Asian Journal of Medicine and Health

9(3): 1-10, 2017; Article no.AJMAH.37772
ISSN: 2456-8414

Gender Specific Predictive Performance and Optimal Threshold of Anthropometric Indices for the Prediction of Hypertension among a Ghanaian Population in Kumasi

William K. B. A. Owiredu[1,2*], James Osei-Yeboah[3], Christiana Aryee[4], Ellis Owusu-Dabo[5,6], Edwin F. Laing[1,2] and Isaac K. Owusu[7]

[1]Department of Molecular Medicine, School of Medical Sciences, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.
[2]Department of Clinical Biochemistry, Diagnostic Directorate, Komfo Anokye Teaching Hospital, Kumasi, Ghana.
[3]Department of Medical Laboratory Sciences, School of Allied Health Sciences, University of Health and Allied Sciences, Ho, Ghana.
[4]Becton Dickinson Biosciences Technical Services, West Africa, Accra, Ghana.
[5]School of Public Health, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.
[6]Kumasi Centre for Collaborative Research in Tropical Medicine, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.
[7]Department of Medicine, School of Medical Sciences, Kwame Nkrumah University of Science and Technology, Komfo Anokye Teaching Hospital, Kumasi, Ghana.

Authors' contributions

This work was carried out in collaboration between all authors. Authors WKBAO, IKO, EFL, EOD and JOY conceptualized and designed the study. Authors IKO, CA and EOD recruited the study participants. Authors IKO, CA, JOY, WKBAO and EOD generated the data. Authors CA, JOY, WKBAO and IKO analyzed the data. Authors IKO, CA, WKBAO and JOY drafted the manuscript. Authors WKBAO, CA, JOY, EFL, EOD and IKO reviewed the manuscript for intellectual content and each author approved the final manuscript.

Article Information

DOI: 10.9734/AJMAH/2017/37772
Editor(s):
(1) Alexandre Sérgio Silva, Professor, Department of Physical Education, Federal University of Paraíba, Brasil.
(2) Giuseppe Murdaca, Professor, Clinical Immunology Unit, Department of Internal Medicine, University of Genoa, Italy.
Reviewers:
(1) Kwame Opare-Asamoah, University for Development Studies, Ghana.
(2) Ramy Hanna, University of California Los Angeles, USA.
(3) Randa F. Salam, Cairo university, Egypt.
(4) Olga Berillo, McGill University, Canada.
Complete Peer review History: http://www.sciencedomain.org/review-history/22540

Original Research Article

Received 28th October 2017
Accepted 26th December 2017
Published 1st January 2018

**Corresponding author: E-mail: wkbaowiredu@yahoo.com;*

ABSTRACT

Despite the extensive use of anthropometric indices in the risk prediction of hypertension, there is lack of consensus on the type and the optimal threshold to be used. This current work evaluates the optimal threshold points, discriminative power and comparative performance as discriminators of hypertension for ten (10) anthropometric indices. Standard methods were used to measure weight, height, waist circumference, hip circumference for calculating BMI, PI, WHR, WhtR, CI, AVI, and BAI. Gender specific predictive performance of anthropometric indices were assessed using the area under the curve (AUC) of the receiver operator characteristic curves (ROC). In this Ghanaian cohort, body mass index, waist-to-hip ratio and ponderal index were poor predictors of hypertension. Among the commonly used anthropometric measures, waist circumference at a lower threshold (>75 cm and 80 cm for females and males respectively) than the currently recommended cutoffs was the index of choice for the prediction of hypertension, however significant improvement in prediction was achieved with the use of conicity index (>1.08 female, >1.05 male).

Keywords: Hypertension; anthropometry; obesity; optimal threshold; predictive performance.

1. INTRODUCTION

The rapidly increasing worldwide burden of obesity has been termed Globesity [1]. Many anthropometric indices have been developed and used as non-invasive, easy to determine, economical and effective proxies for the assessment of body adiposity [2,3]. Evidence of the link between obesity, measured by anthropometric indices and hypertension among different populations abound in literature [4-8]. However, consensus on the utility of which anthropometric variable(s) that best predict hypertension at defined optimal threshold points remain largely elusive among scholars [7,9]. Both genetic and environmental factors have been adduced for the varying performance of anthropometric parameters and their standard cutoff scales in different populations [1,3]. Among African populations, it has been suggested that the current definitive threshold cutoff may not be appropriate due to the difference in the genetic makeup, environment, body composition and architecture of Africans compared to Western populations [1,10]. However adequate evidence on the appropriate cutoffs to be used is lacking [11].

