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Anthropometric cut points for identification of cardiometabolic risk factors in an urban Asian Indian population

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Abstract

The aim of this study was to determine the anthropometric cut points for risk of cardiometabolic risk factors in an urban Asian Indian population. The Chennai Urban Rural Epidemiology Study representatively sampled 26 001 individuals aged 20 years or older and detailed measures were obtained in every 10th subject: 90.4% (2350/2600). An oral glucose tolerance test was performed in all individuals except self-reported diabetic subjects. Anthropometric measurements such as body mass index (BMI) and waist circumference (WC) were obtained and serum lipid estimations were done in all subjects. Sensitivity, specificity, and distance on receiver operating characteristic curve were used to determine the optimal cut points for BMI and WC with cardiometabolic risk factors. Maximum sensitivity and specificity of BMI for all cardiometabolic risk factors such as diabetes mellitus, prediabetes, hypertension, hypertriglyceridemia, hypercholesterolemia, and low high-density lipoprotein cholesterol ranged from 22.7 to 23.2 kg/m^2 for men and 22.7 to 23.8 kg/m^2 for women, and that of WC ranged from 86 to 88.2 cm for men and 81 to 83.8 cm for women. The optimal BMI cut point for identifying any 2 cardiometabolic risk factors was 23 kg/m^2 in both sexes, whereas that of WC was 87 cm for men and 82 cm for women. The study validates the World Health Organization Asia Pacific guidelines of BMI of 23 kg/m^2 for the designation of overweight; WC of 87 cm for men and 82 cm for women appear to be appropriate cut points to identify cardiometabolic risk factors including prediabetes in urban Asian Indians.

1. Introduction

Several epidemiologic studies have shown that South Asians have higher amounts of body fat at lower body mass index (BMI) and waist circumference (WC) than do Europeans, and this contributes to the higher prevalence of cardiovascular risk factors at lesser degrees of obesity [1-3]. South Asians also have greater predisposition to abdominal obesity and visceral fat [4-10]. This is attributed to the so-called "Asian Indian phenotype" characterized by increased WC despite lower body mass indices, increased visceral fat [3], and greater insulin resistance [11]. Thus, the application of the current World Health Organization (WHO) BMI cut points of 25 or higher to define overweight and 30 or higher for obesity will underestimate obesity-related risks in these populations [2].

Cut points for obesity as defined by the WHO [12] are based on BMI values derived from studies looking at the relationship between BMI and cardiovascular disease in Western populations [13,14]. Lower cut point values of BMI to define overweight ($\geq$23 kg/m^2) and obesity ($\geq$25 kg/m^2) and lower limits of WC to define abdominal obesity ($\geq$90 cm in men and $\geq$80 cm in women) have recently been proposed for Asians by the WHO Asia Pacific guidelines [15]. It is necessary to validate these cut points in Asian populations. This study was undertaken to validate the cut points for generalized obesity (BMI) and abdominal obesity (WC) with individual cardiometabolic risk factors such as diabetes mellitus, prediabetes, hypertension, hypercholesterolemia, hypertriglyceridemia, and low high-density lipoprotein (HDL) cholesterol based on Asian Indians who have very high rates of type 2 diabetes mellitus [16] and premature coronary artery disease [17].

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2. Study design

The Chennai Urban Rural Epidemiology Study (CURES) is a large cross-sectional study done on a representative population of Chennai (formerly Madras) city in southern India with a population of about 5 million people. The detailed study design of CURES is described elsewhere [18] and the sampling frame is shown on our Web site (http://www.drmohansdiabetes.com/mdrf/CURES.pdf).

Briefly, in phase 1 of the urban component on CURES, 26 001 individuals (aged ≥20 years) were recruited based on a systematic random sampling technique. A detailed questionnaire was administered to all study subjects to collect information regarding demographic, socioeconomic, behavioral, and health status. A fasting capillary blood sugar, blood pressure, and basic anthropometric measures were done in all individuals.

Phase 2 of CURES deals with studies on the prevalence of microvascular and macrovascular complications of diabetes. Phases 1 and 2 are not discussed further in this article.

In phase 3 of CURES, every 10th subject recruited in phase 1 (n = 2600) was invited to our center for detailed anthropometric measurements and biochemical tests. Of these, 2350 participated in the present study (response rate, 90.4%). This sample is thus representative of the Chennai population.

