Relationship of Anthropometric Adiposity Indices with Blood Pressure in urban community of Ahmedabad

Prerna Agarwal, Jayendrasinh M. Jadeja, Geeta B Nair, Anju S. Mehta, Shobha S. Naik, Jagdeep Kaur S. Dani

Department of Physiology, B.J. Medical College, Ahmedabad-380016 India

Abstract: **Background and objectives:** Hypertension is a leading cause of the global burden of disease. Obesity and weight gain are strong independent risk factors for hypertension. The prevalence of both hypertension and obesity is increasing rapidly. The present study was done to assess the relationship of anthropometric indices of adiposity and BP in people of urban community of Ahmedabad. **Material and method:** Data about BMI, waist circumference (WC), waist hip ratio (WHR), waist height ratio (WHtR), and blood pressure in terms of systolic blood pressure (SBP), diastolic blood pressure (DBP) and mean arterial pressure (MAP) was obtained by cross sectional survey of 85 people aged 40- 79 years by simple random sampling. **Results & Discussion:** The prevalence of hypertension was 58.82% and of obesity was 40% according to WHR but only 15.29% according to BMI. Obesity was more prevalent among hypertensives (48%) than non hypertensives (42.86%). Significant difference was seen among hypertensives and non hypertensives with regard to BMI, WC, WHR, WHtR ($p<0.05$). These findings are comparable to the results of earlier studies by A. Ramchandran et al in 2002 (hypertension), R. Gupta et al in various studies in early 2000s (obesity) and P. R. Deshmukh et al in 2005(WHR better marker) **Conclusion:** Obesity and hypertension are both widely prevalent. WHR, marker of central obesity is a better determinant of raised blood pressure than BMI. Substantial reduction in blood pressure can, therefore, be obtained by decreasing central obesity.

Key Words: body mass index, central obesity, hypertension, waist circumference, waist height ratio, waist hip ratio

Author for correspondence: Prerna Agarwal, Tutor, Department of Physiology, B.J. Medical College, Ahmedabad-380016 India Phone no 9426382337 e-mail preranaagarwal@gmail.com

Introduction: Hypertension and obesity are one of the leading causes of global burden of disease. And their prevalence has increased to epidemic proportions with rapid urbanization.[1] In 2004, 7.5 million deaths worldwide were due to high blood pressure and 2.8 million due to overweight and obesity, accounting for 12.8 % and 4.8% of the total deaths respectively. [2]

Hypertension and obesity independently double the risk of cardiovascular diseases, which is a leading cause of death worldwide. [3, 4] Globally, 51% of stroke and 45% of ischemic heart disease deaths are attributable to high systolic blood pressure. [2]

Obesity is associated with increased mortality with a 50-100% increased risk of death from all causes, particularly when it is associated with increased intra-abdominal fat. [4] Obesity and weight gain are strong independent risk factors for hypertension. Approximately, 60-70% of hypertension in adults may be directly attributable to adiposity. [4]

Because of escalating obesity and population aging in developed and developing countries the global burden of hypertension is rising and is projected to affect 1.5 billion people, one third of world's population by 2025. [5]

Several studies assessing the relationship of obesity markers and blood pressure have been carried out worldwide. They emphasize the impact of central obesity on blood pressure in terms of WC, WHR and WHtR. But there is limited data available for these parameters among various Indian populations. This study was, therefore, designed to assess the relationship of various anthropometric indices of adiposity and blood pressure in people belonging to urban community of Ahmedabad

Material and Method: The study was done by means of a cross sectional survey of 85 people aged 40-79 years through a questionnaire based personal interview and measurements at the participant's home in a convenient population of urban Ahmedabad, during November- December 2011. The subjects were selected by simple random sampling. Pregnant women and those suffering from diseases which can affect weight and blood pressure, like renal disease, thyroid disorders, auto immune diseases, and allergic conditions requiring steroid treatment were excluded.

An informed consent of the participants was taken.

Instruments used: For waist circumference and hip circumference: a tailor's inelastic measure tape graduated in centimeters (0-150). For height: a steel measuring tape graduated in centimeters (0-500). For weight: a portable digital weighing scale (Omron make) (0-180 kg) weighing to the nearest 100g. For blood pressure: mercury-in-glass sphygmomanometer (Diamond make) calibrated in mmHg (0–300) and stethoscope - Littmann's Cardiology III.

