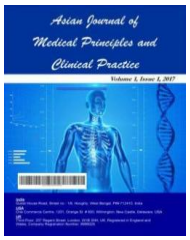

Asian Journal of Medical Principles and Clinical Practice

1(2): 56- 64, 2018; Article no.AJMPCP.44149

Use of Selected Anthropometric Indices for Screening Hypertension in an Adult Ghanaian Population

Nafiu Amidu[1*], William K. B. A. Owiredu[2], Benedict Boateng Antuamwine[1] and Otchere Addai-Mensah[3]

[1]Department of Biomedical Laboratory Science, School of Allied Health Sciences, University for Development Studies, Tamale, Ghana.
[2]Department of Molecular Medicine, School of Medical Sciences, College of Health Sciences, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.
[3]Department of Medical Laboratory Technology, School of Allied Health Sciences, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

Authors' contributions

This work was carried out in collaboration between all authors. Author NA designed the study and performed the statistical analysis. Author WKBAO wrote the protocol and managed the analyses of the study. Authors BBA and OA wrote the first draft of the manuscript and managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJMPCP/2018/44149
Editor(s):
(1) Dr. Kumud Kumar Kafle, Department of Clinical Pharmacology, Tribhuvan University, Kathmandu, Nepal.
Reviewers:
(1) Kolade O. Sharaye, Ahmadu Bello University Teaching Hospital (ABUTH), Nigeria.
(2) Basil N. Okeahialam, University of Jos, Nigeria.
(3) Lohini Athiththan, University of Sri Jayewardenepura, Sri Lanka.
Complete Peer review History: http://www.sciencedomain.org/review-history/26762

Original Research Article

Received 7th July 2018
Accepted 2nd October 2018
Published 23rd October 2018

ABSTRACT

Objective: Hypertension is on the rise in Ghana, necessitating rapid and early diagnosis for better patient care. Anthropometric indices such as body mass index (BMI), waist circumference (WC), hip circumference (HP), waist to hip ratio (WHR) and waist-to-height ratio (WHtR) may reflect obesity related conditions. However, cut off values for these indictors of hypertension are lacking. The study aims to establish cut off values for such anthropometric indices in order to timely predict hypertension among adult Ghanaians.

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

Design, Setting and Participants: This was a cross-sectional study among apparently healthy adult Ghanaians domiciled within the Kumasi metropolis of the Ashanti region.
Methodology: Participants anthropometric measurements were used to determine their BMI, WHR and WHtR. Systolic and diastolic blood pressures were also measured and used to determine hypertension among participants. The Receiver Operating Characteristic (ROC) analysis was conducted to determine the anthropometric indices that accurately predict hypertension in the study.
Results: The prevalence of hypertension was 35.4% which did not differ by gender (p=0.590). WHtR, WC and BMI consistently showed the better area under the curve values for both genders, suggesting their increased potential to screen hypertension compared to WHR and HP. The WHtR, WC and BMI cut-off values for classifying hypertension in males were 46.0 cm, 80.0 cm and 23.1 kg/m^2 respectively while that of females were 50.2 cm, 81.7 cm and 26.3 kg/m^2 respectively.
Conclusion: These cut off values correctly classified more than 70% hypertensives with high sensitivity and specificity. WHtR, WC and BMI have shown to be better screening tools for hypertension.

Keywords: Body weight; anthropometry; cardio metabolic risk; screening; hypertension.

1. INTRODUCTION

Low and middle income countries record the majority of years lived with disability and deaths from non-communicable diseases [1]. Even though deaths from infectious diseases are falling, deaths from non-communicable diseases are rising and are estimated to account for nearly half of the deaths in Sub-Saharan Africa by 2030 [2]. Obesity, diabetes and hypertension are highly prevalent among the African population and unfortunately are largely undiagnosed and untreated [3].

Hypertension, the commonest cardiovascular disorder affects at least 20% of adults in many countries [4]. Hypertension is a culprit in an estimated 13% of global deaths [5] and is highest among people of African descent [6]. Developed countries generally have a lower prevalence of hypertension with the Americas recording the lowest prevalence of 35% and highest among developing countries which record a prevalence of 46% among their adult population [7].

The prevalence of hypertension in Ghana is reported to be 48% [8], making the condition the second most predominant outpatient disease in the country. Nutritional transition [9] and increased socioeconomic status are believed to contribute to the rise in hypertension among Ghanaians [10]. The consequences of hypertension are huge, among which renal and heart failures have been reported in several Ghanaian population [11].

