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Cut-Off Values of Anthropometric Indices for the Prediction of Hypertension in a Sample of Egyptian Adults

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Key words: Cut-off values; anthropometric indices; hypertension; adult Egyptians.

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Abstract

Background: Obesity, particularly abdominal adiposity, is closely associated with premature atherosclerosis and many metabolic modifications including insulin resistance dyslipidemia hypertension and diabetes. Cut-off values for abdominal obesity predicting future cardiovascular disease are known to be population specific.

Objective: To identify cut-off points of some anthropometric measurements (BMI, WC, WHR and WHtR) that associated with hypertension in a sample of Egyptian adults.

Subjects and Methods: This is a cross-sectional analysis. The blood pressure of 5550 Egyptian adults was measured (2670 females – 2880 males).The subjects represented different geographic localities and different social classes. Anthropometric measurements including height, weight, waist circumferences, and hip circumferences were also measured by practitioners.

Results: The cut-off values to detect hypertension in females were 30.08 for BMI, 87.75 for WC , 0.81 for WHR and 0.65 for WHtR, and the corresponding sensitivity and specificity were 69.1; 60.7-80.9; 48.6 -65.3; 53.4 and 61.4; 58.9, respectively. The cut-off values to detect hypertension in males were 27.98 for BMI, 95.75 for WC, 0.92 for WHR, and 0.57 for WHtR and the corresponding sensitivity and specificity were 62.8; 59.9 -71.9; 51.9 -64.6; 55.8 and 59.7; 55.8, respectively.

Conclusion: The BMI, Waist circumference, WHR and WHtR values can predict the presence of hypertension risk in adult Egyptians.

Introduction

The increase prevalence of obesity, particularly abdominal adiposity, is closely associated with premature atherosclerosis and many metabolic modifications including insulin resistance dyslipidemia hypertension and diabetes [1, 2]. The diagnosis of abdominal obesity in routine clinical practice depends on the measurement of waist circumference (WC) [3]. However, cut-off values for abdominal obesity predicting future cardiovascular disease are known to be population specific [4].

Body mass index (BMI) (weight in Kilograms divided by the square of the height in meters) is promulgated by the World Health Organization (WHO) as the most useful epidemiological measure of obesity. It is nevertheless a crude index that does not take into account the distribution of body fat, resulting in variability in different individuals and populations [5]. Waist-hip circumference ratio (WHR), waist-height ratio (WHtR) and waist circumference (WC) are commonly used to predict the risk of obesity related morbidity and mortality as they account for regional abdominal adiposity [6-8]. The original cut off values for abdominal obesity in the National Cholesterol Education Program's Adult Treatment Panel III (NCEP III) [9] definition (WC >102 cm for men and >88 cm for women) has previously been shown to be inappropriate for Asian populations but still applicable to US citizens, according to the new International Diabetes Federation (IDF). For Europeans, the cut-off was 94 cm for men and 80 cm for women. For eastern Mediterranean and Middle East (Arab) populations, the IDF recommended the use of European data until more specific data is available. The WHO [10] defines overweight as BM ≥25 kgm^2, obesity as BMI ≥ 30 kgm^2, and central adiposity as WC ≥94 cm for men and ≥ 80 cm for women, and WHR of ≥ 0.90 in men and ≥ 0.85 in women. Thus Identification of the normal cut-off values for Egyptian population is needed for health policy planners when developing cardio vascular disease prevention programs, since universal criteria do not apply on all races. The main objective of this study was to identify cut-off points of some anthropometric measurements (WC, BMI, WHR, WHtR) that associated with hypertension in a sample of Egyptian adults.

Participants and Methods

This is a cross-sectional study included 5550 adult Egyptian individuals of both sexes (2670 women – 2880 men) aged between 20 and 75 years. In 2010 a team from NRC started a community – based cross-sectional survey for establishing comprehensive anthropometric measurements for the dimensions of the Egyptian human body to be used for obtaining the standards needed for the Egyptian clothing industry. The study sample for this survey included 8250 adult subjects of both sexes aged 20-75 years old. The blood pressure of 5550 subjects was measured (2670 females – 2880 males).The subjects represented different geographic localities and different social classes (The Greater Cairo, Alexandria and El Mehala cities representing lower Egypt; El Fayoum, Bany Souif and El Menia cities representing upper Egypt). The survey included subjects working in governmental organizations, factories, and attending social clubs. This study design was approved by the ethical committee board of the National Research Centre of Egypt (No.09/038). An informed written consent was obtained from all participants. All participants completed a questionnaire that includes personal, socioeconomic, demographic, and medical data.