Measurements: Waist circumference (WC): midway between lowest palpable rib and top of iliac crest in standing position to the nearest 1 cm. Hip circumference (HC): at the fullest part of the girth of hip in standing position to the nearest 1 cm. Height (Ht): standing height against a straight wall on level surface with feet close together to the nearest 1 cm. Weight (Wt): the subject stood bare feet on the scale with minimum clothing. Waist Hip Ratio (WHR): dividing waist circumference WC and hip circumference HC correct to two places of decimal. Waist Height Ratio (WHtR): dividing waist circumference WC and height Ht correct to two places of decimal. Body Mass Index (BMI): dividing weight in kg and square of height in meters correct to two places of decimal. Blood Pressure (BP): auscultatory method: SBP- appearance and DBP- disappearance of Korotkoff sound. The average of two readings taken 5 minutes apart on a comfortably seated person in the left arm, correct to the nearest 2 mmHg was taken. Mean Arterial Pressure MAP: it was calculated according to the formula (2DBP + SBP)/3.

Classifications and cut-offs of parameters: Blood Pressure: those subjects whose systolic blood pressure SBP was ≥140 mmHg and / or diastolic blood pressure DBP ≥90 mmHg and known cases of hypertension, irrespective of treatment being taken or not and blood pressure being controlled or uncontrolled, were taken as Hypertensives. Rest all were taken as Non Hypertensives (pre hypertensives and normotensives). (JNC 7 report on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure, U. S. Department of Health and Human Services) Body Mass Index: subjects with BMI ≥ 30 kg/m² were classified as being Obese and those with BMI ≥25 kg/m² but <30 kg/m² were identified as being Overweight. (Global database on BMI, WHO 2005) Waist circumference: WC> 90 cm in males and WC > 80 cm in females were taken as markers of abdominal obesity, Waist Hip Ratio: a WHR > 1.0 in males and WHR > 0.9 in females was taken as abnormal. (Waist Circumference and Waist–Hip Ratio: Report of WHO Expert Consultation 2008) Waist Height Ratio: a cut-off of 0.5 was used for both the sexes. WHtR <0.5 is taken as normal. WHtR ≥0.5 indicates central fat distribution and WHtR ≥0.6 shows central adiposity (Margaret Ashwell, Open Adiposity Journal, 2011)

Statistical analysis: The data was analyzed by applying independent t test. Correlation coefficients and Odds ratio were calculated for the different anthropometry indices and blood pressure variants. Significance level was taken as $p < 0.05$

Results: The baseline characteristics of the 85 participants- 51 females and 34 males were as given in the table 1. There were 30 (19 females and 11 males), 26 (12 females and 14 males), 16 (9 females and 4 males), and 13 (9 females and 4 males) people in the age groups 40-49, 50-59, 60-69, 70-79 respectively. No significant difference was noted in the means of age, BMI, WC, WHtR, MAP, SBP and DBP among females and males. But significant difference was seen in the mean values of weight, height, and WHR. (p0.05)Hypertensive and non hypertensives in the study (figure 1 and table 2):

When the subjects were grouped into hypertensives and non hypertensives, 58.82% were hypertensive (50 hypertensives and 35 non hypertensives). 54.9% (28) females and 62.8% (22) males were hypertensive. The prevalence of hypertension in the study subjects increased with increasing age. There were 50%, 53.85%, 56.25%, and 92.31% hypertensives in the age groups 40-49, 50-59, 60-69 and 70-79 respectively.

Obese and non obese in the study (figures 2, 3, 4 and table 3): Obesity prevalence according to BMI was 15.29% overall, 17.65% among females

and 11.78% among males. As per the cut-off of WC, 68.24% were obese. 72.55 % of the females and 61.77 % of the males were obese. Considering the WHR criteria, obesity prevalence was 40 % overall, 45.10 % among females and 32.35% among males. And applying the WHtR cut-off, 88.24% of the participants had central fat distribution. Among the females the figure was 90.20% and among males the same was 85.29%. Central obesity prevalence as per WHtR was at 40% overall, 49.02%% among females and 26.47% among males. The prevalence of obesity increased in the middle ages except in the elderly where it was relatively less. (table 3)

