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Reference values of body adiposity measures and hand digit ratio (2D:4D) for dyslipidemia: A case study of the Hausa ethnic group in Kano, Nigeria

Abdullahi Yusuf Asuku, Barnabas Danborno[1], Shehu Abubakar Akuyam[2], James Abrak Timbuak[1], Abdurrazaq Mohammed[3], Lawan Hassan Adamu

Department of Anatomy, Faculty of Basic Medical Sciences, College of Health Sciences, Bayero University, [3]Department of Internal Medicine, Aminu Kano Teaching Hospital, Kano, Kano State, [1]Department of Anatomy, Faculty of Basic Medical Sciences, College of Health Sciences, Ahmadu Bello University, [2]Department of Chemical Pathology, Faculty of Allied Health Sciences, College of Health Sciences, Ahmadu Bello University, Zaria, Nigeria

Address for correspondence:
Dr. Abdullahi Yusuf Asuku, Department of Anatomy, Faculty of Basic Medical Sciences, College of Health Sciences, Bayero University, Kano, PMB 3011, Kano State, Nigeria.
E-mail: abdullahiyusufasuku@gmail.com

Abstract:

BACKGROUND: Dyslipidemia is an important component of the metabolic syndrome (MetS) and constitutes a leading cause of cardio-metabolic-related deaths globally. There are currently ongoing efforts to define upper reference values (URVs) of anthropometric parameters for the components of MetS in different ethnic groups.

OBJECTIVES: The aim of the present study was to determine URV of digit ratio (2D:4D) and body adiposity measures for dyslipidemia in Hausas of Kano.

MATERIALS AND METHODS: This was a cross-sectional observational study involving 465 (266 males and 199 females) Hausas of Kano, with a mean age of 34.4 years and 32.0 years for males and females, respectively. Systematic random sampling technique was employed. Adiposity indices were measured using standard anthropometric techniques. Serum lipids were measured using standard laboratory analyses of overnight fasting serum sample. Data were described using a mean and SD. Receiver operating characteristic (ROC) curve and Younden Index were used to determine URV.

RESULTS: In male and female participants, the waist-to-hip ratio had the largest area under the ROC curve (AUROCC) with the highest sensitivity and specificity for total cholesterol, triglyceride, and high-density lipoprotein cholesterol, while neck circumference and body adiposity index had the lowest AUROC curve with lower sensitivity and specificity.

CONCLUSION: Hand digit ratio (2D:4D) has a URV for dyslipidemia. The URV of adiposity indices for Hausa ethnic group of Kano for abnormal serum lipids is different from the popularly adopted URV for estimating the risk of MetS.

Keywords:

Adiposity indices, dyslipidemia, Hausa ethnic group, metabolic syndrome

Introduction

Abnormal serum lipid commonly described as dyslipidemia is an important component of the metabolic syndrome (MetS) (Akuyam *et al.*, 2009; Moller and Kaufman, 2005). MetS is a complex medical disorder characterized by hyperglycemia, dyslipidemia, and hypertension in addition to obesity (Moller and Kaufman, 2005; Owolabi *et al.*, 2016). It is a leading cause of morbidity and mortality in both developed and developing nations and therefore, a subject of recent discussion among scientist and clinician (Moller and Kaufman, 2005; Akuyam *et al.*, 2009). The diagnosis of MetS often involves a number of invasive laboratory investigations in

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additions to the physical examination, which may not be pragmatic in resource-limited settings or in large-scale epidemiological studies. This has made clinicians and community health physicians to explore cheap and easily measurable anthropometric indices in the risk assessment for the syndrome. Accordingly several anthropometric variables, especially those of body adiposity (Bergman *et al*., 2011; Mbanya *et al.*, 2015) and recently, the ratio of second-to-fourth digit of the hand (Ravinder and Manju, 2016; Asuku *et al*., 2017) have been proven to correlate with the syndrome and its components.

Despite the robust correlations between body adiposity indices and MetS documented in the literature, ethnicity is well-known to significantly modulate the interrelationship between the two. On this note, it is now generally accepted that anthropometric risk criteria, including upper reference values (URVs) should be race- or ethnic-specific. Consequently, URV for defining MetS phenotype now exist for Asians (Tulloch-Reid *et al.*, 2003), Europeans (Tulloch-Reid *et al*., 2003), Arabs (Al-Rubean *et al.*,2017), and a few African population (Prinsloo *et al.*, 2011; Crowther and Norris, 2012). However, due to the lack of population-specific data, European URV are still currently being adopted to predict MetS and its components in many African populations, including Nigerians.