In affirmation of the advocacy for ethnic specific definition cutoff points of anthropometric variables for the prediction of health and disease [12-14], we, Owusu et al. [15] earlier reported different cutoff points for three commonly used anthropometric variables (BMI,WC and WHR) for the prediction of hypertension among a cohort of Ghanaian adult population in Kumasi. The current work is an expanded analysis evaluating the optimal threshold points, discriminative power and comparative performance as discriminators of hypertension of six (6) commonly used and four (4) candidate anthropometric indices.

2. MATERIALS AND METHODS

2.1 Study Population

The study population for this research work included one hundred and eighty (180) known non-diabetic hypertensive patients, attending the hypertension clinics at the Komfo Anokye Teaching Hospital (KATH) and the Precise Specialist Clinic all in Kumasi, Ghana and sixty one (61) age matched normotensive controls from the Kumasi metropolis. Among the hypertensive group, 140 were on antihypertensive therapy and 40 were antihypertensive therapy naïve hypertensive patients. The study participants were recruited purposively from a population of adult Ghanaian individuals between the ages of 22-87 years. Criteria for cases group were patients diagnosed with hypertension who were not presenting with diabetes and were of consenting age. The control group were normotensive age matched healthy individuals with no past history of diabetes, cardiac, renal, hepatic dysfunction or dyslipidaemia, living in the Kumasi metropolis and consented to participate in this study. This study was carried out between November 2012 and September 2013.

2.2 Blood Pressure (BP) Measurement

Blood pressure (BP) and pulse rate measurements were done using the Omron M5-I

digital fully automatic blood pressures monitor (OMRON Healthcare Europe B.V., The Netherlands). After participants had sat quietly for at least ten minutes, three measurements were taken at one minute interval on the mid upper part of the right arm in a seated position, with arm supported at heart level and feet flat on the floor using an appropriate sized cuff. Hypertension was diagnosed when the mean of the second and third blood pressure (BP) measurements was equal or above 140/90 mmHg at more than one visit [16,17].

2.3 Anthropometric Variables

Anthropometric measurements including height to the nearest centimeter without shoes and weight to the nearest 0.1 kg in light clothing were taken. Subjects were weighed on a bathroom scale (Zhongshan Camry Electronic Co. Ltd, Guangdong, China) and their height measured with a Secastadiometer (Seca Gmbh & Co. Kg, Germany), with the participant standing erect with back straight, heels together, and toes slightly apart at a 60 degree angle. Waist circumference (to the nearest centimeter) was measured with a Gulick II spring-loaded measuring tape (Country Technology, Inc., USA) midway between the inferior angle of the ribs and the suprailiac crest. The hip circumference was measured as the maximal circumference over the hip circumference (HC) at the level of the widest diameter around the gluteal protuberance in centimetres. Body mass index (BMI) was calculated by dividing weight (kg) by height squared (m^2). The ponderal index (PI) was calculated by dividing weight (kg) by height cube (m^3). The waist to hip ratio (WHR) was calculated by dividing the waist circumference (cm) by the hip circumference (cm). Waist-to-Height Ratio was calculated by dividing the waist circumference (cm) by the height (cm). Other calculated adiposity indices were as follows

1. Conicity Index (CI) [18],

$$\mathrm{CI} = \frac{\text{Waist Circumference (m)}}{\left[0.109 \times \sqrt{\frac{\text{Weight (Kg)}}{\text{Height (m)}}}\right]}$$

2. Abdominal Volume Index (AVI) [19],

$$\mathrm{AVI} = \frac{\left[\begin{array}{c} 2(\text{Waist C (cm)})^2 + \\ 0.7(\text{Waist C (cm)} - \text{Hip C (cm)})^2 \end{array}\right]}{1000}$$

3. BAI-Body Adiposity Index [20],

$$\mathrm{BAI} = \frac{\text{Hip Circumference(cm)}}{[\text{Height (m)}]^{1.5}} - 18$$

2.4 Statistical Analysis

After testing of normality, continuous parametric variables were expressed as mean and standard deviation of the mean. Comparison of two means was evaluated with an independent t test. The Youden Index was computed to identify population-specific cut-off points of anthropometric parameters for the optimal differentiation between cases and controls. The Youden Index was derived from (sensitivity + specificity) - 1 and ranged from 0 to 1. Using the receiver operator characteristic curves (ROC), area under the curve (AUC), the discriminative power of the population gender specific cut-off points for identifying hypertension cases was estimated [14]. Gender specific comparative performance of individual anthropometric indices was evaluated using the difference between the AUC. A level of P <.05 was considered as statistically significant for all analysis. MedCalc version 12.3.2 for windows was used for statistical analysis (MedCalc software bvba, Acacialaan 22, B-8400 Ostend, Belgium, www.medcalc.org).