Treatment options are available for hypertensives [12] and the Ghana Health Service encourages screening and referral for further treatment. Current efforts in hypertension prevention and control in Ghana include the Community based Hypertension Improvement Project in the Southern parts of Ghana which has reported increased hypertension awareness [13].

Reports of increased prevalence of hypertension among overweight and obese individuals and which however could be 50% lower among normal weight individuals [14] implies that appropriate weight control is important in hypertension prevention and control programmes. Hence, minimum weight and associated indices which could imply lower hypertension risk would be an important measure.

Several studies have shown that increased anthropometric indices such as BMI, WC and WHR are directly associated with increased blood pressure and adverse cardiovascular risks, hence their cut-off values have been determined in several populations to screen for hypertension [15-20]. Despite the determination of cut-off values for anthropometric indices' paramount in the prevention and management of obesity and its associated conditions, these values are unavailable in the Ghanaian population. An appropriate hypertension prevention programme will normally encourage weight reduction, however, the minimum weight by gender which could ensure minimal hypertension occurrence is unknown in the Ghanaian population. As weight and related indices may vary greatly in different geographic areas and ethnicity [21], developing country specific thresholds could be useful.

The present study was aimed at determining the cut off values for selected anthropometric indices which correctly classifies hypertension in an

apparently healthy adult population in Ghana. Such cut off values could be useful in intervention programmes to encourage loss of appropriate weight towards hypertension prevention.

2. METHODS

2.1 Study Design and Population

This was a cross-sectional study conducted among adult Ghanaians aged 18-73 years. Two hundred and twenty-six (226) apparently healthy individuals domiciled in the Kumasi metropolis of the Ashanti region participated in the study after their prior consent. The study participants were recruited from Atonsu, Meduma, Sofoline and Adum locations of the metropolis. Pregnant women, individuals on anti-hypertensive and cholesterol lowering therapies and as well as those with certified underlying clinical conditions were excluded from the study.

2.2 Demographics

Socio-demographic characteristics such as age, gender, marital status, behavioural activities including smoking and alcohol intake, education, occupation and health status were obtained using a structured questionnaire.

2.3 Measurement of Anthropometric Characteristics

Anthropometric data were measured following WHO standard procedure [22]. Body weight was measured with an electronic scale to the nearest 0.1 kg with subjects in light clothes. Height was measured to the nearest 0.5 cm with the subject standing upright and barefooted, with the heels put together and the head in the horizontal plane against a wall-mounted ruler. WC was taken midway between the lowest rib and the iliac crest, and HP at the level of the greater trochanters was measured to the nearest millimetre with a Gulick II spring loaded measuring tape. WHR were obtained by dividing WC by HP. WHtR were also obtained by dividing WC by height.

2.4 Measurement of Blood Pressure

Recording of blood pressure were done by qualified nurses between the hours of 7:00 am and 10:00 am. Blood pressure was calculated as the mean of two measurements taken under standardised conditions with a mercury sphygmomanometer, with the subject in a sitting position. Systolic and diastolic blood pressure measurements (representing the appearance of the first and the disappearance of the fifth Korotkoff sound respectively) were recorded. The standard blood pressure cuff was 12 by 35 cm. In subjects having an upper arm circumference of more than 35 cm, a cuff measuring 15 by 43 cm was used, and in subjects having an upper arm circumference of less than 20 cm, a cuff measuring 9 by 25 cm was used [23].

2.5 Statistical Analysis

Data analyses were performed using SPSS version 20. Continuous variables were presented as means and standard deviations while categorical variables were presented as frequencies and percentages. Unpaired student's t-test was used to compare mean differences among gender while the Chi-square and Fisher's Exact test were used where appropriate to find differences in categorical variables. The hypertension predictive cut-off values for the selected anthropometric indices BMI, WC, HP, WHR and WHtR were determined by ROC analysis. Statistical significance was set at $p<0.05$.

3. RESULTS

3.1 Background Characteristics of the Study Participants

A total of 116 females and 110 males participated in this study. There was a significant difference in the mean age of participants ($p<0.001$) with females being older. Marital status was not different between male and female participants ($p=0.722$). Participants differed by educational status ($p=0.003$), with males more likely to have attained higher educational status than their female counterparts. Males were also more likely to engage in strenuous occupations ($p<0.001$) and exercise ($p=0.007$) than females. Males and females in this study, however, did not differ by alcohol intake ($p=0.583$), smoking behaviour ($p=0.114$) and prevalence of high blood pressure ($p=0.590$). Even though the men were more likely to take alcohol and smoke, the prevalence of hypertension was higher among women (37.1%) than the men (33.6%) (Table 1).