Furthermore, most documented attempts to determine URV for MetS often proposed a single reference value for all the components of MetS. We, therefore, hypothesize in the present study that, in addition to the wide ethnic variation that exists in the URV of anthropometric indices for MetS, the individual components of the MetS (dyslipidemia, hypertension, and hyperglycemia) do not have the same absolute URV. The present study, therefore, seeks to investigate the URV for dyslipidemia in the Hausa ethnic group of Kano, Nigeria.

Materials and Methods

Study area and population

Systematic random sampling technique was employed in selecting 465 original Hausa population of Kano based on a history of at least two parental generations being Hausas from Kano. Participants were recruited from the outpatient units of Murtala Muhammad Specialist Hospital, Khadija Memorial Hospital and the old campus of Bayero University, Kano as urban participants and from Shehu Uran clinic Gabasawa, General Hospital Dawakin – Tofa as rural participants.

The study included only participants in the age range of 18–68 years. Participants with congenital and/or acquired deformity of the spine and those on medications, which affect adiposity or MetS components were, however, excluded from the study.

Ethical approval was obtained from the Kano state hospitals management board (copy attached) and written informed consent was obtained from the participants.

Anthropometric measurements

Height was measured to the nearest 0.1 cm as the vertical distance between the standing surface and the vertex of the head while the subject was standing erect in the frank forth plane and without shoes using a stadiometer (Seca 206IN, Body Meter stadiometer, calibrated in meters, USA). The weight was measured in kilograms using a digital weighing scale (Seca 769 Digital weighing scale, calibrated in kilograms, USA) while the subject is in light clothes. Body mass index (BMI) was calculated by dividing the weight (kg) by the square of the height (m^2) and expressed in kg/m^2. Waist circumference (WC) was measured in centimeter with a nonstretchable plastic tape (Butterfly model, made in China, graduated in cm, 0–150 cm) horizontally placed over the abdomen at the narrowest point between the lowest rib and the iliac crest (Lean *et al*., 1995). Hip circumference (HC) was measured while the subject was standing erect with the feet fairly close together; pockets emptied and the tape passed around the point with the maximum circumference over the bottom (Lean *et al*., 1995). Digit lengths were measured on the ventral surface of the hand from the basal crease of the digit to the tip of the finger using a digital sliding caliper (MicroMak, USA) measuring to 0.01 mm as shown in plate III and reported on the questionnaire. This measurement has been reported to have a high degree of repeatability (Manning *et al*., 1998). Neck circumference (NC) was measured in centimeter with a nonstretchable plastic tape horizontally placed over the unclothed neck at the level of the thyroid cartilage (Lean *et al*., 1995). Body adiposity index (BAI) was obtained using the formula proposed by Bergman *et al.* (2011). This formula has been shown to be a good measure of central adiposity in some populations (Bergman *et al.*, 2011).

$$\text{BAI} = \frac{\text{Hip circumference (cm) - 18}}{\text{Height (m)}^{1.5}}$$

Blood collection and serum analysis for lipids

For the estimation of serum lipids, blood specimen was collected from the participants after 10–12 h of fasting through superficial veins of the upper limb. From each selected subject, 5 ml of venous blood sample was collected using a sterile 21G needle fitted with syringe. Blood collection was done during the morning hours to avoid the effect of diurnal variation or circadian rhythm in the blood parameters to be measured. The standard technique of venipuncture and universal safety precaution was employed. Blood sample was transferred into a plain blood specimen bottle and allowed to stand until it was properly clotted.

The blood samples were preserved in an ice pack insulating container to preserve the temperature and then transported to the laboratory immediately after each exercise of sample collection. Sample was then centrifuged at 300 rpm for 5 min after which serum was separated and immediately used for analysis.

Total cholesterol (TC) concentration was measured using the enzymatic method by Wybenga, *et al*. (1970).

In this method, TC was measured enzymatically in serum in a series of coupled reactions that hydrolyze cholesteryl esters and oxidize the 3-OH group of cholesterol. One of the reaction by-products, H_2O_2 is measured quantitatively in a peroxidase catalyzed reaction that produces a color. Absorbance is measured at 500 nm. The color intensity is proportional to cholesterol concentration.

$$\text{Cholesterolester} \xrightarrow{\text{CH Esterse}} \text{Cholesterol} + \text{FattyAcid}$$

$$\text{Cholesterol} + O_2 \xrightarrow{\text{CH Oxidase}} \text{Cholesterol - 4en - 3one} + H_2O_2$$

$$2H_2O_2 + 4AAP + \text{phenol} \xrightarrow{\text{Peroxides}} \text{Quinoneimine} + 4H2O \text{ (endpoint) RED}$$

Three test tubes were labeled as test, Standard and Blank and to each test tube, 1000 µl of the reagent R1 was added. Ten microliters sample was added to test and 10 µl Standard to Standard tube and 10 µl distilled water to Blank. It was then mixed well and incubated for 5 min at 37°C or at room temperature for 15 min. Reading was taken at 530 nm.