2.5 Ethical Consideration

The participation of the respondents who are all indigenes of Ghana was voluntary and informed consent was obtained from each of them after thorough explanation of what the study entailed. This study was approved by the School of Medical Sciences and KATH Committee on Human Research Publications and Ethics (CHRPE/08/11).

3. RESULTS

In general, significantly higher anthropometric indices were recorded among the hypertension groups compared to the normotensives (height, weight, waist circumference, hip circumference, waist-to-height ratio, conicity index, abdominal volume index and body adiposity index). However, in the case of body mass index (BMI), waist-to-hip ratio (WHR) and ponderal index (PI) the difference between the two groups was not statistically significant (Table 1).

Using the receiver operator characteristic curve analysis, a population and gender specific

diagnostic criterion for the prediction of hypertension and the discriminating power was determined for the commonly used anthropometric measures. With the exception of BMI, for both sexes and waist-to-hip ratio (WHR_M) for male subjects, all the commonly used anthropometric indices evaluated for this study demonstrated significant ability of differentiating between hypertensives and normotensives at various optimal thresholds among the study population. Among the commonly used indices of obesity, waist circumference (WC_F) at a cut-off point of >75 cm and Hip circumference (HC_F) at a cut-off point of >79 cm, were the best predictors of hypertension for the female population based on their discriminatory power (Area under the curve - AUC), Youden J index, sensitivity and specificity. For the male population, hip circumference (HP_M) at a cutoff of >90 cm and waist circumference (WC_M) at cutoff of >80 cm were the anthropometric variables of choice (Table 2).

With the exception of ponderal index (PI), all candidate anthropometric measures evaluated in this study demonstrated significant ability of differentiation between hypertensives and normotensives at various optimal thresholds irrespective of gender. The leading candidate anthropometric index was conicity index at a gender specific optimal threshold of >1.08 for females and >1.05 for males (Table 3).

Table 1. Commonly used and candidate anthropometric variables of a cohort of Ghanaian adult population in Kumasi stratified by Hypertension status

Parameter	Total (n-241)	Normotensive (n-61)	Hypertensive (n-180)	*P-value*
Ht(cm)	160.96±12.28	155.24±14.1	162.90±10.98	.0002
Wt(Kg)	78.46±15.54	71.90±12.8	80.68±15.78	.0001
WC(cm)	89.29±20.72	69.10±12.23	96.13±18.43	<.0001
HC(cm)	94.06±25.23	71.82±12.17	101.59±24.04	<.0001
BMI(Kg/m^2)	29.52±4.7	29.36±5.08	29.58±4.58	.75
WHR	0.96±0.06	0.96±0.05	0.97±0.06	.72
WHtR	0.56±0.13	0.45±0.08	0.59±0.12	<.0001
CI	1.18±0.25	0.93±0.11	1.26±0.23	<.0001
AVI	16.86±8.02	9.86±3.51	19.24±7.73	<.0001
BAI	28.34±12.91	19.49±7.02	31.34±13.09	<.0001
PI(Kg/m^3)	19.28±5.68	19.92±5.5	19.07±5.74	.31

Data is presented as mean ± standard deviation of the mean. Wt-Weight, Ht-Height, WC- Waist Circumference, HC- Hip Circumference, BMI-Body Mass Index, WHR- Waist-to-Hip Ratio, WHtR- Waist-to-Height Ratio, CI-Conicity Index, AVI-Abdominal Volume Index, BAI-Body Adiposity Index, PI-Ponderal Index.P is significant at 0.05

Table 2. Receiver operating characteristic curve threshold Cut-off values of selected variables and their ability to predict hypertension