All the study subjects underwent an oral glucose tolerance test using 75 g glucose load, except self-reported diabetic subjects, for whom fasting venous plasma glucose was measured. After 8 hours of overnight fasting, the fasting blood sample was taken for estimation of plasma glucose and serum lipids with a Hitachi 912 Autoanalyser (Roche Diagnostics, Mannheim, Germany) using kits supplied by Boehringer Mannheim (Mannheim, Germany). Glycated hemoglobin level was measured by the high-pressure liquid chromatography method using the Variant machine (BIO-RAD, Hercules, CA). Anthropometric measurements including weight, height, and waist and hip measurements were obtained using standardized techniques [18].

Height was measured with a tape to the nearest centimeter. Subjects were requested to stand upright without shoes with their back against the wall, heels together, and eyes directed forward.

Weight was measured with a traditional spring balance that was kept on a firm horizontal surface. Subjects were asked to wear light clothing, and weight was recorded to the nearest 0.5 kg.

Body mass index (BMI) was calculated by using the formula weight (kg)/height $(m)^2$.

Waist circumference was measured by using a non-stretchable measuring tape. The subjects were asked to stand erect in a relaxed position with both feet together on a flat surface; one layer of clothing was accepted. Waist girth was measured as the smallest horizontal girth between the costal margins and the iliac crests at minimal respiration.

Blood pressure was recorded in the sitting position in the right arm to the nearest 2 mm Hg using the mercury sphygmomanometer (Diamond Deluxe BP apparatus, Pune, India). Two readings were taken 5 minutes apart and mean of 2 was taken as the blood pressure.

The institutional ethical committee approval was obtained and informed consent was obtained from all study subjects.

3. Definitions

3.1. Diabetes

Diagnosis of diabetes was based on WHO consulting group criteria, ie, 2-hour postload (75 g glucose) plasma glucose of 200 mg/dL or greater (≥11.1 mmol/L) or self-reported diabetic subjects under treatment by a physician [19].

3.2. Prediabetes

Prediabetes was diagnosed as the presence of impaired glucose tolerance (IGT) and/or impaired fasting glucose (IFG). IGT was diagnosed if the 2-hour plasma glucose was 140 mg/dL or greater (≥7.8 mmol/L) and less than 200 mg/dL (<11.1 mmol/L), and normal glucose tolerance (NGT) if 2-hour plasma glucose was less than 140 mg/dL (<7.8 mmol/L) [19]. IFG was diagnosed if the fasting plasma glucose was 100 mg/dL or greater (≥5.6 mmol/L) and less than 126 mg/dL (<7.0 mmol/L) based on American Diabetes Association definition [20].

3.3. Hypertension

Hypertension was diagnosed based on drug treatment for hypertension or if the blood pressure was greater than 140/90 mm Hg (Joint National Committee on Prevention, Detection, Evaluation and Treatment of High Blood Pressure criteria) [21].

3.4. Dyslipidemia

National Cholesterol Education Program guidelines [22] were used for definition of dyslipidemia.

Hypercholesterolemia was diagnosed if serum cholesterol levels were 200 mg/dL or greater (≥5.2 mmol/L) or if subjects were under drug treatment for hypercholesterolemia.

Hypertriglyceridemia was diagnosed if serum triglyceride levels were 150 mg/dL or greater (≥1.7 mmol/L) or they were under drug treatment for hypertriglyceridemia.

Low HDL cholesterol was diagnosed if HDL cholesterol levels were less than 40 mg/dL (<1.04 mmol/L) for men and less than 50 mg/dL (<1.3 mmol/L) for women.