The results were calculated as follows:

$$\text{Conc.of test} = \frac{\text{Absorbance of Test x Concentration of standard}}{\text{Absorbance of STD}}$$

Where the concentration of the TC standard is 5.17 mmol/L.

Serum high-density lipoprotein cholesterol (HDL-C) concentrations was measured using enzymatic method by Wybenga, *et al*. (1970).

In the serum chylomicrons, LDL is precipitated in the presence of phosphotungstic acid and magnesium chloride and the supernatant is treated as cholesterol.

In to a clean test tube, 0.5 ml serum + 0.5 ml HDL reagent was mixed and allowed to stand for 10 min. It was then centrifuged for 20 min at 2000 rpm or 10 min at 4000 rpm. Cholesterol reagent 1000 µl was dispensed into three cleaned test tubes labeled blank, standard and sample. 50 µl of supernatant was dispensed into tube sample, 50 µl of standard was dispensed into the standard tube, and 50 µl dispensed in to blank tube. All were mixed and incubated at 37°C for 5 min and absorbance was read at 530 nm.

The results were calculated as follows:

$$\text{Conc.of test} = \frac{\text{Absorbance of Test x Concentration of standard}}{\text{Absorbance of STD}}$$

where the concentration of the TC standard is 5.17mmol/L.

Serum TG concentration was measured using enzymatic method proposed by Wybenga *et al*. (1970).

Serum triglyceride (TGs) was measured enzymatically using a series of coupled reactions, in which TGs are hydrolyzed to produce glycerol. Glycerol is then oxidized using glycerol oxidase, and H_2O_2, one of the reaction products, was then measured as described above for cholesterol. Absorbance was measured at 500 nm.

$$\text{Triglycerides} + H_2O_2 \xrightarrow{\text{Lipopoteinlipase}} \text{Glycerol} + \text{Fatty acid}$$

$$\text{Glycerol} + \text{ATP} \xrightarrow{\text{Glycerol Kinase}} \text{Glycerol-3-phosphate} + \text{ADP}$$

$$\text{Glycerol - 3 - } PO_4 + O_2 \xrightarrow{\text{GPO}} \text{DHAP} + H_2O_2$$

$$H_2O_2 + 4AAP \xrightarrow{\text{POD}} \text{P - Chloropheol Red quinoneimine}$$

Serum TG concentration was then calculated as follows:

$$\text{Conc.of test} = \frac{\text{Absorbance of Test x Concentration of standard}}{\text{Absorbance of STD}}$$

where the concentration of the TGs standard is 2.28 mmol/L.

Data were described using mean and standard deviation. Receiver operating characteristic (ROC) curve and the Younden Index were used to determine the percentage of area under the ROC curve (AUROCC) with the sensitivity and specificity of each anthropometric parameter. Younden's index was used to determine the optimal cut-off value of digit ratio (2D:4D) and the adiposity indices for TC, TG, and HDL-C. The discriminatory strength of the anthropometric variables was classified based on the percentage of area covered under the

ROC curve as excellent (>90%), very good (80%–90%), good (70%–80%), weak (50%–70%), and poor (<50%).

Results

Table 1 shows descriptive statistics of age, digit ratio, adiposity indices, and serum lipids of participants. From Figures 1 and 2 and Tables 2 and 3 which show the ROC curve and its interpretation for TC in both males and females, it can be observed that only waist-to-hip ratio (WHR) in both sexes and WC in females had an excellent discriminatory strength for serum TC with AUROCC of 90%–100%. Digit ratio (2D:4D) of both hands, NC, WHtR and WC in males were very good discriminator of TC with AUROCC of between 80%–90%, BMI, HC, and BAI were relatively weak discriminator of TC having AUROCC of <80%. The URV of BMI, WC, HC, NC, WHR, WHtR, BAI, R2D:4D, and L2D:4D for TC were 24.1 kg/m^2, 87.65 cm, 93.95 cm, 37 cm, 0.95, 0.48, 26.57, 0.98, 0.99 and 22.821 kg/m^2, 87.65 cm, 89.8 cm, 33.2 cm, 0.9, 0.53, 26.61, 0.97, 0.99 in males and females, respectively.

