Predictive Values of Anthropometric Measurements for Cardiometabolic Risk Factors and Cardiovascular Diseases Among 44 048 Chinese

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Background—The predictive value of adiposity indices and the newly developed index for cardiometabolic risk factors and cardiovascular diseases (CVDs) remains unclear in the Chinese population. This study aimed to compare the predictive value of A Body Shape Index with other 5 conventional obesity-related anthropometric indices (body mass index, waist circumference, hip circumference, waist-to-hip ratio, waist-to-height ratio) in Chinese population.

Methods and Results—A total of 44 048 participants in the study were derived from the baseline data of the PURE–China (Prospective Urban and Rural Epidemiology) study in China. All participants' anthropometric parameters, CVDs, and risk factors (dyslipidemia, abnormal blood pressure, and hyperglycemia) were collected by standard procedures. Multivariable logistic regression models and receiver operator characteristic curve analysis were used to evaluate the predictive values of obesity-related anthropometric indices to the cardiometabolic risk factors and CVDs. A positive association was observed between each anthropometric index and cardiometabolic risk factors and CVDs in all models ($P<0.001$). Compared with other anthropometric indices (body mass index, waist circumference, hip circumference, waist-to-hip ratio, and A Body Shape Index), waist-to-height ratio had significantly higher areas under the curve (AUCs) for predicting dyslipidemia (AUCs: 0.646, sensitivity: 65%, specificity: 44%), hyperglycemia (AUCs: 0.595, sensitivity: 60%, specificity: 45%), and CVDs (AUCs: 0.619, sensitivity: 59%, specificity: 41%). Waist circumference showed the best prediction for abnormal blood pressure (AUCs: 0.671, sensitivity: 66%, specificity: 40%) compared with other anthropometric indices. However, the new body shape index did not show a better prediction to either cardiometabolic risk factors or CVDs than that of any other traditional obesity-related indices.

Conclusions—Waist-to-height ratio appeared to be the best indicator for dyslipidemia, hyperglycemia, and CVDs, while waist circumference had a better prediction for abnormal blood pressure. (*J Am Heart Assoc.* 2019;8:e010870. DOI: 10.1161/JAHA.118.010870.)

Key Words: adiposity indices • cardiometabolic risk factors • obesity • predictors

W orldwide, obesity is one of the leading risk factors for cardiovascular diseases (CVDs) driven by the elevated level of cardiometabolic risk factors that are highly influenced by increased adiposity.[1–5] In 2015, ≈107 million children and 603 million adults were obese, with a global prevalence of 5% and 12%, respectively. The World Health Organization (WHO) reported that obesity (ie, body mass index [BMI] ≥30 kg/m^2) was linked to 4 million excess deaths worldwide and the loss of 120 million disability-adjusted life-years, equivalent to 7.1% of all causes of death and 4.9% of all adults' disability-

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adjusted life-years.[6,7] In China, the prevalence of overweight and obesity was 30.1% and 11.9%, respectively, in 2002, and increased to 32.0% and 67.6%, respectively, in 2012.[8] In every 100,000 people, it was estimated that about 49 men and 34 women died from obesity.[7]

BMI ≥ 30 kg/m^2 is a widely used indictor for defining general obesity in a non-Chinese population, and waist circumference (WC) >90 cm for men (80 cm for women) is a cutoff measurement of abdominal obesity recommended by the WHO.[9,10] Many epidemiological studies investigated the predictive value of BMI for cardiometabolic risk factors and cardiovascular events and consistently showed that BMI had a lower discriminatory power than WC and waist-to-height ratio (WHtR) to distinguish individuals with high muscle mass from those with excess fat or abdominal obesity.[11–15] Two systematic reviews indicated that WHtR was a better predictor for cardiometabolic risk factors and CVDs than BMI and WC,[16,17] but the results had significant heterogeneities as they identified more than 30 studies covering 15 ethnic populations.

A Body Shape Index (ABSI) is a new comprehensive adiposity index combining BMI and WC, which was developed by Krakauer in 2012, showing a better predictive value for mortality and CVDs than that of BMI or WC in whites.[18–21] ABSI has also been adopted by several small Asian studies (Indonesia, Iran, and China) to investigate the association with hypertension, mortality, and metabolic syndrome,[22–24] but none of these previous studies examined the association with

CVDs and there is a lack of knowledge on the predictive value of ABSI for cardiovascular risk factors among the Chinese population. In addition, there has been no research comparing the discriminatory power between ABSI and other anthropometric measurements for cardiometabolic risk factors and CVD risk in a single large Chinese population.

