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Thresholds of Anthropometric Indices of Adiposity and Digit Ratio (2d:4d) for High Blood Pressure Among the Hausa Ethnic Group in Kano, Nigeria

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ABSTRACT

Body adiposity measures and the ratio of the second-to-fourth digit (2D:4D) of the hand is documented to exhibit strong relationship with cardio-metabolic risk factors (CMRF). High blood pressure is a hall mark of CMRF. Globally, the predictors of CMRF do not demonstrate universal validity across ethnic groups. This cross-sectional study was therefore aimed at determining the cut-off values (COV) of the anthropometric indices adiposity and 2D:4D for HBP among the Hausas of Kano. The study included 465 (266 males and 199 females) subjects, 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 and 2D:4D were measured using standard anthropometric techniques. Systemic blood pressure was measured following standard clinical procedures. SPSS version 20 (IBM Corporation, NY) software was used for statistical analysis and Receiver operating characteristic (ROC) curve was used to determine the COV of 2D:4D and adiposity indices for HBP. The COV of body mass index (BMI), waist circumference (WC), hip circumference (HC), neck circumference (NC), waist-to-hip ratio (WHR), waist-to- height ratio (WHtR), body adiposity index (BAI), right digit ratio (R2D:4D) and left digit ratio (L2D:4D) for diastolic blood pressure (DBP) in males and females were 23.24 kg/m^2, 79.45cm, 88.05cm, 34.95cm, 0.87, 0.47, 18.20, 0.97, 0.97 and 23.32 kg/m^2, 72.15cm, 88.05cm, 31.32cm, 0.87, 0.43, 27.52, 0.98, 0.99 respectively. While COV of BMI, WC, HC, NC, WHR, WHtR, BAI, R2D:4D and L2D:4D for systolic blood pressure (SBP) in males and females were 24.10 kg/m^2, 76.65cm, 89.30cm, 35.05cm, 0.89, 0.45, 26.15, 0.97, 0.98 and 23.32 kg/m^2, 71.95cm, 88.05cm, 31.05cm, 0.87, 0.43, 27.52, 0.97, 0.98 respectively. Conclusively, Digit ratio has a threshold for HBP and the COV of adiposity indices for HBP in Hausas are slightly different from the commonly adopted values.

Key words: Cut-off values, adiposity indices, digit ratio, high blood pressure, Kano

INTRODUCTION

The sexually dimorphic second-to-fourth digit of the hand (2D:4D) is a structural variable that is known to be a retrospective index of intrauterine fetal exposure to testosterone concentration [1, 2] and a major determinant of the architectural framework of the body and brain. [1] The ratio has been extensively studied and still receiving great attention from investigators. [1, 3, 4, 5, 6, 7] The ratio has demonstrated significant correlations with important biological traits including disease conditions. Accordingly, 2D:4D was shown to correlate significantly with MetS indices among Nigerians [8] and Indians, [9] with body adiposity measures among Nigerians [2, 5] and Europeans. [4] The tight association between 2D:4D and MetS indices have been explained from the point of view of its association with body adiposity [8], a strong correlate of MetS. Despite these reported tight association between MetS and 2D:4D, little attempts have been made to determine its cut-off value for the component of MetS.

Documented evidences on the significant relationship between body adiposity measures with HBP and other components of MetS such as hyperglycemia and hyperlipidemia has led to the proposal of cut-off thresholds for MetS and its components. [10] However, the various COV that have been proposed demonstrate ethnic and racial discrepancies such that, the sensitivity and specificity of each COV are not universally applicable on populations of varying ethnicity and races. [11, 12, 13] This has provided the rationale for the current global recommendation that COV of adiposity indices for the MetS and its components should be ethnic specific. [14, 15, 16] This is further substantiated by the remarks that, the current World Health Organization anthropometric cut-off marks for MetS components cannot be uniformly applied on all races and ethnic groups. [10] The reported racial and ethnic variation is said to be due to the fact that blacks have lower absolute total fat reserve compared with the Europeans and Caucasians for the same anthropometric value of adiposity measure [17.] with the attendant implication on the cut-off values of adiposity measures and their interrelationships with MetS. Accordingly, there currently exist COV for different races and ethnic groups. [10] In Nigeria and many Sub-saharan African countries, ethnic specific COV are still lacking and this has led to the adoption European COV in risk