From Figures 3 and 4 and Tables 4 and 5 which show the ROC curve and its interpretation for HDL-C in the participants, it can be observed that the discriminatory strength of L2D:4D, WHR and WHtR for HDL-C were excellent (>90%) in females, while in males, only WHR had AUROCC of >90% BMI, HC, and BAI were also observed to be relatively weaker discriminator of TC in both sexes, having AU ROC of <80%. The URV of BMI, WC, HC, NC, WHR, WHtR, BAI, R2D:4D and L2D:4D for HDL-C were

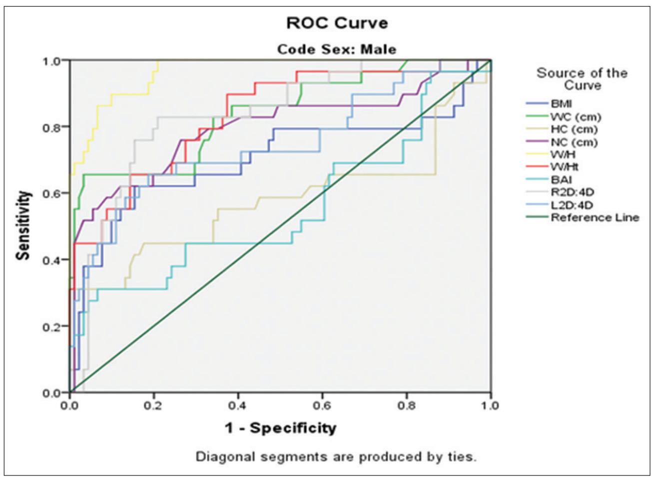

Figure 1: ROC curve for the determination of URV of digit ratio, BMI, WC, HC, WHR, WHtR, BAI for TC in male participants. ROC - Receiver operating characteristic, URV - Upper reference value, BMI - Body mass index, WC - Waist circumferences, HC - Hip circumferences, BAI - Body adiposity index, TC - Total cholesterol, WHR- Waist-to-hip ratio, WHtR - Waist-to-height ratio

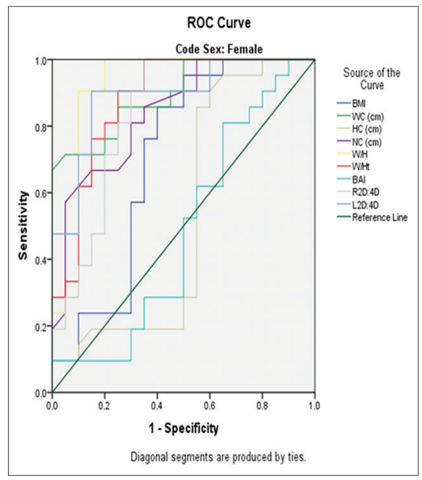

Figure 2: ROC curve for determination of URV of digit ratio, BMI, WC, HC, WHR, WHtR, BAI for TC in female participants. ROC - Receiver operating characteristic, URV - Upper reference value, BMI - Body mass index, WC - Waist circumferences, HC - Hip circumferences, BAI - Body adiposity index, TC - Total cholesterol, WHR- Waist-to-hip ratio, WHtR - Waist-to-height ratio

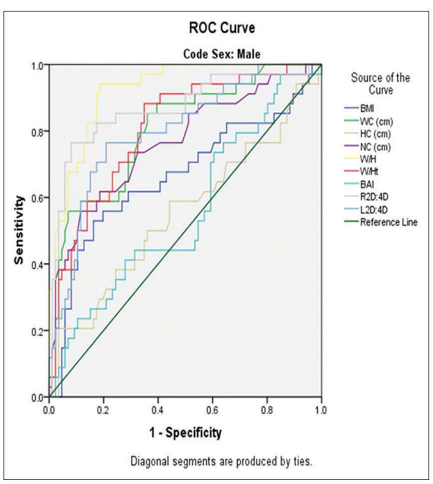

Figure 3: ROC curve for the determination of URV of digit ratio, BMI, WC, HC, WHR, WHtR, BAI for HDL-C in male participants. ROC - Receiver operating characteristic, URV - Upper reference value, BMI - Body mass index, WC - Waist circumferences, HC - Hip circumferences, BAI - Body adiposity index, WHR- Waist-to-hip ratio, WHtR - Waist-to-height ratio, HDL-C - High-density lipoprotein cholesterol

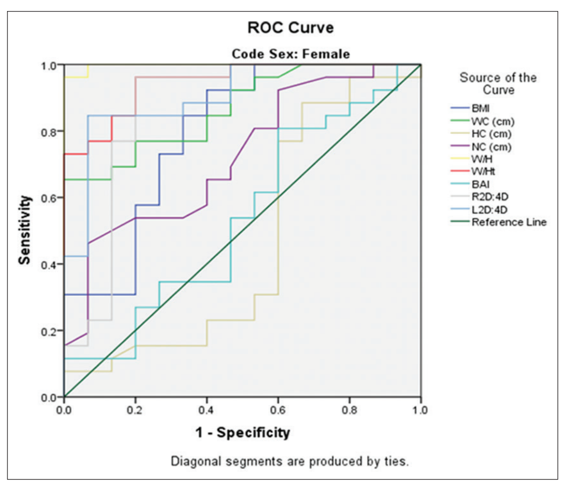

Figure 4: ROC curve for determination of URV of digit ratio, BMI, WC, HC, WHR, WHtR, BAI for HDL-C in female participants. ROC - Receiver operating characteristic, URV - Upper reference value, BMI - Body mass index, WC - Waist circumferences, HC - Hip circumferences, BAI - Body adiposity index, WHR- Waist-to-hip ratio, WHtR - Waist-to-height ratio, HDL-C - High-density lipoprotein cholesterol

