropometric traits and 2D:4D

		Female	Male
Weight (kg)	R2D4D	0.424**	0.467**
	L2D4D	0.346**	0.370**
BMI (kg/m^2)	R2D4D	0.497**	0.616**
	L2D4D	0.397**	0.548**
NC (cm)	R2D4D	0.283**	0.416**
	L2D4D	0.410**	0.418**
WHtR	R2D4D	0.320**	0.448**
	L2D4D	0.452**	0.458**

** Correlation is significant at the 0.01 level (2-tailed).
BMI; Body mass index, NC; Neck circumference, WHtR; Waist to height ratio, R2D:4D, Ratio of the right-hand second to the fourth digit and L2D:4D, Ratio of the left-hand second to the fourth digit

Table 2. Differences in anthropometrics stratified by obesity status in female and male under study

	Female*			Male*		
	Normal (199)	Obesity (52)	CES	Normal (344)	Obesity (106)	CES
R2D:4D	0.9700 (0.012)	0.9814 (0.012)	0.950	0.9592 (0.010)	0.9700 (0.010)	1.08
L2D:4D	0.9628 (0.013)	0.9732 (0.015)	0.741	0.9485 (0.010)	0.9588 (0.013)	0.89
Weight (kg)	56.04 (6.91)	72.73 (9.52)	2.01	64.02 (8.58)	80.10 (9.87)	1.74
BMI (kg/m^2)	21.47 (2.23)	26.94 (1.77)	2.72	22.21 (1.77)	26.69 (1.70)	2.58
NC (cm)	29.17 (4.41)	34.57 (4.72)	1.18	31.27 (4.34)	37.11 (4.60)	1.29
WHtR	0.3965 (0.053)	0.4650 (0.062)	1.19	0.4032 (0.042)	0.4662 (0.055)	0.88

Data are presented as mean (SD). Student T-test was used to compare geometric mean levels across obesity category.
BMI; Body mass index, NC; Neck circumference, WHtR; Waist to height ratio, CES; Cohen's effect size, R2D:4D, Ratio of right hand second to fourth digit and L2D:4D, Ratio of left hand second to fourth digit. Obesity was defined as BMI ≥ 25.00 kg/m^2; *p was considered significant at the 0.01 level

Table 4. Differences in anthropometrics stratified by tribe

	Female				Male			
	H (67)	I (86)	Y (98)	p	H (149)	I (150)	Y (151)	p
R2D:4D	0.9757 (0.013)	0.9714 (0.013)	0.9710 (0.013)	0.051	0.9613 (0.009)	0.9628 (0.012)	0.9613 (0.012)	0.403
L2D:4D	0.9686 (0.015)	0.9627 (0.014)	0.9644 (0.012)	0.032	0.9497 (0.011)	0.9516 (0.012)	0.9516 (0.012)	0.25
Weight (kg)	61.04 (9.97)	60.21 (10.56)	57.81 (9.65)	0.094	67.74 (10.12)	68.27 (11.13)	67.42 (12.33)	0.806
BMI (kg/m^2)	23.17 (3.14)	22.40 (3.21)	22.38 (2.91)	0.206	23.18 (2.23)	23.43 (2.58)	23.20 (2.92)	0.637
NC (cm)	30.00 (4.68)	30.86 (5.70)	29.99 (4.47)	0.423	32.33 (5.13)	32.40 (4.66)	33.19 (5.33)	0.261
WHtR	0.4104 (0.064)	0.4113 (0.065)	0.4102 (0.056)	0.993	0.4138 (0.051)	0.4160 (0.050)	0.4242 (0.056)	0.2

Data are presented as mean (SD). One-way ANOVA was used to compare geometric mean levels across obesity category
H; Hausa, I; Igbo, Y; Yoruba, BMI; Body mass index, NC; Neck circumference, WHtR; Waist to height ratio, R2D:4D, Ratio of right-hand second to fourth digit and L2D:4D, Ratio of left-hand second to the fourth digit

Table 5. ROC analysis for optimal cutoff point of digit ratio for obesity as measured by BMI*