assessment of MetS. This will undoubtedly affect the validity of anthropometric measures as screening tools for MetS and its components. The present study therefore seeks to determine the cut-off values of 2D:4D and adiposity indices (BMI, NC, WC, HC, WHR, WHtR and BAI) for HBP 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 Hausas of Kano based on a history of at least two parental generation being Hausas from Kano. Participants were recruited from 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 subjects in the age range of 18 years to 68 years. Subjects with congenital and/or acquired deformity of the spine and those on medications which affect adiposity or metabolic syndrome components were however excluded.

Ethical approval was obtained from Kano state hospitals management board and written informed consent obtained from the subjects.

Anthropometric Measurement

Height was measured to the nearest 0.1cm 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. The weight was measured in kilograms using a digital weighing scale while the subject is in light clothes. BMI was calculated by dividing the weight (kg) by the square of the height (m^2) and expressed in kg/m2. Waist circumference (WC) was measured in centimeter with a non-stretchable plastic tape horizontally placed over the abdomen at the narrowest point between the lowest rib and the iliac crest. [18] 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. [18] Digit lengths was 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 0.01mm as shown in plate III and reported on the questionnaire. This measurement has been reported to have high degree of repeatability. [19] Neck circumference was measured in centimeter with a non-stretchable plastic tape horizontally placed over the unclothed neck at the level of the thyroid cartilage. [18] Body adiposity index was obtained using the formula proposed by Bergman *et al.* [20]

$$\text{Body Adiposity Index (BAI)} = \frac{\text{Hip Circumference (cm)}}{\text{Height (m)}^{1.5}} - 18$$

Blood Pressure Measurement

A mercury sphygmomanometer was used for measuring blood pressure. Two measurements were taken, and at least 2 minutes was allowed between readings. While the diastolic reading was taken at the level when sounds disappear (Korotkoff phase V), the systolic was taken at the level when it appears. The brachial artery was the site of auscultation. Subjects were asked to refrain from smoking or ingesting caffeine for 30 minutes before measurement and the measurement was taken after at least 5 minutes of rest. [21]

Statistical Analysis

Mean and standard deviation were used to describe Data. Receiver operating characteristic (ROC) curve was used to determine the percentage of area under the curve with the sensitivity and specificity of the adiposity indices for blood pressure. Younden's index was used to determine the optimal cut-off value of each anthropometric parameter for both diastolic and systolic component of blood pressure.

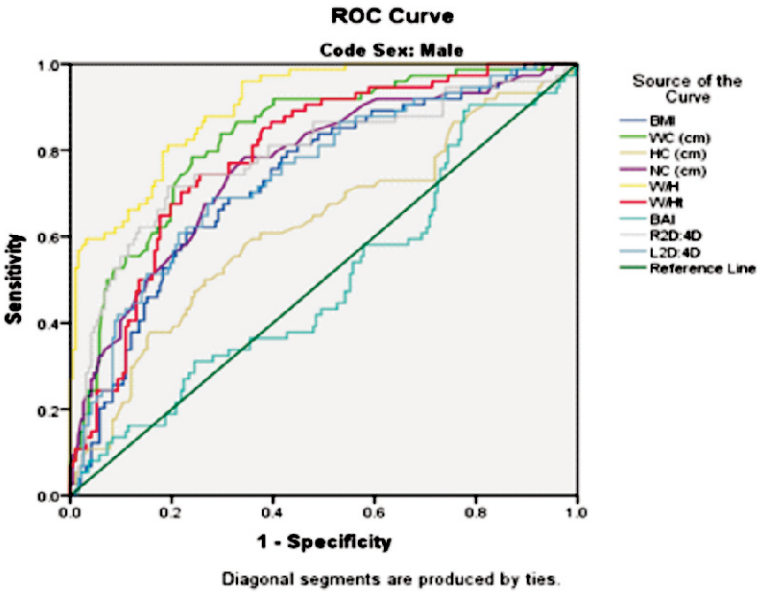
RESULTS

Table 1: Description of age, anthropometric parameters and blood pressure of participants