Table 1: Description of age, digit ratio, adiposity indices, and serum lipids of participants

Variables	Male (*n*=266)		Female (*n*=199)	
	Mean±SD	Minimum-maximum	Mean±SD	Minimum-maximum
Age	34.45±13.52	18-68	32.06±15.18	18-68
BMI (kg/m²)	21.98±3.93	14.52-34.33	22.19±4.70	12.96-39.15
WC (cm)	77.28±11.17	57-111	76.02±13.00	51-118.5
HC (cm)	87.01±7.80	72.1-109.9	88.96±9.86	65.6-136
NC (cm)	34.99±2.29	30-42	31.58±2.46	26.5-39.5
W/H	0.89±0.08	0.71-1.11	0.85±0.11	0.65-1.25
W/Ht	0.46±0.06	0.34-0.65	0.48±0.08	0.30-0.72
BAI	21.60±3.71	13.88-33.90	26.61±4.62	15.38-45.58
R2D:4D	0.96±0.03	0.79-1.05	0.99±0.03	0.86-1.07
L2D:4D	0.96±0.03	0.85-1.10	0.99±0.03	0.92-1.09
TC (mg/dl)	174.35±32.31	123.7-256.10	187.32±43.85	127.3-290.7
HDL (mg/dl)	44.10±6.32	28-54.10	47.83±6.71	38.9-60.6
TG (mg/dl)	117.18±31.76	74.3-196.5	121.83±29.25	80.4-165

BMI - Body mass index, WC - Waist circumference, HC - Hip circumference, NC - Neck circumference, W/H - Waist-to-hip ratio, W/Ht - Waist-to-height ratio, BAI - Body adiposity index, R - Right hand, L - Left hand, 2D:4D - Second-to-fourth digit ratio, TC - Total cholesterol, HDL - High-density lipoprotein cholesterol, TG - Triglycerides, SD - Standard deviation

Table 2: Sensitivity, specificity, and upper reference values for the anthropometric parameters for total cholesterol (males)

Variables	Area	SE	Significant	Lower CI	Upper CI	Cut off	Sensitivity	Specificity	YI
BMI	0.73	0.08	0.002	0.573	0.888	24.10	0.71	0.81	1.51
WC (cm)	0.856	0.054	<0.0001	0.751	0.962	87.65	0.76	0.91	1.68
HC (cm)	0.628	0.087	0.091	0.458	0.798	93.95	0.53	0.81	1.34
NC (cm)	0.819	0.056	<0.0001	0.71	0.928	37.00	0.71	0.83	1.54
W/H	0.937	0.026	<0.0001	0.886	0.988	0.95	0.88	0.87	1.76
W/Ht	0.837	0.056	<0.0001	0.727	0.946	0.48	0.88	0.70	1.58
BAI	0.581	0.083	0.284	0.419	0.743	26.57	0.35	0.91	1.27
R2D:4D	0.879	0.042	<0.0001	0.798	0.961	0.98	0.88	0.83	1.71
L2D:4D	0.845	0.057	<0.0001	0.734	0.956	0.99	0.88	0.80	1.68

BMI - Body mass index, WC - Waist circumferences, HC - Hip circumferences, NC - Neck circumferences, W/H - Waist-to-hip ratio, WHt - Waist-to-height ratio, R2D:4D - Right second-to-fourth digit ratio, L2D:4D - Left second-to-fourth digit ratio, SE - Standard error, YI - Youden's index, BAI - Body adiposity index

Table 3: Sensitivity, specificity, and upper reference values for the anthropometric parameters for total cholesterol (females)

Variables	Area	SE	Significant	Lower CI	Upper CI	Cut off	Sensitivity	Specificity	YI
BMI	0.70	0.09	0.0266	0.53	0.87	22.82	0.86	0.60	1.46
WC (cm)	0.90	0.05	0.0000	0.80	0.99	87.65	0.67	1.00	1.67
HC (cm)	0.53	0.10	0.7346	0.34	0.73	89.80	0.86	0.45	1.31
NC (cm)	0.84	0.06	0.0002	0.72	0.96	33.20	0.57	0.95	1.52
W/H	0.92	0.05	0.0000	0.82	1.00	0.90	0.90	0.90	1.80
W/Ht	0.88	0.05	0.0000	0.77	0.99	0.53	0.90	0.75	1.65
BAI	0.49	0.09	0.8756	0.30	0.67	26.61	0.81	0.35	1.16
R2D:4D	0.84	0.07	0.0002	0.71	0.97	0.97	1.00	0.65	1.65
L2D:4D	0.89	0.05	0.0000	0.79	0.99	0.99	0.90	0.85	1.75