This study aimed to compare the predictive value of a newly developed ABSI in a large Chinese population with other 5 conventional obesity-related anthropometric indices (BMI, WC, hip circumference [HC], waist-to-hip ratio [WHR], and WHtR) for predicting cardiometabolic risk factors and CVDs. The optimal thresholds of these anthropometric indices were also evaluated.

Methods

The data, analytic methods, and study materials will not be made available to other researchers for purposes of reproducing the results or replicating the procedure.

Enrollment of Participants

Participants in this study were a subset of Chinese subjects who were enrolled from the baseline survey of the PURE (Prospective Urban and Rural Epidemiology) study during 2005–2009. PURE is a large prospective cohort of 153 996 individuals enrolled from 628 urban and rural communities in 17 low-, middle-, and high-income countries including China.[25–27]

Being a major partnership of PURE, PURE-China recruited 46 285 subjects (aged 35–70 years) from 115 communities (70 urban and 45 rural) in 12 provinces in China, representing various levels of development and encompassing a large sociocultural diversity.[28,29] The PURE-China cohort study was approved by an institutional review committee and all participants gave informed consent. For the current analyses, we excluded participants without anthropometric indices (n=715; 1.5%) or blood sample data (n=1522; 3.3%). Thus, 44 048 participants were included in this study.

Data Collection

Trained research staff interviewed each participant using standardized questionnaires and collected information on demographic data, lifestyle behaviors (such as physical activity level and energy intake), and medical history.[30] Physical activity was obtained using the International Physical Activity Questionnaire and evaluated in metabolic equivalents.[31] Daily energy intake was assessed using a validated Food Frequency Questionnaire.[32,33]

Anthropometric Measurements

Anthropometric measurements were collected by trained staff following standard procedures. Height was measured to the nearest 0.1 cm without shoes using a standard stadiometer. Weight was measured in subjects wearing light indoor clothing to the nearest 0.1 kg using a rigid measurement device. WC was measured to the nearest 0.1 cm at the midpoint between the lowest rib margin and the level of the anterior superior iliac crest by a flexible anthropometric tape. HC was measured to the nearest 0.1 cm at the greatest protrusion of the gluteal muscles. WHR and WHtR were calculated as WC/HC and WC/height, respectively. ABSI was calculated using the following formula: $\frac{WC}{BMI^{2/3}Height^{1/2}}$.[18] Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured 2 times after resting for 5 minutes in the sitting position using an OMRON blood pressure (BP) monitor. If there was a difference >5 mm Hg, measurements were repeated.

Definitions of Outcomes

Dyslipidemia, abnormal BP, and hyperglycemia were considered cardiometabolic risk factors. Dyslipidemia was defined by criteria of the 2016 Chinese guidelines for the management of dyslipidemia in adults.[34] Dyslipidemia was defined if any of the following blood lipid measurements were abnormal: total cholesterol ≥5.2 mmol/L; low-density lipoprotein cholesterol ≥3.4 mmol/L; high-density lipoprotein cholesterol ≤1.0 mmol/L; or triglycerides ≥1.7 mmol/L. Abnormal BP was defined as self-reported hypertension or SBP ≥120 mm Hg and/or DBP ≥80 mm Hg.[35] Participants were regarded as being hyperglycemic if they had self-reported diabetes or a recent laboratory result of fasting blood glucose level ≥5.6 mmol/L.[36] Self-reported physician-diagnosed CVDs included coronary heart disease, heart failure, and other CVDs (arrhythmia, valvular heart disease, cardiomyopathy, and myocarditis).

Statistical Analyses

Continuous data were reported as means and SDs and categorical data as frequencies with proportions. Means and proportions were compared using 2-sided t tests and χ^2, respectively. Three different logistic regression models were used to evaluate standardized (per 1-SD increase) associations of obesity-related anthropometric indices with cardiometabolic risk factors and CVDs. Odds ratios (ORs) were standardized by using transformed observations [(observation−mean)/SD] in the models. Potential confounding factors to be adjusted in the multiple regression models were sociodemographic variables (age, sex, regions, location, and education levels), lifestyle characteristics (physical activity and daily energy intake), self-reported disease history, and family history of chronic diseases. Missing adjusted factors were imputed by maximum frequency for statistical analysis. We also performed sensitivity analysis for original data (Tables S1 through S5) and found that the results remained consistent.

For each index, receiver operator characteristic (ROC) curve analysis was used to identify the value with the maximum sum of sensitivity and specificity as a predictor of cardiometabolic risk factors and CVDs. The optimal cut point for each measure of adiposity in detecting cardiometabolic risk factors was chosen as the point on the curve with the highest Youden Index (sensitivity+specificity−1). Furthermore, we performed 2 subgroup analyses based on sex and age group. All reported P values were 2-sided and <0.05 was considered significant. All analyses were performed in SAS version 9.4 (SAS Institute Inc).