	Male (n=266)		Female (n= 199)	
Variables	Mean ± SD	Min-max	Mean ± SD	Min-max
Age	34.45± 13.52	18-68	32.06 ± 15.18	18-68
Height (cm)	169.15 ± 6.27	142-182.3	158.53 ± 6.83	136.9-175
Weight (Kg)	63.03 ±12.28	40.5-98.3	55.86 ± 12.99	36-108.9
BMI (kg/m^2)	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
DBP (mmHg)	82.59 ± 12.37	54-120	84.50 ± 12.99	60-120
SBP (mmHg)	128.07 ± 20.09	90-200	130.66 ± 21.87	95-205
RII (mm)	72.56 ± 5.09	60.19-87.02	68.94 ± 4.48	55.42-82.09
RIII (mm)	80.12± 5.44	64.17-97.56	75.53 ± 4.98	63.13-94.26
RIV (mm)	75.63 ± 5.29	62.84-89.32	69.94 ± 4.51	55.41-85.35
RV (mm)	62.11 ± 5.31	47.17-85.87	57.60 ± 4.26	44.97-67.32
R2D:4D	0.96 ± 0.03	0.79-1.05	0.99 ± 0.03	0.86-1.07
LI (mm)	74.05 ± 5.36	60.33-87.47	67.77 ± 4.49	55.1-78.83
LII (mm)	73.32 ± 4.85	60.04-85.81	69.08 ± 4.40	57.19-80.44
LIII (mm)	80.50 ± 5.61	66.12-96.55	76.23 ±5.56	50.09-98.92
LIV (mm)	76.03 ± 4.91	62.92-87.81	70.10 ± 4.71	57.45-82.26
LV (mm)	62.21 ± 5.09	47.46-74.36	57.69 ± 4.88	43.14-75.71
L2D:4D	0.96 ± 0.03	0.85-1.10	0.99 ± 0.03	0.92-1.09

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, I: first digit, II: second digit, III: third digit, IV: fourth digit, V: fifth digit, R: right hand, L: left hand, 2D:4D: second to fourth digit ratio, DBP: diastolic blood pressure, SBP: systolic blood pressure

From Fig. 1 and Table 2 which show the ROC curve analyses for DBP in male subjects, it can be observed that the 2D:4D and adiposity markers of male participants were above the reference line of the ROC curve indicating good discriminatory strength for DBP except for BAI where the AUC was exactly on the reference line (50%). WHR had the highest discriminatory power corresponding to the largest area under the curve (90%) with a sensitivity of 0.96 and specificity of 0.66 at a cut-off value of 0.87. BAI had sensitivity and specificity of 0.9 and 0.5 respectively at cut-off of 26.6.



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, L: left hand, R: right hand, 2D:4D: second to fourth digit ratio