BMI - Body mass index, WC - Waist circumferences, HC - Hip circumferences, NC - Neck circumferences, W/H - Waist-to-hip ratio, WHt - Waist-to-height ratio, R2D:4D - Right second-to fouth digit ratio, L2D:4D - Left second-to fouth digit ratio, SE - Standard error, YI - Youden's index, BAI - Body adiposity index

24.1 kg/m², 78.95 cm, 100.15 cm, 37 cm, 0.91, 0.46, 23.34, 0.98, 0.98 and 21.821 kg/m², 87.25 cm, 88.5 cm, 33.2 cm, 0.86, 0.52, 26.61, 0.97, 0.99 in males and females, respectively.

From Figures 5 and 6 and Tables 6 and 7 which show the ROC curve and its interpretation for TG in the study participants, it can be seen that only WHR in male participants showed excellent (AUROCC >90%) discriminatory strength for TG. The URV of BMI, WC, HC, NC, WHR, WHtR, BAI, and R2D:4D and L2D:4D for serum TG were 24.1 kg/m², 86.6 cm, 90.1 cm, 36.4 cm, 0.91, 0.5, 26.3, 0.98, 1.00 and 22.731 kg/m², 89.1 cm, 82.9 cm, 32.9 cm, 0.97, 0.52, 29.74, 0.97, and 1.00 in males and females, respectively.

Discussion

This cross-sectional observational study on a sample of Hausas in Kano, Nigeria, reveals that hand digit

Table 4: Sensitivity, specificity, and upper reference values for the anthropometric parameters for high-density lipoprotein (males)

Variables	Area	SE	Sig	Lower CI	Upper CI	Cut off	Sensitivity	Specificity	YI
BMI	0.66	0.06	0.0053	0.54	0.78	24.10	0.53	0.84	1.37
WC (cm)	0.80	0.04	0.0000	0.72	0.89	78.95	0.85	0.64	1.49
HC (cm)	0.55	0.06	0.3871	0.43	0.67	100.15	0.21	0.97	1.17
NC (cm)	0.76	0.05	0.0000	0.66	0.86	37.00	0.56	0.88	1.44
W/H	0.92	0.02	0.0000	0.88	0.97	0.91	0.94	0.81	1.76
W/Ht	0.81	0.04	0.0000	0.72	0.89	0.46	0.88	0.65	1.53
BAI	0.55	0.06	0.3514	0.44	0.67	23.34	0.41	0.72	1.13
R2D:4D	0.87	0.04	0.0000	0.79	0.95	0.98	0.76	0.92	1.68
L2D:4D	0.80	0.05	0.0000	0.71	0.89	0.98	0.76	0.79	1.56

BMI - Body mass index, WC - Waist circumferences, HC - Hip circumferences, NC - Neck circumferences, W/H - Waist to hip ratio, WHt - Waist to height ratio, R2D:4D - Right second to fouth digit ratio, L2D:4D - Left second to fouth digit ratio, SE - Standard error, YI - Youden's index, BAI - Body adiposity index

Table 5: Sensitivity, specificity and upper reference values for the anthropometric parameters for high-density lipoprotein (females)

Variables	Area	SE	Sig	Lower CI	Upper CI	Cut off	Sensitivity	Specificity	YI
BMI	0.79	0.08	0.0019	0.64	0.95	21.82	0.92	0.60	1.52
WC (cm)	0.87	0.05	0.0001	0.76	0.97	87.25	0.65	1.00	1.65
HC (cm)	0.46	0.11	0.6947	0.26	0.67	88.50	0.88	0.33	1.22
NC (cm)	0.72	0.08	0.0192	0.56	0.88	33.20	0.46	0.93	1.39
W/H	1.00	0.00	0.0000	0.99	1.00	0.86	0.96	1.00	1.96
W/Ht	0.95	0.03	0.0000	0.88	1.00	0.52	0.96	0.80	1.76
BAI	0.54	0.10	0.6847	0.35	0.73	26.61	0.81	0.40	1.21
R2D:4D	0.87	0.07	0.0001	0.72	1.00	0.97	0.96	0.80	1.76
L2D:4D	0.91	0.05	0.0000	0.81	1.00	0.99	0.85	0.93	1.78