Parameter	Cutoff	Sensitivity	Specificity	(AUC)	*P -value*	Youden J
Wt_F	>77	64.1(54.3-73.2)	66.7(51.0-80.0)	0.662	.0007	0.3082
Wt_M	>80	50.0(38.1-61.9)	81.3(54.4-96.0)	0.675	.015	0.3125
HC_F	>79	90.6(83.3-95.4)	80.0(65.4-90.4)	0.909	<.0001	0.7057
HC_M	>90	70.3(58.5-80.3)	93.8(69.8-99.8)	0.889	<.0001	0.6402
WC_F	>75	90.6(83.3 - 95.4)	77.8(62.9 - 88.8)	0.911	<.0001	0.6834
WC_M	>80	81.1(70.3 - 89.3)	81.3(54.4 - 96.0)	0.885	<.0001	0.6233
BMI_F	>28.3	67.0(57.2 - 75.8)	48.9(33.7 - 64.2)	0.546	.38	0.1587
BMI_M	≥31.02	64.9(52.9 - 75.6)	62.5(35.4 - 84.8)	0.561	.495	0.2736
WHR_F	>0.97	45.3(35.6 - 55.2)	77.8(62.9 - 88.8)	0.616	.02	0.2306
WHR_M	>0.91	85.1(75.0 - 92.3)	0.00(0.0 - 20.6)	0.523	.76	0.1486
$WHtR_F$	>0.49	83.0(74.5 - 89.6)	75.6(60.5 - 87.1)	0.870	<.0001	0.5857
$WHtR_M$	>0.53	70.3(58.5 - 80.3)	75.0(47.6 - 92.7)	0.833	<.0001	0.5541

WC- Waist Circumference, BMI-Body Mass Index, WHR- Waist-to-Hip Ratio, WHtR- Waist-to-Height Ratio, C.I-Conicity Index, AVI-Abdominal Volume Index, BAI-Body Adiposity Index,$_F$-Female and $_M$-Male. AUC-Area under the Receiver operative characteristics curve.Pis significant at 0.05

Table 3. Receiver operating characteristic curve threshold cutoff of selected less commonly used candidate anthropometric variables and their ability to predict hypertension

Parameter	Cutoff	Sensitivity	Specificity	(AUC)	*P* -value	Youden J
CI_F	>1.08	80.2(71.3 - 87.3)	95.6(84.9 - 99.5)	0.944	<.0001	0.7574
CI_M	>1.05	87.8(78.2 - 94.3)	87.5(61.7 - 98.4)	0.937	<.0001	0.7534
AVI_F	>11.25	91.5(84.5 - 96.0)	77.8(62.9 - 88.8)	0.910	<.0001	0.6929
AVI_M	>12.83	81.1(70.3 - 89.3)	81.3(54.4 - 96.0)	0.885	<.0001	0.6233
BAI_F	>22.85	84.0(75.6 - 90.4)	71.1(55.7 - 83.6)	0.827	<.0001	0.5507
BAI_M	>16.96	91.9(83.2 - 97.0)	50.0(24.7- 75.3)	0.764	.0001	0.4189
PI_F	≤18.95	55.7(45.7-65.3)	57.8(42.2-72.3)	0.527	0.62	0.1344
PI_M	≤19.99	77.0(65.8-86.0)	56.3(29.9-80.2)	0.623	0.19	0.3328

WC- Waist Circumference, BMI-Body Mass Index, WHR- Waist-to-Hip Ratio, WHtR- Waist-to-Height Ratio, C.I-Conicity Index, AVI-Abdominal Volume Index, BAI-Body Adiposity Index, PI- Ponderal Index, $_F$-Female and $_M$-Male, AUC - Area under the Receiver operative characteristics curve. P is significant at 0.05

On the comparative performance of anthropometric indices as predictors of hypertension, Conicity index (CI), irrespective of gender outperformed all other anthropometric measures evaluated in this study by presenting a significantly higher discriminatory power (Area under the curve - AUC) compared to every other index of body adiposity assessed. The use of CI_M among the male population improved the prediction of hypertension by 5.62% against its closest competitor (HC_M) and 78.39% against the least (WHR_M). Among the females, CI_F improved the prediction by 3.29% against the closest competitor (WC_F) and 79.70% against ponderal index (PI_F) the least performing anthropometric index. In comparison to BMI, CI improved hypertension prediction by 67.74% and 71.43% among male and female populations respectively. In both the female and male populations, the performance of HC, WC and AVI were statistically comparable. Though the predictive differences between HC_M, WC_M and AVI_M against $WHtR_M$ were statistically comparable among the males, the predictive performance of $WHtR_F$ significantly reduced by 4.60% in the females compared to either HC_F, WC_F or AVI_F. The performances of BMI, WHtR and PI among the study population irrespective of gender were near to a worthless test (AUC = 0.5) (Table 4).

4. DISCUSSION

Obesity is noted as a risk factor of hypertension with a 2 to 6 folds preponderancy over normotensives [21]. Anthropometric indices provide an effective, simple, inexpensive, and non-invasive means for a first-level screening for hypertension [22,23]. Among different populations, varied predictive performances of different anthropometric indices for health and disease with varied threshold cutoff values have been reported [20,22,24-31].