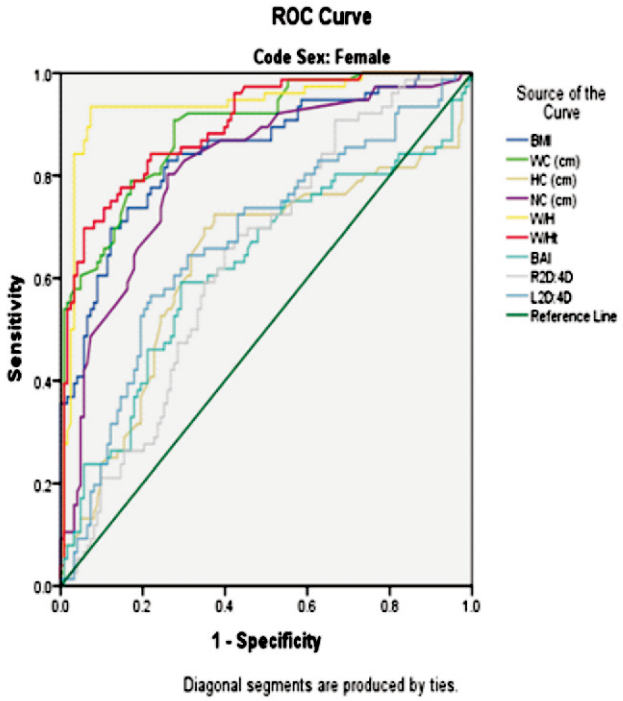
Figure 1: ROC curve for determination of cut off values of the adiposity indices and 2D:4D for DBP in males.
Table 2: Area under the ROC curve and cut-off values of 2D:4D and adiposity indices for DBP in males

Variables	AUC	SE	Sig	Lower CI	Upper CI	COV	Sensit	Specif	YI
BMI	0.73	0.03	0.0000	0.66	0.80	23.24	0.61	0.77	1.38
WC (cm)	0.83	0.03	0.0000	0.78	0.88	79.45	0.78	0.76	1.54
HC (cm)	0.62	0.04	0.0019	0.55	0.70	88.05	0.58	0.66	1.24
NC (cm)	0.76	0.03	0.0000	0.70	0.83	34.95	0.78	0.66	1.44
W/H	0.90	0.02	0.0000	0.87	0.94	0.87	0.96	0.66	1.62
W/Ht	0.79	0.03	0.0000	0.73	0.85	0.47	0.74	0.74	1.49
BAI	0.50	0.04	0.9433	0.42	0.58	18.20	0.91	0.21	1.12
R2D:4D	0.78	0.03	0.0000	0.72	0.85	0.97	0.72	0.81	1.52
L2D:4D	0.74	0.03	0.0000	0.68	0.81	0.97	0.69	0.72	1.41

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, L: left hand, R: right hand, 2D:4D: second to fourth digit ratio, AUC: area under the curve, SE: standard error, CI: confidence interval, COV: cut-off value, YI: Younden index

From Fig. 2 and Table 3 which show the ROC curve analyses for DBP in female subjects, it can be observed that the 2D:4D and adiposity markers of female participants were above the reference line of the ROC curve indicating good discriminatory strength for DBP with WHR having the largest AUC (94%) and sensitivity and specificity of 0.93 each. WHR had a COV of 0.87. HC had the lowest discriminatory power for DBP in females corresponding to the smallest area under the curve (61%) with a sensitivity of 0.72 and specificity of 0.63 at a cut-off value of 88.05cm.

Figure 2: ROC curve for determination of cut-off values of adiposity indices and 2D:4D for DBP in females