4. Statistical analysis

By varying the cut points of BMI and WC, sensitivity and specificity were estimated for determining the presence or

Table 1
Sensitivity, specificity and distance on the ROC curve for BMI cut points

BMI cut point (kg/m^2)	Percentile	Diabetes			Prediabetes			Hypertension			Hypercholesterolemia			Hypertriglyceridemia			Low HDL cholesterol		
		Sens (%)	Spec (%)	Distance in ROC	Sens (%)	Spec (%)	Distance in ROC	Sens (%)	Spec (%)	Distance in ROC	Sens (%)	Spec (%)	Distance in ROC	Sens (%)	Spec (%)	Distance in ROC	Sens (%)	Spec (%)	Distance in ROC
Men																			
20	26.1	93.9	30.5	0.698	87.7	28.4	0.726	90.5	31.2	0.695	86.8	30.6	0.706	91.7	34.2	0.663	79.5	33.3	0.698
21	35.7	85.3	40.4	0.614	76.8	37.8	0.664	83.0	41.4	0.610	79.6	41.0	0.624	84.1	44.7	0.575	71.1	44.4	0.627
22	43.1	77.7	47.7	**0.569**	729	45.8	0.606	79.1	49.8	0.544	72.5	48.5	0.584	77.6	52.5	0.525	64.2	52.4	**0.596**
23	54.0	61.4	57.5	0.574	60.6	56.5	**0.587**	63.6	59.5	**0.544**	59.3	58.7	**0.580**	63.7	62.1	**0.525**	52.8	62.6	0.602
24	65.0	45.2	67.4	0.638	49.7	67.6	0.598	51.4	70.2	0.570	46.8	69.3	0.614	49.6	71.8	0.577	39.9	71.5	0.665
25	75.6	32.5	77.4	0.712	34.8	77.3	0.690	39.1	80.8	0.639	30.4	77.6	0.731	33.9	79.8	0.691	27.6	79.5	0.752
26	82.7	21.8	83.7	0.799	20.6	83.3	0.811	26.9	85.6	0.745	22.1	84.4	0.794	23.9	85.7	0.774	19.3	85.2	0.820
27	88.8	14.2	89.4	0.865	13.5	89.1	0.872	19.4	91.2	0.811	15.4	90.2	0.852	15.9	90.8	0.846	12.0	89.7	0.886
Women																			
20	23.8	94.0	26.6	0.736	88.8	26.0	0.748	87.4	26.2	0.789	88.0	28.3	0.727	92.4	27.9	0.725	81.9	37.2	0.654
21	31.3	89.3	34.5	0.664	82.7	33.7	0.685	81.4	34.0	0.686	78.9	35.2	0.681	85.3	35.5	0.662	74.3	44.6	0.611
22	40.4	79.2	43.5	0.602	73.7	42.8	0.630	72.6	43.1	0.632	67.7	43.5	0.651	76.1	44.5	0.604	64.9	53.0	**0.587**
23	50.2	72.0	53.6	**0.542**	61.5	52.1	**0.615**	60.9	52.5	**0.615**	57.8	53.1	**0.631**	66.9	54.4	**0.563**	54.9	62.0	0.590
24	59.0	57.7	62.1	0.568	49.7	60.9	0.637	49.8	61.3	0.634	46.3	61.6	0.660	54.6	62.9	0.586	45.0	69.8	0.627
25	69.1	44.6	71.4	0.623	38.0	70.4	0.687	40.0	71.1	0.666	35.2	70.9	0.710	44.6	72.7	0.618	34.6	78.3	0.689
26	78.0	32.7	79.7	0.703	26.3	78.7	0.767	28.4	79.3	0.745	24.0	78.8	0.789	33.5	80.8	0.692	25.4	85.9	0.759
27	85.5	20.8	86.5	0.803	18.4	86.1	0.828	16.7	85.9	0.845	15.2	85.8	0.860	22.3	87.4	0.787	17.2	91.8	0.832

Sens indicates sensitivity; Spec, specificity.

absence of the cardiometabolic risk factors such as diabetes, prediabetes, hypertension, hypercholesterolemia, hypertriglyceridemia and low HDL cholesterol. Sensitivity was defined by the proportion of subjects with a given risk factor who where identified correctly by BMI or WC greater or equal to the cut point. Specificity was defined by the proportion of subjects without the risk factor who were identified by BMI and WC below the cut point. The area under the receiver operating characteristic (ROC) curves and the 95% confidence intervals (CIs) were computed. The distance on the ROC curve of each BMI and WC was calculated as the square root of $[(1 - \text{sensitivity})^2 + (1 - \text{specificity})^2]$. The BMI or WC with the shortest distance on the ROC curve was determined for each of the cardiometabolic risk factors.