Anthropometric measurements including height, weight, waist circumferences, and hip circumferences were also measured by practitioners. Body weight was measured in light clothing with electronic scales to 0.1 kg precision (Seca, Hamburg, and Germany). Height was measured in a standing position with fixed stadiometers (Seca). Waist circumference (WC) was measured at the midpoint between the lower rib margin and the iliac crest with the subject standing at the end of normal expiration. Hip circumference was measured at the level of the greater trochanters with the subject wearing minimum clothing. Non stretchable tap was used for both circumferences. The mean of two readings was taken in for calculating the waist-to-hip ratio. The mean of three consecutive measurements of each anthropometric measure was evaluated using standardized equipment and following the recommendations of the International Biological Program [11]. Body mass index (BMI) was calculated as weight divided by height squared (kg/m^2). Systolic and diastolic blood pressures were measured in the sitting position using a standard mercury sphygmomanometer with appropriate cuff sizes after a 5-min rest. Systolic blood pressure was measured at the first appearance of a pulse sound (Korotkoff phase 1) and diastolic blood pressure at the disappearance of the pulse sound (Korotkoff phase 5). Three blood pressure readings were averaged, and it was used for analyses according to the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC VII) criteria [12]. Hypertension was defined as systolic blood pressure ≥ 140 mmHg and/or diastolic blood pressure ≥ 90 mmHg, or current use of antihypertensive medication; prehypertension was if the systolic blood pressure was120 to 139 mmHg and/or diastolic blood pressure was 80 to 89 mmHg; and normal was if the systolic blood pressure was < 120 mmHg and diastolic blood pressure was < 80 mmHg [13].

Table 1: Prevalence of hypertension in the studied subjects.

Gender	NT		HT	
	n	%	n	%
Males	1932	67.1	984	32.9**
Females	1998	74.8	672	25.2**
Total	3930	70.8	1620	29.2

NT=Normotensive; HT=hypertensive; n= observed number; ** Significance p< 0.05 versus females.

Data were analyzed using SPSS for Windows (version 16;SPSS Inc., Chicago, Illinois, USA). The Kolmogorov–Smirnov test was used to check for normality in the continuous variables. Quantitative variables are presented as mean ± SD. The analysis of variance test was used to compare groups. All post-hoc comparisons were made using t-tests with Bonferroni adjustment. Significance was assumed for P-values less than 0.05. Receiver Operating Characteristic Curve (ROC curve) ROC curve was used to determine a cut-off that suggested the best accuracy of the waist circumference, WHR, WHtR and BMI risk score values to development the hypertension. Area under the curve (AUC) and 95% confidence interval (CI) was used to indicate the best discrimination cut-off points, reflecting the overall accuracy of the diagnostic test derived from an ROC analysis. In ROC analysis, the true-positive rate (sensitivity) is plotted against the false-positive rate (1-specificity) across a range of values from the diagnostic tests. This provides an estimate of the cut-off that corresponds to the best trade-off between sensitivity and 1- specificity (i.e., minimal false negative and false-positive cases) which suggest the development of hypertension. The decision threshold for the best trade-off is the criterion value with the highest accuracy that maximizes the sum of the sensitivity and specificity. The use of ROC curves allowed the identification of the optimal cut-off point, which considered in this study to be the point that maximizes both specificity and sensitivity. This occurs when specificity and sensitivity become almost equal.

Results

Table 1 shows the percentage of the affected individuals with hypertension in both sexes. The prevalence of hypertension is significantly increased in males than females.

Table 2: Means and standard deviations of the basic characteristics of the study subjects.

	NT males (n =1932)	HT males (n =984)	NT females (n = 1993)	HT females (n = 662)
Age (years)	36.29±11.44	42.32±11.87*	37.11±12.708	46.97±11.199*
BMI	27.11±4.81	30.31±5.32	29.50±6.22	34.29±7.14*
WC (cm)	95.05±12.39	102.99±11.272*	88.77±11.605	96.35±9.636*
WHR	0.917±0.255	0.948±0.084	0.808±0.079	0.834±0.712
WHtR	0.556±0.072	0.602±0.067*	0.560±0.077	0.612±0.068*
Systolic BP	114.25±10.717	137.02±14.872*	110.61±11.28	137.63±15.75*
Diastolic BP	75.37±7.149	92.27±9.773*	73.09±7.895	92.54±10.680*

NT = Normotensive; HT = hypertensive; n = observed number; BMI = Body mass index; WC = waist circumference; WHR = waist to hip ratio; WHtR = waist to height ratio;,BP = blood pressure; ** significance p< 0.05 versus NT.

The basic characteristics of the study subjects were represented in Table 2.