Table 1. Background characteristics of study participants

Characteristic	Total (n=226)	Male (n=110)	Female (n=116)	p-value
Age, (years)	35.21±12.87	31.95±0.83	38.31±13.90	<0.001[a]
Marital status				0.722[b]
Married	100 (44.2%)	50 (45.5%)	50 (43.1%)	
Single	126(55.8%)	60(54.5%)	66(56.9%)	
Education				0.003[b]
None	12(5.3%)	1(0.9%)	11(9.5%)	
Primary	130(57.5%)	62(56.4%)	68(58.6%)	
Secondary	62(27.4%)	39(35.5%)	23(19.8%)	
Tertiary	22(9.7%)	8(7.3%)	14(12.1%)	
Nature of occupation				<0.001[b]
Strenuous	64(28.3%)	63(57.3%)	1(0.9%)	
Less strenuous	162 (71.7%)	47(42.7%)	115(99.1%)	
Alcohol consumption				0.583[b]
Take alcohol	30(13.3%)	16(14.5%)	14(12.1%)	
No alcohol	196(86.7%)	94(85.5%)	102(87.9%)	
Smoking				0.114[c]
Smoke	3(1.3%)	3(2.7%)	0(0.0%)	
No smoke	223(98.7%)	107(97.3%)	116(100%)	
Exercise				0.007[b]
Yes	56(24.8%)	36(32.7%)	20(17.2%)	
No	170(75.2%)	74(67.3%)	96(82.8%)	
Hypertension				0.590[b]
Normal	146(64.6%)	73(66.4%)	73(62.9%)	
Hypertensive	80(35.4%)	37(33.6%)	43(37.1%)	

[a]t-test, [b]Chi-square test, [c]Fisher's Exact test

3.2 Anthropometry and Blood Pressure Characteristics of Study Participants

The anthropometric characteristics and blood pressure of the sampled population are presented in Table 2. Males (1.67±0.06m) were significantly taller than the females (1.58±0.07m), whiles the females were heavier (69.43kg vs 65.25kg, p=0.013). The participants also differed significantly by WC and HP. The women had significantly higher waist (85.20cm vs 80.10, p=0.013) and hip (90.09 vs 99.92 cm, p<0.001) circumference than the men. BMI was higher among the women compared to the men (27.69 Kg/m^2 vs 23.38 Kg/m^2, p<0.001). Males (0.89±0.07), however, had higher WHR compared to the females (0.85±0.14). The women (53.95±10.07) also had higher WHtR ratios compared to the men (48.46±5.14, p<0.001). Participants did not, however, differ in their systolic and diastolic blood pressures.

3.3 Anthropometric Cut off Values to Predictive of Hypertension among Ghanaian Adults

ROC analysis was performed to determine the cut-off values of the selected anthropometric indices BMI, WC, HP, WHR, and WHtR that predict high blood pressure in males (Fig.1) and females (Fig. 2). Among the indices considered, WHtR, WC and BMI consistently showed larger AUCs across gender, indicating their better suitability for predicting hypertension in the Ghanaian population.

WHtR predictive cut-off values for males (46.04) and females (50.15) proved to be the best anthropometric index for classifying hypertension, as they showed the largest AUC values of 0.713 and 0.733 respectively as shown in Table 3. Both male and female WHtR cut-off values showed a sensitivity of 92% and 81% respectively with a specificity of 45% and 51% respectively. WC predictive cut-off values for males (80.00cm) and females (81.65cm) were next to WHtR in classifying hypertension. Both male and female cut-off values showed sensitivity of 78% and 81% respectively with specificity of 54% and 55% respectively. The predictive cut-off values of the other anthropometric indices their respective sensitivities and specificities are also shown in Table 3.