BMI - Body mass index, WC - Waist circumferences, HC - Hip circumferences, NC - Neck circumferences, W/H - Waist to hip ratio, WHt - Waist to height ratio, R2D:4D - Right second to fouth digit ratio, L2D:4D - Left second to fouth digit ratio, SE - Standard error, YI - Youden's index, BAI - Body adiposity index

Table 6: Sensitivity, specificity and upper reference values of the anthropometric parameters for triglyceride (males)

Variables	Area	SE	Sig	Lower CI	Upper CI	Cut off	Sensitivity	Specificity	YI
BMI	0.68	0.07	0.0064	0.53	0.82	24.10	0.65	0.84	1.49
WC (cm)	0.81	0.05	0.0000	0.71	0.91	86.60	0.65	0.87	1.53
HC (cm)	0.56	0.07	0.3361	0.42	0.70	90.10	0.58	0.65	1.23
NC (cm)	0.76	0.06	0.0000	0.64	0.88	36.35	0.65	0.82	1.47
W/H	0.92	0.02	0.0000	0.88	0.97	0.91	0.96	0.76	1.72
W/Ht	0.82	0.05	0.0000	0.73	0.91	0.50	0.69	0.85	1.54
BAI	0.56	0.07	0.3524	0.43	0.69	26.26	0.31	0.88	1.19
R2D:4D	0.75	0.06	0.0001	0.64	0.86	0.98	0.69	0.81	1.50
L2D:4D	0.74	0.06	0.0002	0.62	0.86	1.00	0.58	0.88	1.46

BMI - Body mass index, WC - Waist circumferences, HC - Hip circumferences, NC - Neck circumferences, W/H - Waist to hip ratio, WHt - Waist to height ratio, R2D:4D - Right second to fouth digit ratio, L2D:4D - Left second to fouth digit ratio, SE - Standard error, YI - Youden's index, BAI - Body adiposity index

ratio (2D:4D) and the anthropometric indices of adiposity have good discriminatory strength for serum lipids and therefore demonstrate URV for defining dyslipidemia. This finding may not be unconnected with the significant correlation between serum lipids and body adiposity measures which has long been documented (Schmidt *et al*., 1996; Shaw *et al.*, 2010; Amato and Giordano, 2014). However, the observations from the present study that 2D:4D has a discriminatory ability and even an URV for serum lipids may be fascinating. Recent studies have, however, reported the significant relationship of 2D:4D with many determinants of the MetS, adiposity inclusive. Accordingly, 2D:4D was shown to correlate with body adiposity measures among Europeans (Fink *et al.,* 2003), among Nigerians (Danborno *et al*., 2008; Oyeyemi *et al*., 2016; Asuku *et al.*, 2017) and among Ugandans (Abba *et al*., 2012). The recent study of Asuku *et al*. (2017), Ravinder and Manju (2016), and Asuku (2018) demonstrating a strong relationship between 2D:4D and MetS components and a cut-off value for hyperglycemia strengthen the notion that 2D:4D may serve as an anthropometric screening tool for metabolic derangement.

The discriminatory strength of the body adiposity measures for serum lipids as observed in this study may be rooted to "the insulin resistance theory" which is the major

Table 7: Sensitivity, specificity and upper reference values for the anthropometric parameters for triglyceride in females

Variables	Area	SE	Sig	Lower CI	Upper CI	Cut off	Sensitivity	Specificity	YI
BMI	0.63	0.09	0.2568	0.45	0.80	22.73	1.00	0.44	1.44
WC (cm)	0.72	0.10	0.0508	0.51	0.92	89.05	0.67	0.88	1.54
HC (cm)	0.47	0.11	0.7768	0.25	0.68	82.90	1.00	0.16	1.16
NC (cm)	0.75	0.09	0.0243	0.57	0.92	32.95	0.78	0.69	1.47
W/H	0.80	0.08	0.0068	0.65	0.95	0.97	0.78	0.81	1.59
W/Ht	0.73	0.09	0.0376	0.55	0.90	0.52	1.00	0.41	1.41
BAI	0.56	0.11	0.6143	0.34	0.77	29.74	0.67	0.63	1.29
R2D:4D	0.61	0.09	0.3289	0.43	0.78	0.97	1.00	0.44	1.44
L2D:4D	0.77	0.07	0.0128	0.63	0.92	1.00	1.00	0.63	1.63

BMI - Body mass index, WC - Waist circumferences, HC - Hip circumferences, NC - Neck circumferences, W/H - Waist to hip ratio, WHt - Waist to height ratio, R2D:4D - Right second to fouth digit ratio, L2D:4D - Left second to fouth digit ratio, SE - Standard error, YI - Youden's index, BAI - Body adiposity index