Table 3: Correlation between blood pressure and anthropometric variables in the studied subjects.

		BMI		WC		WHR		WHtR	
		M	F	M	F	M	F	M	F
SB	R	0.308*	0.397*	0.323*	0.372*	0.072*	0.181*	0.059*	0.067*
P	P	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.001
DB	R	0.310*	0.342*	0.318*	0.330*	0.066*	0.135*	0.058*	0.037
P	P	0.000	0.000	0.000	0.000	0.002	0.000	0.002	0.059

*Correlation is significant at the 0.01 level (2-tailed); M = male; F = female; SBP = systolic blood pressure; DBP = diastolic blood pressure; BMI = body mass index; WC = waist circumference; WHR = waist hip ratio; WHtR= waist height ratio; P = probability.

All the variables are significantly higher in hypertensive females than normotensive ones except the WHR. Hypertensive males had also significantly higher values, than normotensive males except in age, BMI values and WHR.

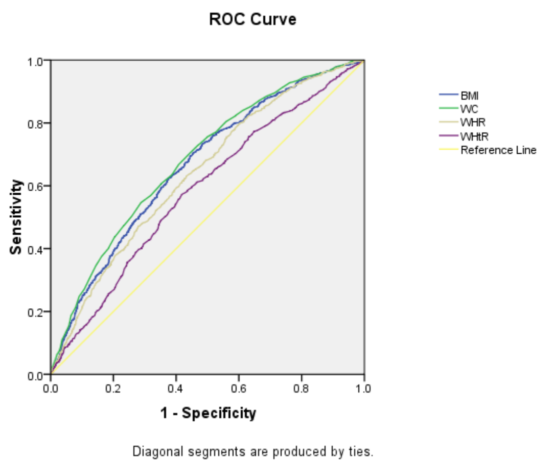

Figure 1: The ROC (receiver operating characteristic) curves for BMI, WC, WHR and WHtR values to detect high blood pressure in males.

There was a significant relationship between the systolic and diastolic blood pressure and the indices of adiposity of all the participants (P < 0.01) except WHtR with the diastolic blood pressure in females (Table 3).

Figures 1 and 2 showed the ROC curves to determine the appropriate BMI, waist circumference,

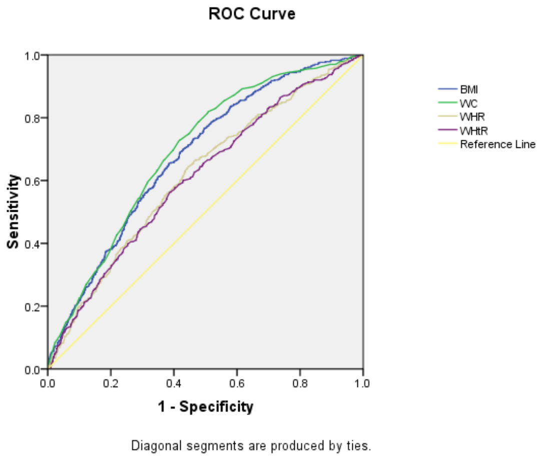

Figure 2: The ROC (receiver operating characteristic) curves for BMI, WC, WHR and WHtR values to detect high blood pressure in females.

WHR and WHtR values for detecting the presence of hypertension in males and females respectively. In ROC analyses for diagnosis of hypertension, the area under curve (AUC) of BMI and WC were the largest followed by WHR in males and females (Table 4).

Table 4: Area under Curves of BMI, WC, WHR and WHtR for hypertension.

	BMI		WC		WHR		WHtR	
	AUC	CI	AUC	CI	AUC	CI	AUC	CI
Males	0.664	0.642-0.686	0.681	0.660-0.686	0.640	0.618-0.662	0.584	0.561-0.608
Females	0.678	0.652-0.704	0.693	0.668-0.719	0.616	0.588-0.644	0.609	0.581-0.638

AUC, area under curves; CI, confidence interval.

The cut-off values to detect hypertension in females were 30.08 for BMI, 87.75 for WC, 0.81 for WHR and 0.65 for WHtR, and the corresponding sensitivity and specificity were 69.1; 60.7- 80.9; 48.6-65.3; 53.4 and 61.4; 58.9, respectively. The cut-off values to detect hypertension in males were 27.98 for BMI, 95.75 for WC, 0.92 for WHR, and 0.57 for WHtR and the corresponding sensitivity and specificity were 62.8%; 59.9 -71.9; 51.9-64.6; 55.8 and 59.7; 55.8, respectively (Table 5).

Table 5: Optimal cut off values to indicate hypertension risks.