Results

Demographic data of 44 048 eligible participants included in the current study are presented in Table 1. There was a statistically significant difference between participants with and without CVDs with respect to age, sex, living area, education, lifestyle characteristics, and family disease history. People with CVDs had significantly higher anthropometric indices ($P<0.001$) and laboratory indicators than those without CVDs.

The associations between anthropometric measurements and cardiometabolic risk factors and CVDs are illustrated in Table 2. Higher levels of adiposity were associated with greater risks of cardiometabolic risk factors and CVDs in both the univariable and multivariable models ($P<0.001$). The standardized adjusted ORs for dyslipidemia, abnormal BP, hyperglycemia, and CVDs ranged from 1.284 to 1.674, from 1.150 to 1.879, from 1.064 to 1.343, and from 1.176 to 1.353, respectively. WHtR showed a higher OR than BMI, WC, HC, WHR, and ABSI for all cardiometabolic risk factors and CVDs.

Table 3 presents the AUCs (95% CIs) and optimal cut points for anthropometric measurements in relation to cardiometabolic risk factors and CVDs. The discriminatory ability of the anthropometric indices in identifying cardiometabolic risk factors and CVDs was not high. Compared with other cardiometabolic parameters, WHtR tended to be the best predictor for dyslipidemia (AUCs: 0.646, sensitivity 65%, specificity 44%, cutoff point: 0.49), hyperglycemia (AUCs: 0.595, sensitivity 60%, specificity 45%, cutoff point: 0.50), and CVDs (AUCs: 0.619, sensitivity 59%, specificity

Table 1. Participants Sociodemographic and Lifestyle Characteristics

Characteristic*	Total Sample (N=44 048)	CVDs[†] (n=2755)	No CVDs (n=41 293)	P Value[‡]
Age	51.2±9.8	51.3±8.8	50.8±9.7	<0.001
Sex (Male)	18 139 (41.2)	954 (34.6)	17 185 (41.6)	<0.001
Education				<0.001
Low (none, primary, or unknown)	14 941 (34.0)	1129 (41.1)	13 812 (33.5)	
Middle (secondary, high, higher secondary school)	25 142 (57.2)	1342 (48.9)	23 800 (57.8)	
High (trade, college, or university)	3857 (8.78)	276 (10.0)	3581 (8.7)	
Regions				<0.001
Eastern	23 313 (52.9)	1372 (49.8)	21 941 (53.1)	
Middle	10 014 (22.7)	598 (21.7)	9416 (22.8)	
Western	10 721 (24.3)	785 (28.5)	9936 (24.1)	
Current smoking[§]	9806 (22.5)	420 (15.4)	9386 (23.0)	<0.001
Current drinking[‖]	9258 (21.1)	402 (14.7)	8856 (21.6)	<0.001
Physical activity (MET score level)				0.0182
Low (<600 MET min/wk)	5354 (12.7)	290 (11.1)	5064 (12.8)	
Middle (600–3000 MET min/wk)	5354 (43.7)	1189 (45.5)	17 217 (43.6)	
High (>3000 MET min/wk)	5354 (43.5)	1132 (43.4)	17 197 (43.6)	
SBP, mm Hg	133.5±22.4	140.3±23.4	133.1±22.3	<0.001
DBP, mm Hg	82.8±13.2	85.3±12.6	82.6±13.3	<0.001
Glucose, mmol/L	5.6±1.6	5.9±2.1	5.56±1.5	<0.001
Cholesterol, mmol/L	4.7±1.0	4.9±1.1	4.67±1.0	<0.001
Triglyceride, mmol/L	1.6±1.2	1.8±1.3	1.6±1.2	<0.001
HDL-C, mmol/L	1.4±0.4	1.4±0.5	1.4±0.3	<0.001
LDL-C, mmol/L	2.6±0.8	2.8±0.9	2.6±0.8	<0.001
Weight, kg	63.8±12.1	65.4±12.7	63.7±12.1	<0.001
Height, m	160.8±8.2	159.8±8.3	160.9±8.3	<0.001
BMI, kg/m^2	24.6±4.0	25.6±4.3	24.6±4.0	<0.001
WC, cm	81.1±10.5	84.6±10.9	80.9±10.5	<0.001
HC, cm	94.3±8.1	96.7±8.5	94.1±8.0	<0.001
WHR	0.86±0.07	0.87±0.08	0.86±0.07	<0.001
WHtR	0.50±0.06	0.53±0.07	0.50±0.06	<0.001
ABSI, m$^{7/6}$/kg$^{2/3}$	0.08±0.01	0.08±0.01	0.08±0.01	0.0657
Dyslipidemia[¶]	22 959 (52.12)	1785 (64.8)	21 174 (51.3)	<0.001
Abnormal BP[#]	33 278 (75.55)	2345 (85.1)	30 933 (74.9)	<0.001
Hyperglycemia**	16 977 (38.54)	1294 (47.0)	15 683 (38.0)	<0.001

ABSI indicates A Body Shape Index; BMI, body mass index; HC, hip circumference; MET, metabolic equivalent; WC, waist circumference; WHR, waist-to-hip ratio; WHtR, waist-to-height ratio.