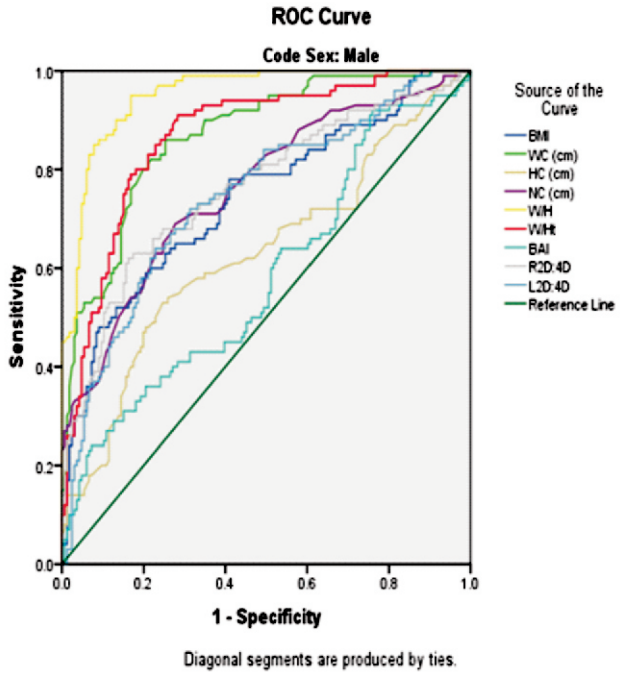
BMI: body mass index, WC: waist circumference, HC: hip circumference, NC: neck circumference, W/H: waist-to-hip ratio, W/Ht: waist-to-height ratio, BAI: body adiposity index, L: left hand, R: right hand, 2D:4D: second-to-fourth digit ratio

Table 3: Area under the ROC curve, and cut-off values of 2D:4D and adiposity indices for DBP in females

Variables	Area	SE	Sig	Lower CI	Upper CI	Cut off	Sensit	Specif	YI
BMI	0.85	0.03	0.0000	0.79	0.90	23.32	0.70	0.88	1.58
WC (cm)	0.89	0.02	0.0000	0.84	0.94	72.15	0.91	0.72	1.63
HC (cm)	0.61	0.04	0.0019	0.55	0.72	88.05	0.72	0.63	1.35
NC (cm)	0.81	0.03	0.0000	0.75	0.87	31.25	0.80	0.74	1.54
W/H	0.94	0.02	0.0000	0.90	0.98	0.87	0.93	0.93	1.86
W/Ht	0.90	0.02	0.0000	0.85	0.94	0.43	0.97	0.47	1.45
BAI	0.62	0.04	0.0035	0.54	0.71	27.52	0.59	0.71	1.30
R2D:4D	0.64	0.04	0.0011	0.56	0.71	0.98	0.66	0.60	1.26
L2D:4D	0.67	0.04	0.0000	0.60	0.75	0.99	0.57	0.78	1.35

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, sensit: sensitivity, specif: specificity, SE: standard error, YI: Youden's index

From Fig. 3 and Table 4 which show the ROC curve analyses for SBP in males, it can be observed that the 2D:4D and adiposity markers of male participants were above the reference line of the ROC curve indicating good discriminatory strength for SBP with WHR having the largest AUC (95%) and sensitivity and specificity of 0.95 and 0.83 respectively and a COV of 0.89 for SBP. BAI had the lowest discriminatory power for SBP in males corresponding to the smallest area under the curve (58%) with a sensitivity of 0.24 and specificity of 0.93 at a cut-off value of 26.15.



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, L: left hand, R: right hand, 2D:4D: second-to-fourth digit ratio

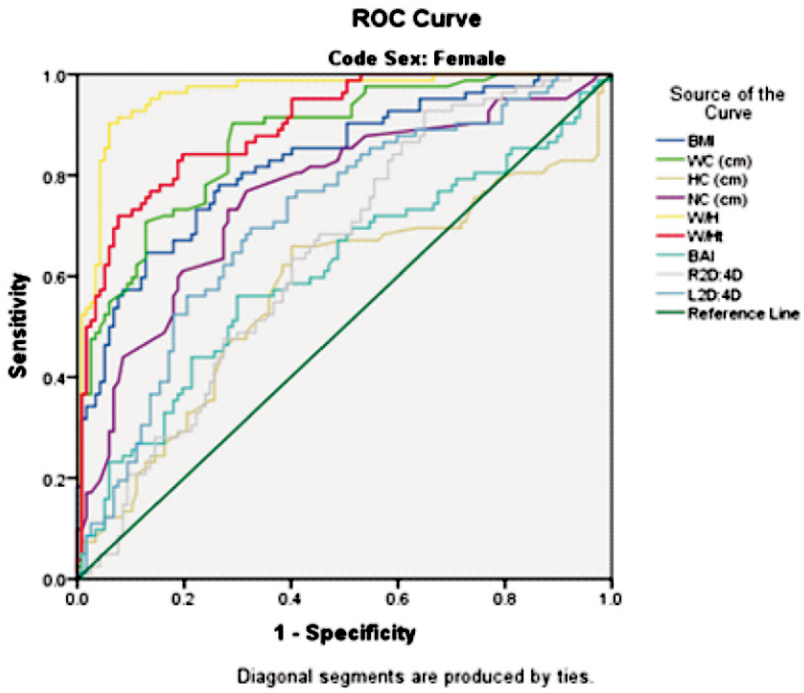
Figure 3: ROC curve for determination of cut-off value of adiposity indices and 2D:4D for SBP in males