Table 1: Baseline Characteristics of the Subjects

S. no.	Parameter	Total (85)		Females(51)		Males (34)		p value by student's t test	*
		Mean	S.D.	Mean	S.D.	Mean	S.D.		
1.	Age(yrs)	54.34	10.64	54.57	10.97	54.00	10.27	0.808456	NS
2.	Weight (kg)	60.74	14.18	56.70	12.76	66.83	14.20	0.001327548	S
3.	Height (m)	1.55	0.09	1.49	0.06	1.63	0.06	$8.08458x10^{-17}$	S
4.	BMI(kg/m^2)	25.33	5.24	25.52	5.51	25.04	4.87	0.67437653	NS
5.	WC (cm)	90.55	11.33	88.20	9.17	94.09	13.35	0.028891196	S
6.	HC (cm)	96.91	11.23	97.77	10.64	95.62	12.10	0.403648594	NS
7.	WHR	0.94	0.08	0.90	0.06	0.99	0.09	$2.24624x10^{-05}$	S
8.	WHtR	0.59	0.07	0.59	0.07	0.58	0.08	0.349994058	NS
9.	SBP (mmHg)	136.49	22.05	136.55	24.00	136.41	19.10	0.995181	NS
10.	DBP (mmHg)	86.21	14.18	86.20	15.10	86.24	12.90	0.976740044	NS
11.	MAP(mmHg)	102.97	15.01	102.98	16.02	102.96	13.61	0.989810136	NS

*result at p=0.05: S = significant; NS = not significant

Table 2: Prevalence of Hypertension in Different Age Groups (percentage %)

Age groups	Hypertensives Total	Hypertensive Females	Hypertensive Males
40 – 49	50	42.11	63.64
50 – 59	53.85	33.33	71.43
60 – 69	56.25	63.64	40
70 – 79	92.31	100	75

Table 3: Prevalence of Obesity in Different Age Groups (percentage %)

Age group	BMI			WC			WHR			WHtR		
	T	F	M	T	F	M	T	F	M	T	F	M
40-49	13.33	21.02	0	80	84.21	72.73	30.00	42.11	9.09	26.67	36.84	9.09
50-59	15.39	8.33	21.43	69.23	75.00	64.29	46.15	50.00	42.86	46.15	58.33	35.71
60-69	31.25	36.36	20.00	68.75	81.82	40.00	31.25	36.36	20.00	50.00	63.64	20.00
70-79	0	0	0	76.92	66.67	100	61.54	55.56	75.00	30.77	22.22	50.00

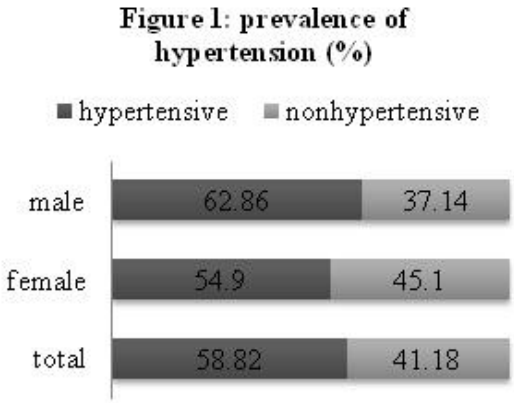
F: females; M: males; T: total

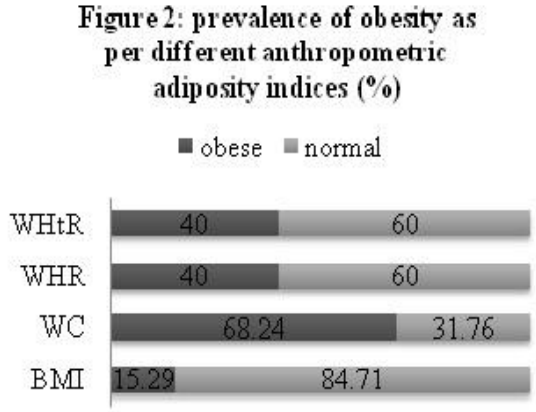
Prevalence of obesity among hypertensives and non hypertensives (figures 5, 6 and 7): When the obese were sub grouped into male and female hypertensives and non hypertensives, it was seen that obesity was more prevalent among hypertensives. 18% hypertensives were obese as per BMI criteria while a 11.43% non hypertensives were obese. According to WC cut-off, 70% hypertensives were obese while 65.71% non hypertensives were obese. Applying the WHR cut-off 50 % hypertensives were obese and only 25.71% non hypertensives were obese. The maximum prevalence of obesity was seen by applying WHtR cut off in the study subjects. 48% of the hypertensives had central obesity here and 28.57% of non hypertensives had central obesity. Though obesity was seen more among female non hypertensives as per BMI (56.52%), WC (73.91%) and WHtR (95.65%) cut-offs.