		AUC	95% CI	Cutoff	Sensitivity	Specificity
Female	R2D4D	0.753	0.677-0.829	0.976	0.673	0.673
	L2D4D	0.684	0.606-0.762	0.966	0.596	0.598
Male	R2D4D	0.798	0.756-0.840	0.963	0.708	0.709
	L2D4D	0.755	0.705-0.804	0.951	0.67	0.674

*p was significant at the 0.01 level, AUC; Area under curve

Oyeyemi *et al.*, 2014; Xu and Zheng, 2015). The data of the current findings show no significant difference in 2D:4D among major ethnic groups (Igbo, Hausa and Yoruba) residing in Ilorin, whereas this result was incongruent with studies in Nigeria that examined differences in 2D:4D among Yoruba and Igbo (Oladipo *et al.*, 2009), Irobo and Igbo (Oladipo *et al.*, 2006) and China where Xu and Zheng (2015) reported no significant differences in the 2D:4D between Han and ethnic minorities. Gwunireama and Ihemelandu (2010) reported ethnic differences in 2D:4D among Andoni and Ikwerre ethnic groups of Niger delta and a recent report stated no difference in 2D:4D among men in Ancona, Italy and Oradea, Romania (Tomulescu and Nicoras, 2015). 2D:4D ratio reported in Ilorin might not necessarily be influenced by ethnicity or tribe, but probably by race from different countries as reported by Manning *et al.* (2007). Thus, it is possible that significant differences are more likely to be observed when comparing races from different countries along different latitude than ethnic groups or tribal groups (Loehlin *et al.*, 2006). In the view of such contradicting results, more studies are needed to verify this claim.

Previous studies suggested BMI, WHtR and NC as a simple screening measure for identifying overweight and metabolic syndrome (MetS) (Onat *et al.*, 2009; Ashwell *et al.*, 2012). Significant positive correlations between BMI and body weight, and also WHtR when weight was controlled, support this measure. Moreover, the positive correlation between 2D:4D ratios and BMI and WHtR suggest that digit ratio (2D:4D) could be suggestive for overweight and being prone to metabolic syndrome; this may be an additional simple screening measure. Also, earlier studies by Manning and Bundred (2001) and Manning *et al.* (2003) reported that men with low 2D:4D ratios tend to have their first myocardia infarction (MI) later in life than men with high 2D:4D ratio, whereas MI was strongly linked with 2D:4D (Kyriakidis *et al.*, 2010). The present findings of positive correlations between 2D:4D ratios and BMI and WHtR in men suggest a possible predisposition towards cardiovascular health disease (CHD) via 2D:4D as proxy to early sex steroid exposure. The authors were also buttressed by the significant correlation between 2D:4D and NC, which was in agreement with data reported by Fink *et al.* (2006).

Based on the currently obtained results it can be reported a fair to good AUC, sensitivity and specificity in the cutoff for 2D:4D for obesity, similar to results of Wu *et al.* (2013). This opens up a window of opportunities for researchers to explore the possibility of using 2D:4D as surrogate marker for obesity.

The outcome of the current study suggests there may be a link between early-life androgen exposure and the risk of obesity. A foundation of this theory can be found also into a study on 2D:4D ratio proposed by Manning *et al.* (1998) that might serve as a noninvasive study for prenatal hormonal (androgen) conditions, implying that 2D:4D might be predictive for some anthropometric traits. The ratio can be relevant due to the fact that 2D:4D values tend to be stable throughout lifespan (Trivers *et al.*, 2006; Galis *et al.*, 2010).

The current report can be supported or disputed with more robust sample size for accurate 2D:4D, the data obtained can be useful for future investigations upon ethnic differences in Nigeria, or studies using in 2D:4D and its relationship with metabolic syndrome indices. The results might be useful in creating a database that compares subjects from different geographic area worldwide.

Conclusions

In conclusion, 2D:4D showed no ethnic differences amongst the Nigerian Igbos, Hausas and Yorubas tribes residing in Ilorin metropolis, implying that digit ratio might be determined by the environment rather than the ethnic group. Evermore, a robust study is needed to verify and substantiate this claim. Moreover, measurement of 2D:4D ratio at any stage in life could serve as a simple and practical measure of obesity and MetS risk factors among adult males in Ilorin North-central Nigeria.

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