Table 4: Area under the ROC curve and cut-off values of 2D:4D and adiposity indices for SBP in males

Variables	Area	SE	Sig	Lower CI	Upper CI	Cut off	Sensit	Specif	YI
BMI	0.74	0.03	0.0000	0.68	0.80	24.10	0.48	0.91	1.39
WC (cm)	0.87	0.02	0.0000	0.83	0.91	76.65	0.86	0.75	1.61
HC (cm)	0.63	0.04	0.0004	0.56	0.70	89.30	0.53	0.75	1.28
NC (cm)	0.76	0.03	0.0000	0.70	0.82	35.05	0.69	0.72	1.41
W/H	0.95	0.01	0.0000	0.93	0.98	0.89	0.95	0.83	1.78
W/Ht	0.87	0.02	0.0000	0.82	0.91	0.45	0.91	0.72	1.63
BAI	0.58	0.04	0.0256	0.51	0.65	26.15	0.24	0.93	1.17
R2D:4D	0.76	0.03	0.0000	0.70	0.82	0.97	0.62	0.84	1.46
L2D:4D	0.75	0.03	0.0000	0.68	0.81	0.98	0.64	0.77	1.41

BMI: body mass index, WC: waist circumferences, HC: hip circumferences, NC: neck circumferences, W/H: waist to hip ratio, W/Ht: waist to height ratio, R2D:4D: right second to fouth digit ratio, L2D:4D: left second-to-fourth digit ratio, sensit: sensitivity, specif: specificity, SE: standard error, YI: Youden index

From Fig. 4 and Table 5 which show the ROC curve analyses for SBP in female participants, it can be observed that the 2D:4D and adiposity markers of female participants were above the reference line of the ROC curve indicating good discriminatory strength for SBP with WHR having the largest AUC (96%) and sensitivity and specificity of 0.9 and 0.94 respectively and a COV of 0.87 for SBP. HC had the lowest discriminatory power for SBP in females corresponding to the smallest area under the curve (57%) with a sensitivity of 0.66 and specificity of 0.60 at a cut-off value of 88.0cm.



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, L: left hand, R: right hand, 2D:4D: second-to-fourth digit ratio

Figure 4: ROC curve for determination of cut-off value of adiposity indices and 2D:4D for SBP in females

Table 5: Area under the ROC curve and cut-off values of 2D:4D and adiposity indices for SBP in females

Variables	Area	SE	Sig	Lower CI	Upper CI	Cut off	Sensit	Specif	YI
BMI	0.83	0.03	0.0000	0.77	0.89	23.32	0.65	0.87	1.52
WC (cm)	0.87	0.03	0.0000	0.82	0.92	71.95	0.90	0.71	1.61
HC (cm)	0.57	0.04	0.0840	0.49	0.66	88.05	0.66	0.60	1.26
NC (cm)	0.76	0.04	0.0000	0.69	0.83	31.05	0.77	0.68	1.45
W/H	0.96	0.01	0.0000	0.93	0.99	0.87	0.90	0.94	1.84
W/Ht	0.90	0.02	0.0000	0.86	0.94	0.43	0.99	0.48	1.47
BAI	0.61	0.04	0.0080	0.53	0.69	27.52	0.56	0.70	1.26
R2D:4D	0.65	0.04	0.0005	0.57	0.72	0.97	0.93	0.35	1.28
L2D:4D	0.71	0.04	0.0000	0.64	0.79	0.98	0.70	0.68	1.37