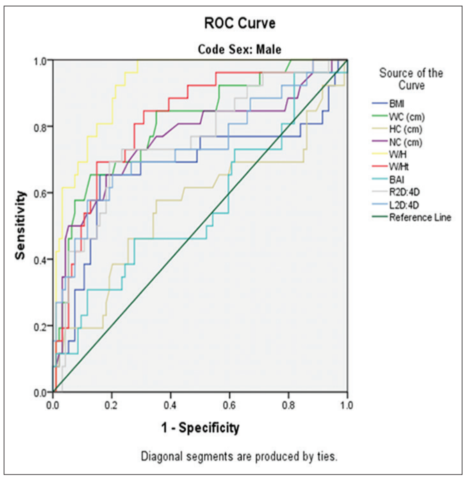

Figure 5: ROC curve for determination of URV of digit ratio, BMI, WC, HC, WHR, WHtR, BAI for TG in male participants. ROC - Receiver operating characteristic, URV - Upper reference value, BMI - Body mass index, WC - Waist circumferences, HC - Hip circumferences, BAI - Body adiposity index, WHR- Waist-to-hip ratio, WHtR - Waist-to-height ratio, TG - Triglycerides

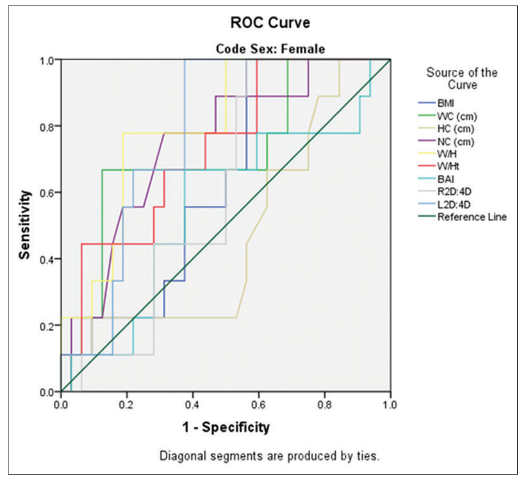

Figure 6: ROC curve for the determination of URV of digit ratio, BMI, WC, HC, WHR, WHtR, BAI for TG in female participants. ROC - Receiver operating characteristic, URV - Upper reference value, BMI - Body mass index, WC - Waist circumferences, HC - Hip circumferences, BAI - Body adiposity index, WHR- Waist-to-hip ratio, WHtR - Waist-to-height ratio, TG - Triglycerides

pathophysiological link between body adiposity reserve with serum glucose and lipid levels. The discriminatory ability of 2D:4D for serum lipids may, however, be viewed from the perspective of a common genetic determinant between 2D:4D and MetS components. This means that, since MetS results from interplay between genetic and environmental factors (Fujioka *et al*., 1987; Grundy, 1999; Kahn and Flier, 2000), and since 2D:4D is an anthropometric variable that is also genetically determined (Zhang *et al*., 2013), it is likely that both have similar genetic determinants. This may offer a plausible explanation for the discriminatory ability and URV of 2D:4D for dyslipidemia as observed in the present study.

From the present study, the URV of 2D:4D for serum lipids were observed to be higher than the normal reference value reported by Loehlin *et al.,* (2006). This may lend support to the validity of 2D:4D in identifying pathological conditions, in that, higher values may indicate vulnerability to disease conditions as observed for dyslipidemia in this study. Further in support of this view, several reports have shown the significant correlation of 2D:4D with several disease conditions (Manning and Bundred, 2001; Brown *et al*., 2002; Okten *et al*., 2002; Cattrall *et al*., 2005; Fink *et al*., 2006). The observation that the URV are not exactly the same in both hands agrees with the documented asymmetry in the strength and pattern of relationships of 2D:4D with body characteristics (Manning *et al*., 1998; Oyeyemi *et al*., 2016).

The variation observed between the cut-off values obtained in this study and those reported for Asians and Europeans (Tulloch-Reid *et al.,* 2003), Arabs (Al-Rubean *et al.,* 2017), and other African population (Prinsloo *et al.,* 2011; Crowther and Norris, 2012) lend support to the current global recommendation that no single adiposity cut-off value should be used for all racial/ethnic population.

The URV of WC and BMI for dyslipidemia observed in this study were higher than the commonly improvised values reported for Asians and Europeans (Tulloch-Reid *et al*., 2003). This finding underscores the role of ethnicity and race in the interrelationships between body adiposity measures and metabolic parameters and emphasizes the need for every ethnic or racial population to define its URV of adiposity measures specific to its populace.

Conclusion

We concluded that, the popularly adopted European URV of adiposity indices is slightly lower than those for the Hausas in Kano and that, digit ratio (2D:4D) has a discriminatory ability and URV for dyslipidemia and therefore may be used as an initial screening tool, particularly in individuals at high risk for abnormal serum lipids.

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Conflicts of interest

There are no conflicts of interest.

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