	BMI	WC	WHR	WHtR
Males				
Cut- off	27.98	95.75	0.92	0.57
Sensitivity; specificity	62.8% ; 59.9	71.9;51.9	64.6; 55.8	59.7 ;55.8
Females				
Cut- off	**30.08**	**87.75**	**0.81**	**0.56**
Sensitivity; specificity	69.1 ; 60.7	80.9 ; 48.6	65.3 ;53.4	61.4 ;58.9

Discussion

Being overweight is associated with two- to six fold increase in the risk of developing hypertension. An increase of 2-3 mmHg in systolic and 1-3 mmHg in diastolic blood pressure has been shown for each 10 kg increase in weight in western population [14].

Excess body weight and obesity are well recognized risk factors for high BP [15]. In particular, central body fat accumulation is associated with both hypertension and insulin resistance [16, 17]. The latter condition is more frequent in overweight than in lean individuals, and also more common in hypertensive individuals than in matched normotensive controls [18, 19, 20].

Several studies have shown that there is a significant relationship between relative weight and hypertension. The anatomical distribution of body adiposity as also been shown to be a factor in determining which people are more susceptible to hypertension and thus at risk of developing cardiovascular diseases [21]. WC, WHR and WHtR are used to predict the risk of obesity related diseases as they account for regional abdominal adiposity [5, 8, 14, 22-24].

In the present study, mean values of all studied anthropometric parameters were significantly higher in hypertensive than in normotensive population in both the genders. The findings were similar to many studies [25-31]. We also found significant positive correlation between all these studied anthropometric indicators and systolic and diastolic blood pressure except for WHtR and diastolic blood pressure in females. Many investigators have earlier reported significant positive correlation of body mass index with systolic and diastolic blood pressure [32, 33, 34, 35]. Significant positive correlation between WHR and systolic and diastolic blood pressure have been reported earlier [14, 32, 34, 36, 37). However, in our study, the correlation between WHtR and DBP in females was not statistically significant. Woo *et al.* [38] reported that waist-hip ratio was not a useful predictor of health outcome while Dalton *et al*. [7] and Al-Lawati and Jousilahti [39] founded that BMI, WC and WHR were equally related with hypertension. Wang and Hoy [40] reported better correlation of BMI and waist circumference with blood pressure than waist hip ratio. In contrast, other investigators [41-44] reported that the waist circumference and not the BMI explain obesity related health risk including hypertension.

Whether specific values measuring central fat distribution could more accurately indicate health risk than BMI remains a controversial issue (45-47). WHtR has received considerable interest and the result suggested keeping one's waist to less than half his height [48, 49]. Some studies reported that waist-height ratio was a better obesity index than body mass index and waist hip ratio for predicting hypertension [50-52]. Lin *et al.* [53] also reported that waist-height ratio may be better indicator for screening obesity related cardiovascular disease risk factors including blood pressure than BMI, waist circumference and waist-hip ratio. Zhang *et al.,* [54] reported that BMI, WC, WHR and WHtR all were positively associated with risk of coronary heart disease in Chinese women.

In this study, the cut off values of BMI to predict hypertension were 27.98 kg/m^2 and 30.08 kg/m^2 in males and females, respectively. Those of WC, WHR and WHtR were 95.75 cm, 0.92 and 0.57 cm in males and 87.75, 0.81 and 0.56 in females, respectively. Ibrahim *et al.* [55] reported the cut-off point for WC with increased risk of hypertension among adult Egyptians aged 25-95 years and suggested values of 93.5 cm in men, and for women, 92.5 cm. The difference in the cut-off points in the present sample with this previous one could be attributed to the difference in the age distribution within the sample as the mean age in the present sample was obviously younger.

In Iraq the cut-off point for WC in men associated with increased risk of type 2 DM and hypertension, is 90 cm and 95 cm, and for women, 91 cm and 95 cm, respectively [56]. In another study, it was suggested that the WC cut-off point for Iraqi population was 99 cm in women and 97 cm in men [57]. Moreover in Omani the optimal cut-off points for men and women respectively were 23.2 and 26.8 kg/m^2 for BMI, 80.0 and 84.5 cm for WC, and 0.91 and 0.91 for WHR for the diagnosis of hypertension [39].

While in a study Korean adults revealed that the WC cut-offs varied from 81.6 to 85.2 cm in men and from 78.1 to 81.9 cm in women. The optimal BMI cut-off point for diagnosis of hypertension varied from 23.0 to 24.7 kg/m^2 in both males and females [58]. In India, it was reported that the optimal WHtR cut-off was 0.56 in males and 0.43 in females [59].

In conclusion, the BMI, waist circumference, WHR and WHtR values can predict the presence of hypertension risk in adult Egyptians.

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