5. Results

Women had higher mean BMI than men (22.6 kg/m^2 for men vs 23.1 kg/m^2 for women; P = .007). The median BMI for men was 22.8 kg/m^2, and for women, 23 kg/m^2. The 25th, 50th, 75th, and 90th percentiles of BMI for men and women were 19.9 and 20.2, 22.8 and 23, 25 and 25.7, and 27.4 and 28 kg/m^2, respectively. The mean WC value was higher in men than in women (men: 85.4 cm vs women: 81.7 cm, P < .001). The median WC for men and women were 86.4 and 82 cm, respectively. The 25th, 50th, 75th, and 90th percentiles of WC for men and women were 77.2 and 74, 86.4 and 82, 93.5 and 89, and 99.3 and 96.1 cm, respectively.

5.1. Optimal cut point for BMI

The sensitivity, specificity, and distance on the ROC curve for the detection of diabetes, prediabetes, hypertension, hypertriglyceridemia, hypercholesterolemia, and low HDL cholesterol of each BMI level are presented for men and women separately in Table 1. The shortest distance on the ROC curve was taken as the optimum cut point. Based on this, the shortest distance on the ROC curve for all risk factors was 23 kg/m^2 for both men and women, with the exception of BMI of 22 kg/m^2 for diabetes (in men) and low HDL cholesterol (in both sexes). In men, a BMI cut point of 23 kg/m^2 was observed to identify those with cardiometabolic risk factors with a sensitivity ranging from 53% to 64% and specificity ranging from 57% to 63%. In women, for a BMI cut point of 23 kg/m^2, the sensitivity ranged from 55% to 72% and the specificity from 52% to 62% for all cardiometabolic risk factors. The WHO Asia Pacific guidelines BMI cut point for obesity (ie, 25 kg/m^2) had higher specificity (77%-81% for men; 70%-78% for women) but much lower sensitivity (28%-39% for men; 35%-45% for women) than a BMI of 23 kg/m^2.

Table 3 shows the optimal cut point for BMI, which was also determined by the point of convergence of sensitivity and specificity (ie, by simultaneously maximizing the two). Based on this, the BMI at which sensitivity equaled specificity for men for all cardiometabolic risk factors ranged from 22.7 to 23.2 kg/m^2. In women, the BMI ranged from 22.7 to 23.8 kg/m^2.

The optimal BMI cut point for identifying any 2 cardiometabolic risk factors and the corresponding area

Table 2
Sensitivity, specificity, and distance in the ROC curve for WC cut points