mass index, WC: waist circumferences, HC: hip circumferences, NC: neck circumferences, W/H: waist-to-hip ratio, W/Ht: waist-to-height ratio, R2D:4D: right second-to-fouth digit ratio, L2D:4D: left second-to-fourth digit ratio, sensit: sensitivity, specif: specificity, SE: standard error, YI: Youden index

DISCUSSION

From the present study, it was observed that digit ratio (2D:4D) shows an upper threshold for both systolic blood pressure (SBP) and diastolic blood pressure (DBP). This finding may be substantiated by the evidences obtained from recent studies that digit ratio is strongly correlated with body adiposity among Nigerians, [2,5,8] Ugandans [22] and Europeans. [3] This may strengthen the likelihood of a significant association of 2D:4D with HBP which is a tight correlate of body adiposity. Consequently, the observation of a COV of 2D:4D for BP in this study is plausible. More recent studies which showed strong relationships of 2D:4D with blood pressure [9] and serum components of MetS [8] reveals the potential of 2D:4D as a possible anthropometric predictor of the components of MetS and thus the existence of its cut-off value as obtained for HBP in the present study.

In the present study, it was observed that the cut-off

values of 2D:4D for both DBP and SBP were higher than the normal reference value reported by Loehlin *et al.* [23] This further lends supports the notion that 2D:4D may be a simple anthropometric tool for screening and predicting pathological states, in that, higher values may indicate susceptibility to disease conditions exemplified by hypertension as obtained in this study. Furthermore, sound evidences have shown the significant correlation of 2D:4D with many disease conditions. [1, 24, 25, 26] The finding from this study that the COV HBP differed in the left and right hand is explainable from previously documented asymmetry in 2D:4D in terms of measurement and in correlation with body characteristics. [2, 19] There are however conflicting reports regarding the side of predilection of 2D:4D asymmetry. Some studies have reported asymmetry in favour of the right hand, [2, 19] while some others reported it in favour of the left hand. [3, 27] This asymmetry may not be unconnected with uneven distribution of the X-linked androgen receptor on the tip of the digit which plays crucial role in the embryogenesis of digit ratio.

COV of indices of adiposity for HBP as observed in the present study is supported by documented evidences which reported strong relationships between adiposity indices and MetS components. [10,11, 12, 13] The slight variation observed between the COV obtained from this study and those reported for Asians and Europeans, [10] Arabs [28] and other African population [29, 30] agrees with the current global recommendation that, upper thresholds of adiposity markers used to define MetS and its components should be racial and ethnic specific. This emphasises the importance of determining COV for the different ethnic populations. This will certainly improve the sensitivity and specificity of adiposity markers as metabolic screening tools.

The observation that WC, WHR and BMI showed relatively higher COV for BP compared with those reported for Asians and Europeans [10] underscores the role of ethnicity in the interrelationships between body adiposity measures and MetS. For example, it is documented that Caucasians and Asians have disproportionately higher total body fat content when compared with Blacks with similar anthropometric measure of adiposity. [17] This may offer explanation for the relatively higher COV of adiposity indices for DBP and SBP observed in the present study compared with those of Europeans or Asians. [10] Similar reasons may explain the closeness in the COV obtained in this study and those of some African populations. [29, 30, 31]

CONCLUSION

We concluded that, similar to anthropometric indices of adiposity, digit ratio (2D:4D) has COV for HBP and that the COV of adiposity indices in Hausa ethnic group slightly differs from the widely improvised cut-off values obtained from other populations.

Conflict of Interest: We declared no conflict of interest

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