In the current study, higher averages of anthropometric indices were observed among the hypertensive group compared to the normotensive group (Table 1). With the exception of BMI, PI for both sexes and waist-to-hip ratio (WHR_M) for male subjects, the anthropometric indices in the current study were able to predict hypertension among the study population (Tables 2 & 3).

Among the commonly used indices irrespective of gender, waist circumference (WC_F) and Hip circumference (HC_F) were the anthropometric measures of choice for prediction of hypertension. The performance of WC as a good predictor of hypertension among other populations in the sub-Saharan Africa region has been reported [32-34].

In agreement with Désilets et al. [35] and Haregu et al. [1], who suggested that standard anthropometric indices of obesity may not be as effective in populations of African descent compared with whites, unless appropriate cut-off values are defined, a lower optimal threshold of waist circumference of >80 cm and >75 cm for men and women respectively was found to be the most significant predictors of hypertension. Compared to currently recommended cutoff point of a waist circumference of ≥94 cm for men and ≥80 cm for women for sub-Sahara African populations proposed by the IDF (Europid) and ≥102 cm for men and ≥93 cm for women proposed by the National cholesterol education programme adult treatment panel III (NCEP ATP III) [13,36,37], this study buttresses the earlier finding that lower cutoff of obesity indices are needed for association with increased health risks among the Ghanaian population [38].

Table 4. Comparison of the ROC AUC for discriminating performance of anthropometric variables for the prediction of hypertension. upper right sided of diagonal (male population), lower lift sided of diagonal (female population)

Parameter	$AUC_{(Male)}$	Wt	HC	WC	WHR	WhtR	BMI	CI	AVI	BAI	PI
A$UC_{(Female)}$		0.675	0.889	0.885	0.523	0.833	0.561	0.937	0.885	0.764	0.623
Wt	0.662		0.21***	0.21***	0.15	0.16**	0.11	0.26***	0.21***	0.09	0.05
HC	0.909	0.25***		0.004	0.37***	0.06*	0.33**	0.05*	0.004	0.13*	0.27*
WC	0.911	0.25***	0.002		0.36***	0.05	0.32**	0.05*	0.00	0.12*	0.26*
WHR	0.616	0.05	0.29***	0.30***		0.31***	0.04	0.41***	0.36***	0.24*	0.10
WhtR	0.870	0.21***	0.04*	0.04**	0.25***		0.27*	0.10**	0.05	0.07*	0.21
BMI	0.546	0.12**	0.36***	0.37***	0.07	0.32***		0.38***	0.32**	0.20	0.06**
CI	0.944	0.28***	0.04*	0.03*	0.33***	0.07**	0.39***		0.05*	0.17**	0.31**
AVI	0.910	0.25***	0.001	0.001	0.29***	0.04**	0.36***	0.04*		0.12*	0.26*
BAI	0.827	0.16***	0.08**	0.08**	0.21**	0.04*	0.28***	0.12***	0.08**		0.14
PI	0.527	0.14	0.38***	0.38***	0.09	0.34***	0.02	0.42***	0.38***	0.30***	

*Data is presented as difference in AUC±Standard error of the difference in AUC. WC- Waist Circumference, BMI-Body Mass Index, WHR- Waist-to-Hip Ratio, WHtR- Waist-to-Height Ratio, C. I-Conicity Index, AVI-Abdominal Volume Index, BAI-Body Adiposity Index. *P is significant at .05, **P is significant at .01 and ***P is significant at .001*

The candidate parameter, conicity index outperformed all other anthropometric variables as the anthropometric marker of choice for the prediction of hypertension. Among the male study participants, the use of conicity index improved the prediction of hypertension by 5.7% against its closest anthropometric competitors (WC and AVI) and 79.2% against the worst (WHR). For the female study population, conicity index predicts hypertension 3.6% and 72.9% better than waist circumference and body mass index, the closest and poorest competitors respectively (Table 4). This findings contradicts the reports of Ononamadu et al. [33], who reported a very poor discriminatory power for the use of CI as a predictor of hypertension and rather listed BMI and PI, markers which recorded poor predictive performance in the current study as the best predictor indices among a Nigerian population. According to Valdez, et al. [39], the advantages of conicity index includes a built-in adjustment of waist circumference for height and weight, allowing direct comparisons of abdominal adiposity between individuals or even between populations.