WC cut point (cm)	Percentile	Diabetes			Prediabetes			Hypertension			Hypercholesterolemia			Hypertriglyceridemia			Low HDL cholesterol		
		Sens (%)	Spec (%)	Distance in ROC	Sens (%)	Spec (%)	Distance in ROC	Sens (%)	Spec (%)	Distance in ROC	Sens (%)	Spec (%)	Distance in ROC	Sens (%)	Spec (%)	Distance in ROC	Sens (%)	Spec (%)	Distance in ROC
Men																			
81	33.9	88.7	39.1	0.619	79.7	36.3	0.447	85.0	39.7	0.621	84.6	40.4	0.616	87.6	43.6	0.577	72.5	42.0	0.642
82	36.1	86.7	41.3	0.602	77.8	38.5	0.428	83.8	42.1	0.601	83.2	42.8	0.596	85.5	45.8	0.561	70.0	43.7	0.638
83	38.5	83.6	43.5	0.588	77.1	41.2	0.398	81.8	44.6	0.583	79.5	44.7	0.590	82.4	47.8	0.551	68.3	46.9	0.618
84	42.0	79.5	47.0	0.568	73.9	44.8	0.373	78.1	48.2	0.562	76.9	48.6	0.564	77.6	50.8	0.541	64.1	49.7	0.618
85	46.0	75.4	50.9	0.549	68.0	48.5	0.368	73.7	52.0	0.547	72.9	52.5	0.547	73.9	54.9	0.521	60.4	54.0	**0.607**
86	49.4	72.8	54.5	0.530	63.4	51.7	0.367	72.5	56.0	0.519	69.6	56.0	0.535	71.2	58.6	**0.504**	56.3	56.5	0.617
87	53.0	68.7	58.0	**0.524**	61.4	55.5	**0.347**	69.6	59.8	**0.504**	65.6	59.4	**0.532**	66.1	61.5	0.513	52.6	60.0	0.620
88	56.8	63.1	61.4	0.534	56.2	59.1	0.359	64.8	63.4	0.508	60.1	62.7	0.546	60.9	64.8	0.526	47.9	62.7	0.641
89	60.8	55.4	64.5	0.570	52.9	63.2	0.357	60.3	67.2	0.515	55.3	66.4	0.559	55.2	67.9	0.551	43.3	66.0	0.661
90	64.1	49.2	67.2	0.605	50.3	66.6	0.358	56.7	70.4	0.525	50.5	69.2	0.583	50.0	70.4	0.581	40.1	69.4	0.673
Women																			
76	31.8	92.1	35.4	0.651	80.5	33.8	0.690	81.0	34.4	0.683	81.5	36.8	0.659	87.4	36.6	0.646	73.6	44.4	0.615
77	35.4	87.2	38.9	0.624	78.7	37.7	0.658	78.1	38.2	0.656	78.3	40.6	0.632	83.7	40.3	0.619	69.7	47.4	0.607
78	38.4	84.1	41.9	0.602	75.3	40.7	0.642	76.2	41.4	0.632	75.3	43.6	0.616	81.3	43.4	0.596	66.2	49.3	0.609
79	41.3	81.1	44.7	0.584	71.3	43.3	0.635	70.5	43.7	0.636	72.6	46.5	0.601	79.7	46.6	0.571	63.8	53.2	**0.592**
80	44.4	79.9	48.2	0.556	69.0	46.6	**0.617**	68.6	47.1	0.615	69.6	49.7	**0.588**	76.4	49.6	0.557	60.4	55.6	0.595
81	48.0	75.6	51.6	0.542	62.6	49.8	0.626	64.8	50.6	0.607	63.7	52.4	0.599	72.4	53.1	0.544	56.6	58.7	0.599
82	52.2	70.1	55.6	0.535	57.5	53.7	0.628	59.5	54.6	0.608	58.3	56.1	0.605	67.5	57.1	**0.538**	52.8	63.6	0.596
83	56.8	64.6	60.1	**0.533**	53.4	58.5	0.624	55.2	63.6	0.605	52.1	60.1	0.623	60.2	61.1	0.557	47.8	67.5	0.615
84	60.9	56.1	63.5	0.571	48.9	62.5	0.633	51.9	66.9	**0.603**	47.0	63.9	0.641	58.1	65.7	0.541	43.5	71.3	0.634
85	64.1	53.7	66.8	0.570	46.0	65.8	0.639	49.5	68.7	0.604	43.2	66.8	0.658	55.3	69.0	0.544	40.3	74.4	0.650

Sens indicates sensitivity; Spec, specificity.

Table 3
Cut points of obesity indices based on optimum sensitivity and specificity for cardiometabolic risk factors in the urban adult population