Table 2. Distribution of anthropometric and blood pressure characteristics by sex of participants

Characteristics	Total (n=226)	Male (n=110)	Female (n=116)	p-value
Height (m)	1.62±0.08	1.67±0.06	1.58±0.07	<0.001
Weight (cm)	67.40±12.91	65.25±8.33	69.43±15.86	0.013
Waist circumference (cm)	83.15±12.94	80.10±8.78	85.20±15.68	0.013
Hip circumference (cm)	95.62±12.19	91.09±8.07	99.92±13.81	<0.001
BMI (Kg/m^2)	25.59±5.23	23.38±2.76	27.69±6.09	<0.001
WHR	0.87±0.11	0.89±0.07	0.85±0.14	0.018
WHtR	51.28±8.5	48.46±5.14	53.95±10.07	<0.001
Systolic blood pressure (mmHg)	127.42±16.50	128.11±15.27	126.76±17.62	0.540
Diastolic blood pressure (mmHg)	79.37±12.82	77.85±11.01	80.80±14.22	0.082

Data are presented as mean±SD

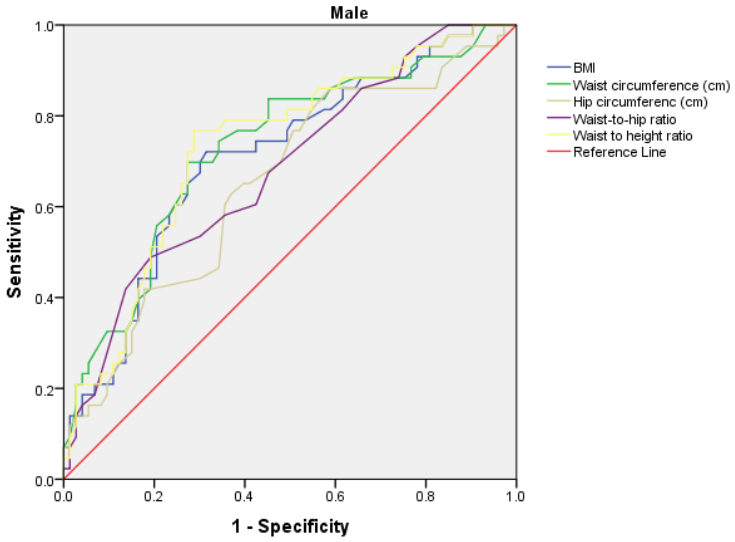

Fig. 1. ROC curves for male BMI, WC, HP, WHR and WHtR

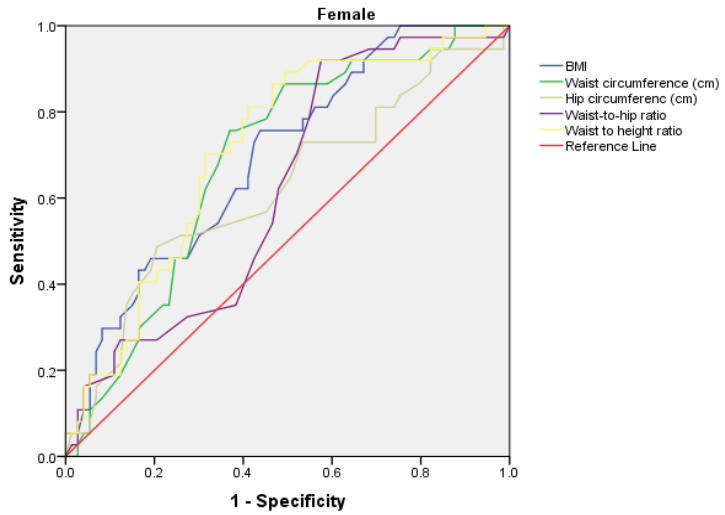

Fig. 2. ROC curves for female BMI, WC, HP, WHR and WHtR

Table 3. Best anthropometric cut off values to predict hypertension among Ghanaian adults

Sex	Anthropometric index	AUC (95% CI)	Hypertension predictive cut off value	Percentage of correctly classified hypertensives	Sensitivity	Specificity
Male	BMI	0.695(0.595-0.794)**	23.05kg/m^2	72.97%	73%	57.5%
	WC	0.689(0.588-0.790)**	80.00cm	78.38%	78%	54.8%
	HP	0.621(0.507-0.736)*	88.95cm	72.97%	73%	41%
	WHR	0.620(0.513-0.727)*	0.855	91.89%	92%	42%
	WHtR	0.713(0.613-0.812)***	46.04	91.89%	92%	45%
Female	BMI	0.709(0.611-0.806)***	26.25kg/m^2	72.09%	72%	57.5%
	WC	0.729(0.633-0.826)***	81.65cm	81.40%	81%	55%
	HP	0.653(0.549-0.757)**	95.00cm	86.05%	86%	41%
	WHR	0.683(0.583-0.782)**	0.865	53.49%	54%	70%
	WHtR	0.733(0.638-0.827)***	50.15	81.40%	81%	51%