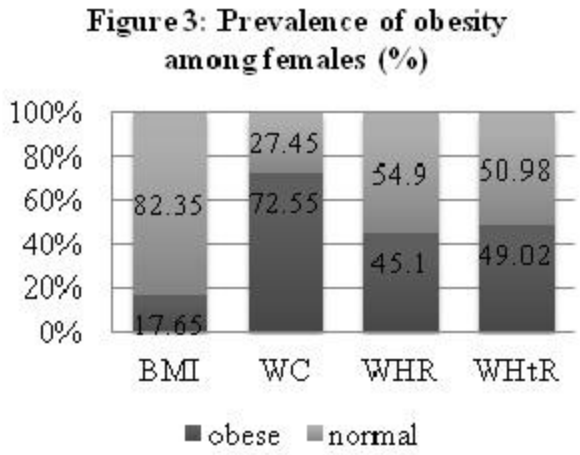
Comparison of anthropometric indices of adiposity in hypertensives and non

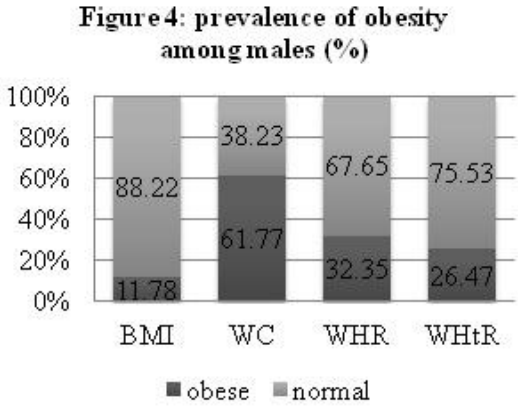
hypertensives (Table 4):Further, the mean values of the adiposity indices were compared between hypertensives and non hypertensives and tested for significance of difference. The mean values of BMI, WC, WHR, and WHtR were higher in case of hypertensives. p-values obtained by applying t test were significantly lower than 0.05. This implied that there was a significant difference in the adiposity markers between hypertensives and non hypertensives. The p value was least for WC (0.004) followed by WHR (0.007), WHtR (0.01), and BMI (0.03). (Table no. 4)

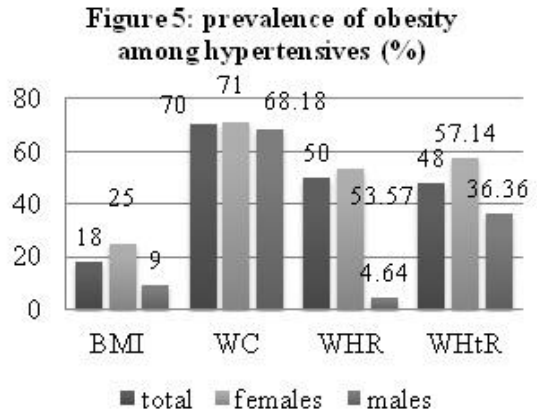
Correlation between anthropometric obesity indices and blood pressure (Table 5): Pearson's coefficient of correlation (r) for $p < 0.05$ was calculated for BMI, WC, WHR, WHtR and MAP, SBP, DBP. The adiposity markers show a definite positive correlation ($0 < r < 1$) with blood pressure in terms of MAP, SBP and DBP. For MAP and SBP value of r was largest for WHR. While DBP showed comparable correlation with both BMI and WHtR. MAP showed least correlation with WC, SBP least with BMI and DBP least with WC. WHR, therefore, affects MAP and SBP most in this study. (Table 5) Odds ratio of various at 95% confidence level (Table 5):The odds ratio (OR) of an obese subject developing raised blood pressure (MAP, SBP and DBP) at 95% confidence level within the lower limit (LL) and upper limit (UL) were as given in the table below. OR for a subject obese as per WHR criteria developing raised MAP and systolic hypertension was highest and OR for an individual with BMI ≥ 25 kg/m² were highest for diastolic hypertension.