Cardiometabolic risk factors	BMI cut point	Sensitivity (95% CI)	Specificity (95% CI)	Area under curve (95% CI)	WC cut point	Sensitivity (95% CI)	Specificity (95% CI)	Area under curve (95% CI)
Men								
Diabetes	23.1	59.4 (52.2-66.3)	58.3 (55.0-61.6)	0.644 (0.614-0.672)	88.2	62.1 (54.8-68.9)	61.8 (58.4-65.0)	0.670 (0.641-0.698)
Prediabetes	23.2	60.0 (51.8-67.8)	58.9 (55.7-62.1)	0.616 (0.586-0.645)	87.8	59.5 (51.3-67.3)	57.0 (53.8-60.3)	0.609 (0.579−0.639)
Hypertension	23.2	62.5 (56.2-68.4)	61.8 (58.5-65.1)	0.674 (0.645-0.701)	88.2	64.4 (58.1-70.3)	64.0 (60.6-67.3)	0.698 (0.669-0.726)
Hypercholesterolemia	23.0	59.3 (53.3-65.1)	58.7 (55.3-62.1)	0.626 (0.597-0.655)	87.8	63.4 (57.4-69.1)	60.9 (57.4-64.3)	0.655 (0.626-0.684)
Hypertriglyceridemia	23.1	62.8 (57.4-68.0)	62.7 (59.2-66.2)	0.683 (0.654-0.710)	87.8	63.6 (58.2-68.8)	62.9 (59.3-66.4)	0.686 (0.657-0.714)
Low HDL cholesterol	22.7	59.2 (55.2-63.2)	58.3 (53.8-62.7)	0.598 (0.568-0.627)	86.0	57.2 (53.1-61.2)	55.5 (50.8-60.0)	0.581 (0.550-0.611)
Women								
Diabetes	23.8	60.1 (52.3-67.6)	59.9 (57.0-62.9)	0.653 (0.626-0.679)	83.8	61.6 (53.7-69.1)	60.7 (57.7-63.7)	0.672 (0.645-0.698)
Prediabetes	23.5	57.0 (49.4-64.3)	56.2 (53.2-59.2)	0.595 (0.567-0.622)	82.8	55.7 (48.0-63.3)	55.3 (52.3-58.4)	0.597 (0.569-0.625)
Hypertension	23.4	55.8 (48.9-62.6)	55.7 (52.6-58.8)	0.597 (0.569-0.624)	82.8	57.6 (50.6-64.4)	56.1 (53.0-59.2)	0.616 (0.588-0.643)
Hypercholesterolemia	23.3	55.7 (50.3-61.1)	55.2 (51.9-58.5)	0.577 (0.549-0.605)	82.5	57.4 (52.0-62.8)	57.3 (54.0-60.6)	0.606 (0.578-0.633)
Hypertriglyceridemia	23.7	60.6 (54.2-66.6)	60.1 (56.9-63.1)	0.650 (0.623-0.676)	82.8	65.0 (58.7-71.0)	58.5 (55.4-61.6)	0.676 (0.649-0.702)
Low HDL cholesterol	22.7	58.6 (55.3-61.9)	58.4 (53.2-63.5)	0.630 (0.602-0.656)	81.0	58.3 (55.0-61.6)	57.3 (52.0-62.4)	0.621 (0.593-0.648)

under the ROC curve are given in Table 4. A BMI of 23 kg/m^2 was found to be optimal for identifying subjects with any 2 cardiometabolic risk factors in both men and women. The corresponding sensitivities were 67% for men and 63% for women, and the specificity, 67% for men and 63% for women.

5.2. Optimal cut point for WC

The sensitivity, specificity, and distance on the ROC curve for the detection of diabetes, prediabetes, hypertension, hypertriglyceridemia, hypercholesterolemia, and low HDL cholesterol for different WC cut points are presented for men and women separately in Table 2. The shortest distance on the ROC curve was taken as the optimum cut point. Based on this, the shortest distance on the ROC curve was 87 cm for diabetes, prediabetes, hypertension, and hypercholesterolemia, 86 cm for hypertriglyceridemia and 85 cm for low HDL cholesterol in men. In women, the corresponding cut point of shortest distance in the ROC curve ranged from 79 cm for low HDL cholesterol to 84 cm for hypertension. In men, a WC cut point of 87 cm was observed to identify those with diabetes, prediabetes, hypertension, and hypercholesterolemia with a sensitivity ranging from 61% to 70% and specificity ranging from 56% to 60%. For hypertriglyceridemia, the sensitivity and specificity at a cut point of 86 cm was 71% and 59% and that for low HDL cholesterol at a cut point of 85 cm was 60% and 54%, respectively. In women, for a WC of 79 to 84 cm, the sensitivity of all cardiometabolic risk factors ranged from 52% to 70%, whereas the specificity ranged from 47% to 67%.

The optimal cut point for WC at which sensitivity equaled specificity was 86 cm for low HDL cholesterol and 88 cm for all the other risk factors in men. In women, the optimal cut point was 84 cm for diabetes, 83 cm for prediabetes, hypertension, hypercholesterolemia, and hypertriglyceridemia and 81 cm for low HDL cholesterol as shown in Table 3. The optimal WC cut point for identifying any 2 cardiometabolic risk factors and the corresponding area under the ROC curve are given in Table 4. WC of 87 cm for men and 82 cm for women were found to be optimal for identifying subjects with any 2 cardiometabolic risk factors. The corresponding sensitivity was 69% for men and 63% for women and the specificity was 68% for men and 62% for women, respectively.