**p<0.05, ** p<0.01, *** p<0.001*

4. DISCUSSION

The present study sought to determine the predictive cut-off values of selected anthropometric indices for screening hypertension in a Ghanaian population. The prevalence of hypertension in the study population was found to be high, where more than three in every ten people had the condition which. The study reveals that anthropometric characteristics such as BMI, WC, HP, WHR, and WHtR could be important screening tools for hypertension among the Ghanaian population. Consistently, WHtR, WC and BMI showed the largest AUCs across gender, suggesting their increased suitability to screen for hypertension in this population. The best predictive cut-off values for classifying hypertension in males using the following indices were WHtR (≥46.04), BMI (≥23.05 kg/m^2) and WC (≥80.00cm). Additionally, that for the female participants were WHtR (≥50.2), WC (81.65cm) and BMI (≥26.25kg/m^2). The prevalence of hypertension reported in the present study is within the prevalence of 19.3% in rural and 54.6% in urban areas as discussed in a recent review of hypertension in Ghana [24]. The prevalence is, however, lower than the 39.4% reported by Solomon et al. [25] among adults in the Hohoe Municipality of Ghana. The lack of gender differences in the prevalence of hypertension in the present study is consistent with an earlier study in Ghana [26].

The increased suitability of WHtR among other anthropometric indices to predict hypertension in the study participants is consistent with earlier studies where WHtR was shown to be a better determinant of hypertension compared to other indices [27]. The WHtR predictive cut-off values; males (≥46.04) and females (≥50.15) could, therefore, be the best in screening for hypertension in Ghana. The predictive cut-off values of WC (males; ≥80.0 cm, females; ≥81.65 cm) and BMI (males; ≥23.05Kg/m^2, females; ≥26.25Kg/m^2) also suggested a good potential to screen for hypertension in Ghana. Similar findings on the good predictive ability of WC in screening hypertension in the present study was shown among a Ghanaian study of non-diabetic hypertensives attending hypertension clinics in Kumasi [28].

Our findings however disagree with the earlier studies that BMI is a poor index for screening hypertension [28]. The discrepancy could be due to the use of different population groups. The BMI predictive cut-off values (males; ≥23.05Kg/m^2, females; ≥26.25Kg/m^2) for screening hypertension among the Ghanaian population were lower than the WHO cut-offs (BMI; ≥30.00Kg/m^2) used to define obesity. Additionally, WC predictive cut-off values for males (≥80.0 cm) and females (81.65 cm) were respectively lower and slightly higher to the WHO cut-offs (males;>94 cm, females;>80 cm) for obesity and its associated risks [29,30]. These lower values which are likely to predict hypertension risk in the Ghanaian population are consistent with an earlier study in Ghana which suggested lower cut-off values of BMI and WC to define obesity and its associated health risks among Ghanaians [31]. Our findings could, therefore, mean that using the WHO cut-off criteria may under estimate overweight and obesity among Ghanaians, which could predispose them to a higher risk of obesity related health risks including hypertension [14].

The relatively higher cut-off values for predicting hypertension in Ghanaian women compared to men is expected, as women in Ghana have significantly heavier compared to men who are generally taller. Ghanaian and other African women generally consider heavier weights as desirable, because beauty and affluence are conventionally associated with such characteristics [32,33]. As a result, most women maintain a heavier weight in these populations. Researchers have generally preferred sensitivity of screening tools to specificity, because of the reduced occurrence of false negative results in open population screening. When a referral is required, however, a higher specificity is desirable [34]. For the purposes of interventions targeting hypertension prevention in Ghana, the present hypertension predictive cut-offs for WHtR (males; ≥46.04 females; ≥50.15), BMI (males; ≥23.05Kg/m^2, females; ≥26.25Kg/m^2) and WC (males; ≥80.0 cm, females; ≥81.65 cm) which present higher sensitivity could be very useful.

5. CONCLUSION

Hypertension is high in the Ghanaian adult population and selected anthropometric indices could be useful screening tools. WHtR, WC, BMI have been shown to be better anthropometric screening tools for hypertension.

ETHICAL APPROVAL AND CONSENT

Ethical clearance for the study was obtained from. The Committee on Human Research, Publications and Ethics, Kwame Nkrumah

University of Science and Technology, School of Medical Sciences, & Komfo Anokye Teaching Hospital Kumasi, Ghana. Participation in this study was voluntary and participants were recruited after an explanation of the study aims were given. Participants also signed/thumb printed informed consent forms.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history/26762