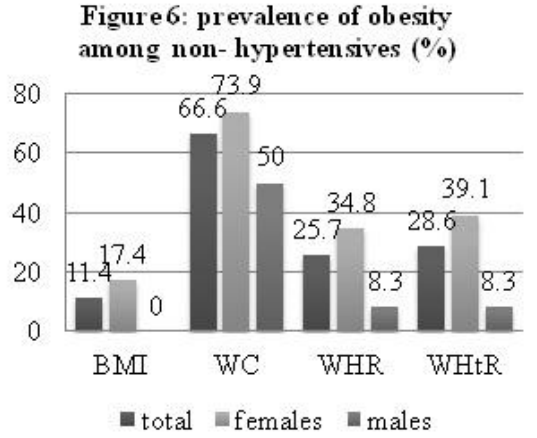




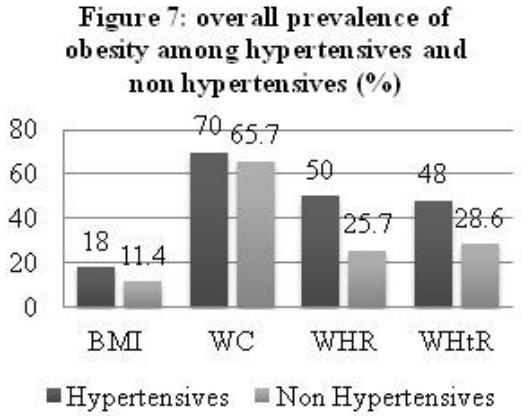








Discussion: Our study documents the high prevalence of both hypertension and obesity [6-10] and their correlation with each other among the study subjects as is evidenced by many recent studies in different populations worldwide. [11] It also emphasizes that blood pressure is better determined by measures of central obesity, particularly the WHR. [12-15] There was a high prevalence of hypertension (58.82%) in our study. Ramchandran A et al and Gupta R et al also reported comparable rates in their study in similar age groups. [6,16] With increasing age, prevalence of hypertension was seen to increase as was evident by proportionately more hypertensives in each age group (50% hypertensives in 40 – 49 year age group against 92.31% in 70-79 year age group).[3] Hypertension was comparatively more prevalent among males than females. P R Deshmukh et al also reported this.[3, 17]



While hypertension was more prevalent in males, the opposite was seen with obesity. According to BMI classification, 17.65% females were evidently obese and only 11.78% males were obese. As per WHR cut off, 45.10% females were categorized as obese; while 32.35% males were obese here.[3] Overall, there was a high prevalence of obesity.[6-10] Central obesity markers identified more participants, than BMI, as obese. BMI identified 15.29% of the subjects as obese, while WHR criteria raised the number of obese to 40%. [12, 13, 14, 18] WHtR identified most of the study participants as obese~90% comparable to the prevalence in another study by Debolina Sarkar et al.[18]

Table 4: Hypertensives vs Non Hypertensives in Terms of Adiposity Indices

Parameter	Hypertensives		Non Hypertensives		p value by t test	Result p= 0.05
	Mean	SD	Mean	SD		
BMI kg/m²	26.11714	5.880457	24.20624	3.972218	0.038728288	S
WC cm	93.04	12.95039	87	7.312359	0.003855415	S
WHR	0.954846	0.093815	0.912209	0.061902	0.006768966	S
WHtR	0.601109	0.081336	0.565773	0.055893	0.009955908	S
MAP mmHg	111.4133	13.43204	90.91429	6.508086	1.6567×10^{-14}	S
SBP mmHg	149.44	18.87462	118	9.443329	4.97975×10^{-16}	S
DBP mmHg	92.4	14.8021	77.37143	6.664594	9.28052×10^{-9}	S

Table 5 Correlation Coefficients and Odds Ratio

correlation coefficients of obesity indices with blood pressure									
	MAP			SBP			DBP		
BMI	0.202927			0.146183			0.208573		
WC	0.18891			0.163457			0.172888		
WHR	0.225881			0.209884			0.195501		
WHtR	0.219243			0.167362			0.218016		
odds ratio at p<0.05									
Obesity type	MAP ≥ 110 mmHg			SBP ≥ 140mmHg			DBP ≥ 90mmHg		
	OR	LL	UL	OR	LL	UL	OR	LL	UL
BMI	1.83	0.68	4.95	1.68	0.71	3.98	1.96	0.81	4.73
WC	1.22	0.41	3.60	1.34	0.54	3.35	0.96	0.38	2.42
WHR	3.33	1.20	9.26	2.84	1.16	6.99	1.63	0.67	3.95
WHtR	1.36	0.23	6.96	0.97	0.26	3.64	1.00	0.26	3.85