The Asia Pacific WC cut points (≥90 cm for men and ≥80 cm for women) to predict diabetes, hypertension, and dyslipidemia in urban adult population had a sensitivity that ranged from 40% to 57% in men and 60% to 80% in women and a specificity that ranged from 67% to 70% in men and

Table 4
Threshold for body mass index and WC that showed optimum sensitivity and specificity for cardiometabolic risk factors

No. of cardiometabolic risk factors	BMI Cut point	Sensitivity (95% CI)	Specificity (95% CI)	Area under curve (95% CI)	*P*	WC Cut point	Sensitivity (95%CI)	Specificity (95%CI)	Area under curve (95% CI)	*P*
Men										
Any 3	23.4	64.6 (58.1-70.8)	64.6 (61.3-67.8)	0.692 (0.663-0.719)	<.001	88.3	63.6 (56.9-69.8)	63.6 (60.3-66.9)	0.701 (0.673-0.729)	<.001
Any 2	22.8	66.8 (62.5-70.9)	66.7 (62.7-70.4)	0.731 (0.704-0.757)	<.001	86.9	69.3 (65.0-73.4)	67.7 (63.7-71.5)	0.745 (0.717-0.771)	<.001
Any 1	21.5	68.7 (65.5-71.8)	68.7 (62.2-74.8)	0.731 (0.703-0.757)	<.001	82.9	71.4 (68.2-74.4)	70.8 (64.1-76.8)	0.757 (0.730-0.783)	<.001
Women:										
Any 3	23.7	60.2 (53.4-66.7)	60.0 (57.0-63.0)	0.663 (0.636-0.689)	<.001	83.8	66.5 (59.8-72.8)	62.9 (59.8-65.9)	0.708 (0.682-0.733)	<.001
Any 2	23.3	63.1 (58.7-67.3)	62.8 (59.2-66.3)	0.671 (0.645-0.697)	<.001	82.1	62.6 (58.2-66.9)	62.4 (58.8-65.9)	0.684 (0.657-0.710)	<.001
Any 1	22.2	61.6 (58.5-64.5)	61.6 (54.7-68.2)	0.668 (0.641-0.694)	<.001	79.5	62.3 (59.3-65.3)	62.3 (55.3-68.9)	0.669 (0.642-0.695)	<.001

Cardiometabolic risk factors include diabetes, hypertension, hypertriglyceridemia, hypercholesterolemia, and low HDL cholesterol.

47% to 56% in women for identifying individual cardiometabolic risk factors (Table 2). Using the optimal cut points observed in the present study (WC ≥87 cm for men and ≥82 cm for women), we found the sensitivity ranged from 53% to 70% in both men and women and the specificity ranged from 56% to 62% in men and 54% to 64% in women for identifying individual cardiometabolic risk factors.

6. Discussion

This study is the first to evaluate the new WHO Asia Pacific cut points for BMI and WC in Asian Indians with respect to cardiometabolic risk factors. It is also the first, to our knowledge, to assess the new cut points in relation to prediabetes (IGT/IFG) in an Asian population.

To determine an optimum cut point for obesity indices, several criteria have been proposed in different studies, for example, greatest sum of sensitivity and specificity, equivalence of positive and negative predictive value, and the shortest distance in the ROC curve [23-26]. Based on the sensitivity, specificity, and ROC calculations, our data suggest a BMI of 23 kg/m^2 for the designation of overweight and a WC of 87 cm for men and 82 cm for women to be the most appropriate cut points to identify cardiometabolic risk factors in urban Asian Indians.

The National Cholesterol Education Program Adult Treatment Panel III WC cut point (≥102 cm for men and ≥88 cm for women) may be suitable for Europeans but not for Asians. Even in the non-Asian populations, lower WC cut points have been reported for several populations including Nigeria, Cameroon, Jamaica, St Lucia and Barbados [27], Brazil [28], Mexico [29], and Iran [30]. The need for setting lower cut points of WC in Asians has been reported in several Asian populations including Japanese [31], Malays [32], Taiwanese [33], and Chinese [34]. The large WHO MONICA study conducted on 32 978 subjects from 19 populations came out with an observation that a substantial proportion of those who would need health advice would be missed according to the presently accepted "Western" WC cut points (action level 1: men, ≥ 94 cm, and women, ≥ 80 cm; action level 2: men, ≥ 102 cm, and women, ≥ 88 cm) and emphasized the need for population-specific WC cut points [35]. A meta-analysis of data from 13 population-based studies that included 239 972 adults in China and Taiwan showed that a BMI of 24 kg/m^2 had the best sensitivity and specificity for identification of cardiovascular risk factors, and if this target is achieved it would prevent approximately 50% clustering of cardiovascular risk factors [34].