The findings of this study confirmed the limited role of waist to hip ratio (WHR) and body mass index (BMI) in predicting hypertension in general and especially in African populations [19,40,41]. The limitation associated with waist to hip ratio is that it co-varies with hip circumference which makes it have a high preponderancy of underestimating the risk of abdominal obesity in those with high hip circumference [41]. Thus, WHR is said to be a poor estimator of abdominal region expansion [19]. Body mass index (BMI) and PI measures total body mass which includes both fat and lean mass [41], body adiposity index (BAI) reflect percentage body adiposity [42], whereas the rest of the anthropometric parameters considered in this study are used as proxy measures for abdominal fat distribution [40,43]. Different fat depots (abdominal visceral, abdominal subcutaneous, total subcutaneous and total body fat) are not equivalent from a functional point of view, with visceral adipose tissue (VAT) composed of adipocytes of smaller size and less storage capacity, more vascular with increased sympathetic innervation and a large number of β3-adrenergic receptors, which facilitates a higher metabolic activity compared with subcutaneous peripheral adipose tissue (SAT) [44]. This makes VAT a more important factor in the patho-etiology of hypertension than SAT. As visceral obesity cannot be identified by the body mass index [45], its functional significance in predicting its risk on hypertension is poor [46].

5. CONCLUSION

In this Ghanaian cohort, body mass index, waist-to-hip ratio and ponderal index were poor predictors of hypertension. Among the commonly used anthropometric measures, waist circumference at a lower threshold (>75 cm female, >80 cm male) than currently recommended cutoffs was the index of choice for the prediction of hypertension, however significant improvement in prediction was achieved with the use of conicity index (>1.08 female, >1.05 male). Though the extrapolation of the current findings among the general Ghanaian population may not be plausible, due to the limited sample size, the value of the findings provides a starting point for further large scale studies which may also take into consideration other cofounding factors such as diet and physical activity.

CONSENT

As per international standard or university standard, patient's written consent has been collected and preserved by the authors.

ETHICAL APPROVAL

As per international standard or university standard, written approval of Ethics committee has been collected and preserved by the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Haregu TN, Oti S, Egondi T, Kyobutungi C. Measurement of overweight and obesity an urban slum setting in sub-Saharan Africa: A comparison of four anthropometric indices. BMC Obesity. 2016;3(1):46. DOI: 10.1186/s40608-016-0126-0
2. Lee JW, Lim NK, Baek TH, Park SH, Park HY. Anthropometric indices as predictors of hypertension among men and women aged 40–69 years in the Korean population: The Korean genome and

epidemiology study. BMC Public Health. 2015;15(1):140.
DOI: 10.1186/s12889-015-1471-5