OR: odds ratio; LL: lower limit; UL: upper limit

There were more hypertensives in any classification of obesity than there were non hypertensives. 18% of the hypertensives and only 11.43% non hypertensives were obese according to BMI. As per WHR, obesity was 50% among hypertensives and 25.71% among non hypertensives. When WC cut off was considered, 70% hypertensives were obese against 65.71% non hypertensives. As per WHtR , 48% of hypertensives were obese and only 28.75% non hypertensives were obese. This finding was also documented by P R Deshmukh et al.[19] A significant difference was seen in the mean values of BMI, WC, WHR and WHtR among hypertensives and non hypertensives.[17, 20-22]

While assessing the correlation of the adiposity indices with the blood pressure determinants, it was seen that systolic blood pressure and mean arterial pressure correlated best with WHR while diastolic blood pressure with BMI and WHtR. Canoy et al and P R Deshmukh et al too had documented this in their studies. [17, 23] When the odds ratio were calculated for different obesity types developing hypertension, the odds ratio for a WHR obese to develop raised SBP and raised MAP were highest.

These findings imply that central obesity is a better determinant of raised blood pressure in the studied urban community of Ahmedabad. This finding is in affirmation of the results of previous studies conducted. [12-14,19, 24-30] Among the anthropometric indices of adiposity, WHR is a better index to assess adiposity and its effect on blood pressure in this sample of study. This correlation has been documented by many earlier studies. [12-15, 19, 24-27, 29,30]

Why is centrally located body fat a more important determinant of blood pressure elevation than peripherally located body fat? There are three independent, but complementary mechanisms: 1.There is increased renal blood flow in obesity. Renin angiotensin system is activated. Surrounding fat and fat infiltrating into medullary sinuses raises intra renal pressure. The intra abdominal pressure is also elevated in the obese. All these factors together cause altered pressure natriuresis by the kidney and raise the sympathetic tone. This causes arterial blood pressure to rise in obesity. 2.Adipose tissue expresses leptin and angiotensin which also cause sympathetic stimulation and 3.Obesity causes glomerulosclerosis that further exacerbates the resultant hypertension by causing volume expansion. [31]

Most widely used among the many clinical measures of obesity is BMI. But it is a crude index which does not take into account the distribution of body fat. [32] Lean but very muscular individuals may be overweight by numerical standards without having increased adiposity. And intra-abdominal and abdominal subcutaneous fat have more significance than subcutaneous fat present

in the lower limbs. [3] In that case, WC, WHR and WHtR assess adiposity better. So, an individual who has been misclassified according to BMI may benefit from the measurement of body fat distribution. [33]

Prevention and treatment of obesity are important for reducing blood pressure and cardio vascular diseases. Even modest reductions in weight cause blood pressure to decrease. Blood pressure decreases by 6.3/3.1 mmHg with a reduction of 9.2 kg in mean body weight. Most anti hypertensive drugs reduce systolic blood pressure by 7-13 mmHg and diastolic blood pressure by 4-8 mmHg which is comparable to blood pressure reduction by weight loss. [3]

Conclusion: There is a high prevalence of both hypertension and obesity in the adult urban community of Ahmedabad. Obese and overweight people have higher blood pressure than their normal counterparts. It is important to assess the predominant location of body fat (central obesity / peripheral obesity) when examining excess weight in relation to hypertension. Central obesity as measured by WHR is a better determinant of blood pressure than BMI. Relationship between WHR and BP should be quantified by further large scale studies. Reduction in central fat will lower the blood pressure. Public health education and intervention programs to reduce the waist circumference through lifestyle modification including diet and physical activity/exercise may have a significant impact on reduction of burden of hypertension and obesity in the society.

Abbreviations: BMI, Body Mass Index; BP, blood pressure; CVD, cardio vascular disease; DBP, diastolic blood pressure; HC, hip circumference; LL, lower limit; MAP, mean arterial pressure; OR, odds ratio; SBP, systolic blood pressure; UL, upper limit; WC, waist circumference; WHR, waist hip ratio; WHO, World Health Organization; WHtR, waist height ratio.

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