Several studies have examined appropriate cut points to define overweight and obesity in Asian populations. The cut points proposed in the present study to define generalized (based on BMI) and abdominal obesity (based on WC) are marginally lower than those recommended in the WHO Asia Pacific guidelines, with the exception of WC for women. Most studies have suggested a BMI cut point of 22 to 24 kg/m^2 for men and women and a WC cut point near 80 to 85 cm for men and 75 to 80 cm for women [36-41]. The findings of the Working Group on Obesity in China recommended a WC of 85 cm for men and 80 cm for women as the optimal cut point [39]. Studies on a North Indian population reported a WC of 78 cm in men and 72 cm in women were optimal in identifying those with at least one cardiometabolic risk factor [42]. A BMI of less than 22 kg/m^2 has also been reported to be the "normal" BMI for a North Indian population [43,44]. However, these studies were carried out predominantly on a slum population representing poorer socioeconomic status and this may explain the lower figures. A study on the Pakistani population reported a BMI of 21.2 and 22.1 kg/m^2 in men and 21.2 and 22.9 kg/m^2 in women to be optimal for the association with hypertension and diabetes, respectively, and thus supports the use of a lower cut point of BMI (23 kg/m^2 or even lower) for identification of subjects with hypertension and diabetes in Indo-Asian populations [45]. A study on urban adult population from 6 cities in India [46] had reported a BMI less than 23 kg/m^2 and WC of 85 cm for men and 80 cm for women as the optimal cut point values; however, that study looked at only diabetes and used capillary blood glucose for diagnosing diabetes. The present study is based on a large representative population of a metropolitan city, Chennai is representative of urban India and uses venous plasma glucose samples. Finally, the study is the first in India to evaluate the predictive performance of BMI and WC for the risk of each of the metabolic abnormalities including prediabetes and lipid abnormalities.

The present study illustrates the potential limitations of applying uniform BMI and WC cut points to assess the health risk of individuals globally. The cut points for WC are likely to be population specific as there are clear differences across ethnic populations in the relationship among overall adiposity, abdominal obesity, and visceral fat accumulation. The recent International Diabetes Federation definition for metabolic syndrome [47] therefore quite recently placed emphasis on developing criteria for central obesity, which would be appropriate for a wide variety of populations, and has come out with ethnic group-specific cut points that are also consistent with the WHO recommendations for Asian Indians [15]. These ethnic-specific WC cut points were based on available data linking WC to other components of the metabolic syndrome in different populations. Moreover, the International Diabetes Federation and WHO labeled these recommendations as provisional and called for their validation by additional clinical and epidemiologic studies in different ethnic groups. Our study reports cut points (WC ≥87 cm for men and ≥82 cm for women) as the most appropriate for this urban south Indian population. A recent meta-analysis [48] reported better outcomes for cardiovascular and total mortality in overweight and mildly obese subjects questioning the need for trying to find cut points for obesity. However, the authors themselves suggest that these findings could be explained by the lack of discriminatory power of BMI to differentiate between body fat and lean mass. It would be worthwhile looking at the effect of WC with mortality and to include non-European populations in future analysis.

The results are of great significance as they would be largely applicable to other South Asian populations. This study also evaluates the cut point of BMI and WC for determining the risk of prediabetes for the first time in a South Asian population. However, there are some limitations of the study. First, it is done in an urban population, which is relatively more affluent than rural areas where in fact 70% of the Indian population lives. Second, being a cross-sectional study, no cause or effect relationship with cardiometabolic diseases can be drawn. Finally, the cut points are based on cardiometabolic risk factors rather than clinical end points or mortality data. Prospective studies are needed to relate the BMI and WC cut points to the incidence of diabetes, hypertension, dyslipidemia, and cardiovascular disease events such as myocardial infarction or all-cause mortality to throw more light on the relationship of obesity to disease-related end points in South Asians.

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