3. Nichols S, Crichlow H. An evaluation of the diagnostic utility of anthropometric and body composition cut-off values in assessing elevated fasting blood sugar and blood pressure. West Indian Medical Journal. 2010;59:253-8.
4. George C, Goedecke J, Kengne AP, Norris S, Micklesfield LK. Body composition measures as predictors of hypertension in urban black South African woman. Journal of Endocrinology, Metabolism and Diabetes of South Africa. 2015;20(1):24-36.
DOI: 10.1080/16089677.2015.1030855
5. Saeed AA, Al-Hamdan NA. Anthropometric risk factors and predictors of hypertension among Saudi adult population – A national survey. Journal of Epidemiology and Global Health. 2013;3(4):197-204.
DOI:http://dx.doi.org/10.1016/j.jegh.2013.08.004
6. Abiodun AG, Egwu MO, Adedoyin RA. Anthropometric indices associated with variation in cardiovascular parameters among primary school pupils in Ile-Ife. International Journal of Hypertension. 2011;2011.
DOI: 10.4061/2011/186194
7. Lee BJ, Kim JY. A comparison of the predictive power of anthropometric indices for hypertension and hypotension risk. PLOS ONE. 2014;9(1):e84897.
DOI: 10.1371/journal.pone.0084897
8. Ramoshaba N, Monyeki K, Zatu M, Hay L, Mabata L. The relationship between blood pressure and anthropometric indicators in rural South African children: Ellisras longitudinal study. Journal of Obesity & Weight Loss Therapy. 2015;5(1).
9. Tarleton HP, Smith LV, Zhang ZF, Kuo T. Utility of anthropometric measures in a multiethnic population: Their association with prevalent diabetes, hypertension and other chronic disease comorbidities. Journal of Community Health. 2014;39(3): 471.
10. Murphy GAV, Asiki G, Nsubuga RN, Young EH, Maher D, Seeley J, et al. The use of anthropometric measures for cardiometabolic risk identification in a Rural African population. Diabetes Care. 2014;37(4):e64-e5.
DOI: 10.2337/dc13-2096
11. Lear SA, James PT, Ko GT, Kumanyika S. Appropriateness of waist circumference and waist-to-hip ratio cutoffs for different ethnic groups. Eur J Clin Nutr. 2009;64(1): 42-61.
12. Yalcin BM, Sahin EM, Yalcin E. Which anthropometric measurements are most closely related to elevated blood pressure? Family Practice. 2005;22(5):541-7.
DOI: 10.1093/fampra/cmi043
13. Alberti K, Eckel RH, Grundy SM, Zimmet PZ, Cleeman JI, Donato KA, et al. Harmonizing the metabolic syndrome a joint interim statement of the International Diabetes Federation task force on epidemiology and prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Atherosclerosis Society; and International Association for the Study of Obesity. Circulation. 2009;120(16):1640-5.
14. Frank LK, Heraclides A, Danquah I, Bedu-Addo G, Mockenhaupt FP, Schulze MB. Measures of general and central obesity and risk of type 2 diabetes in a Ghanaian population. Tropical Med Int Health. 2013;18.
DOI: 10.1111/tmi.12024
15. Owusu IK, Aryee C, Owiredu WK, Osei-Yeboah J, Owusu-Dabo E, Laing EF. Analysis of atherogenic and anthropometric profiles of normotensive and hypertensive Ghanaians in the Kumasi Metropolis. British Journal of Medicine and Medical Research. 2015;5(7):378-97.
16. Lemogoun D, Seedat YK, Onwubere B. Recommendations for prevention, diagnosis and management of hypertension and cardiovascular risk factors in Sub-Sahara Africa. J Hypertens. 2003;21:1993-2000.
17. Owusu IK. Causes of heart failure as seen in Kumasi Ghana. Internet Journal of Third World Medicine. 2007;4(3).
18. Ruperto M, Barril G, Sánchez-Muniz FJ. Conicity index as a contributor marker of inflammation in haemodialysis patients. Nutr Hosp. 2013;28(5):1688-95.
19. Vuga M. Conceptual review of issues with practical abdominal obesity measures. Section on Statistics in Epidemiology – JSM. 2009;4876-90.
20. Lategan R, Van den Berg VL, Walsh CM. Body adiposity indices are associated with hypertension in a black, urban Free State community: Original research. African Primary Health Care and Family Medicine. 2014;6(1):1-7.

21. El Din AMS, Zaki ME, Kandeel WA, Mohamed SK, El Wakeel KH. Cut-off values of anthropometric indices for the prediction of hypertension in a sample of Egyptian adults. Open Access Macedonian Journal of Medical Sciences. 2014;2(1):89-94.
22. Silva D, Petroski E, Peres M. Accuracy and measures of association of anthropometric indexes of obesity to identify the presence of hypertension in adults: A population-based study in Southern Brazil. European Journal of Nutrition. 2013;52(1):237-46.
DOI: 10.1007/s00394-012-0314-8
23. Caminha TC, Ferreira HS, Costa NS, Nakano RP, Carvalho RES, Xavier Jr AF, et al. Waist-to-height ratio is the best anthropometric predictor of hypertension: A population-based study with women from a state of northeast of Brazil. Medicine. 2017;96(2).
24. Shidfar F, Alborzi F, Salehi M, Nojomi M. Association of waist circumference, body mass index and conicity index with cardiovascular risk factors in postmenopausal women: Cardiovascular topic. Cardiovascular Journal of Africa. 2012;23(8):442-5.
25. Taylor RW, Jones IE, Williams SM, Goulding A. Evaluation of waist circumference, waist-to-hip ratio, and the conicity index as screening tools for high trunk fat mass, as measured by dual-energy X-ray absorptiometry, in children aged 3–19 y. The American Journal of Clinical Nutrition. 2000;72(2):490-5.
26. Nadeem A, Naveed AK, Hussain MM, Raza SI. Cut-off values of anthropometric indices to determine insulin resistance in Pakistani adults. J Pak Med Assoc. 2013;51(12.1):51.16-0.62.
27. Kim KS, Owen WL, Williams D, Adams-Campbell LL. A comparison between BMI and Conicity index on predicting coronary heart disease: The Framingham heart study. Annals of Epidemiology. 2000;10(7): 424-31.
DOI:http://dx.doi.org/10.1016/S1047-2797(00)00065-X.
28. Freedman DS, Ogden CL, Goodman AB, Blanck HM. Skinfolds and coronary heart disease risk factors are more strongly associated with BMI than with the body adiposity index. Obesity. 2013;21(1):E64-E70.
29. Lichtash CT, Cui J, Guo X, Chen YDI, Hsueh WA, Rotter JI, et al. Body adiposity index versus body mass index and other anthropometric traits as correlates of cardiometabolic risk factors. PloS One. 2013;8(6):e65954.
30. Vinknes KJ, Elshorbagy AK, Drevon CA, Gjesdal CG, Tell GS, Nygård O, et al. Evaluation of the body adiposity index in a Caucasian population: The Hordaland health study. American Journal of Epidemiology. 2013;177(6):586-92.
31. Okeahialam B, Diala U, Uwakwe J, Ejeh I, Ozoilo U. Abdominal height measures cardiometabolic risk better than body mass index: Result of a preliminary study. JMR. 2016;2(5):149-51.
32. Raimi TH, Fasanmade O, Odusan O, Ohwovoriole AE. The best central adiposity index in the prediction of cardiovascular risk factors in South-Western Nigeria. Open Journal of Endocrine and Metabolic Diseases. 2015;5(12):184.
33. Ononamadu CJ, Ezekwesili CN, Onyeukwu OF, Umeoguaju UF, Ezeigwe OC, Ihegboro GO. Cardiovascular topics. Cardiovascular Journal of Africa. 2016;2.
34. Okafor CI, Fasanmade O, Ofoegbu E, Ohwovoriole AE. Comparison of the performance of two measures of central adiposity among apparently healthy Nigerians using the receiver operating characteristic analysis. Indian Journal of Endocrinology and Metabolism. 2011; 15(4):320.
35. Désilets MC, Garrel D, Couillard C, Tremblay A, Després JP, Bouchard C, et al. Ethnic differences in body composition and other markers of cardiovascular disease risk: Study in matched Haitian and White subjects from Quebec. Obesity. 2006;14(6):1019-27.
36. Zimmet P, Magliano D, Matsuzawa Y, Alberti G, Shaw J. The metabolic syndrome: A global public health problem and a new definition. Journal of Atherosclerosis and Thrombosis. 2005;12(6):295-300.
37. Thomas GN, Ho SY, Janus ED, Lam KS, Hedley AJ, Lam TH, et al. The US national cholesterol education programme adult treatment panel III (NCEP ATP III) prevalence of the metabolic syndrome in a Chinese population. Diabetes Research and Clinical Practice. 2005;67(3):251-7.
38. Owiredu W, Adamu M, Amidu N, Woode E, Bam V, Plange-Rhule J, et al. Obesity and

cardiovascular risk factors in a pentecostal population in Kumasi-Ghana. J Med Sci. 2008;8:682-90.

39. Valdez R, Seidell J, Ahn YI, Weiss KM. A new index of abdominal adiposity as an indicator of risk for cardiovascular disease. A cross-population study. International Journal of Obesity. 1993;17(2):77-82.
40. Thierry G, Benjamin LM, Bertrand EM, Stephan IM, Gisèle KK, Jean-Louis N, et al. Prevalence rates and cardiometabolic determinants of diabetes mellitus and pre-diabetes with projected coronary heart disease at bank site of Brazzaville. World Journal of Cardiovascular Diseases. 2014;2014.
41. Mafra D, Guebre-Egziabher F, Fouque D. Body mass index, muscle and fat in chronic kidney disease: Questions about survival. Nephrology Dialysis Transplantation. 2008;23(8):2461-6.
42. Bergman RN, Stefanovski D, Buchanan TA, Sumner AE, Reynolds JC, Sebring NG, et al. A better index of body adiposity. Obesity. 2011;19(5):1083-9.
43. Guerrero-Romero F, Rodríguez-Morán M. Abdominal volume index. An anthropometry-based index for estimation of obesity is strongly related to impaired glucose tolerance and type 2 diabetes mellitus. Archives of Medical Research. 2003;34(5):428-32.
44. Iglesias P, Díez JJ. Adipose tissue in renal disease: Clinical significance and prognostic implications. Nephrology Dialysis Transplantation. 2010;25(7):2066-77. DOI: 10.1093/ndt/gfq246
45. Després JP. Assessing the cardiometabolic risk of obesity: Importance of Visceral/ectopic fat and of the use of hypertriglyceridemic waist. In: Haslam DW, Sharma AM, le Roux CW, editors. Controversies in Obesity: Springer London. 2014;127-35.
46. Lee CMY, Huxley RR, Wildman RP, Woodward M. Indices of abdominal obesity are better discriminators of cardiovascular risk factors than BMI: A meta-analysis. Journal of Clinical Epidemiology. 2008;61(7):646-53.

Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/22540