*Data are presented as mean±SD or number (percentage). The missing values are as follows: education: 108; smoking status: 464; drinking status: 255; and physical activity level: 1959.

[†]Coronary heart disease or heart failure or other cardiovascular diseases (CVDs; arrhythmia, valvular heart disease, cardiomyopathy, and myocarditis).

[‡]CVDs vs no CVDs.

[§]Current smoking: consuming at least 1 tobacco product per day.

[‖]Current drinking: consuming alcohol at least once a month.

[¶]Dyslipidemia: total cholesterol ≥5.2 mmol/L or low-density lipoprotein cholesterol (LDL-C) ≥3.4 mmol/L or high-density lipoprotein cholesterol (HDL-C) ≤1.0 mmol/L or triglycerides ≥1.7 mmol/L.

[#]Abnormal blood pressure (BP): self-reported hypertension or systolic BP (SBP) ≥120 mm Hg and/or diastolic BP (DBP) ≥80 mm Hg.

**Hyperglycemia: self-reported diabetes or fasting blood glucose level ≥5.6 mmol/L.

Table 2. Crude and Adjusted ORs (Per 1-SD Increase) for Cardiometabolic Risk Factors and CVDs in Relation to Anthropometric Indices (N=44 048)

Outcomes	Model 1 OR (95% CI)*	Model 2 OR (95% CI)†	Model 3 OR (95% CI)‡
Dyslipidemia§			
BMI	1.556 (1.522–1.591)	1.528 (1.494–1.563)	1.524 (1.490–1.559)
WC	1.671 (1.637–1.705)	1.651 (1.616–1.687)	1.647 (1.612–1.683)
HC	1.454 (1.425–1.483)	1.434 (1.404–1.464)	1.431 (1.401–1.461)
WHR	1.513 (1.482–1.546)	1.551 (1.516–1.588)	1.547 (1.511–1.583)
WHtR	1.699 (1.665–1.735)	1.679 (1.643–1.716)	1.674 (1.638–1.711)
ABSI	1.333 (1.307–1.360)	1.285 (1.259–1.313)	1.284 (1.257–1.312)
Abnormal BP‖			
BMI	1.842 (1.791–1.894)	1.738 (1.693–1.785)	1.734 (1.689–1.780)
WC	1.893 (1.846–1.940)	1.810 (1.762–1.860)	1.806 (1.758–1.855)
HC	1.523 (1.488–1.559)	1.553 (1.514–1.593)	1.547 (1.508–1.587)
WHR	1.721 (1.678–1.765)	1.552 (1.510–1.596)	1.551 (1.509–1.595)
WHtR	1.842 (1.797–1.888)	1.886 (1.832–1.943)	1.879 (1.824–1.935)
ABSI	1.340 (1.310–1.371)	1.150 (1.122–1.178)	1.150 (1.122–1.178)
Hyperglycemia¶			
BMI	1.321 (1.293–1.348)	1.321 (1.293–1.350)	1.320 (1.292–1.348)
WC	1.356 (1.330–1.383)	1.335 (1.308–1.364)	1.333 (1.306–1.362)
HC	1.206 (1.183–1.230)	1.211 (1.186–1.237)	1.209 (1.184–1.235)
WHR	1.317 (1.290–1.344)	1.277 (1.250–1.306)	1.276 (1.248–1.304)
WHtR	1.384 (1.357–1.412)	1.346 (1.318–1.374)	1.343 (1.315–1.371)
ABSI	1.136 (1.114–1.158)	1.066 (1.044–1.088)	1.064 (1.042–1.087)
CVDs			
BMI	1.215 (1.178–1.253)	1.185 (1.148–1.225)	1.182 (1.143–1.221)
WC	1.412 (1.360–1.467)	1.315 (1.265–1.367)	1.307 (1.256–1.359)
HC	1.369 (1.317–1.422)	1.323 (1.271–1.377)	1.313 (1.261–1.367)
WHR	1.204 (1.164–1.245)	1.179 (1.137–1.223)	1.176 (1.134–1.220)
WHtR	1.495 (1.441–1.552)	1.362 (1.308–1.418)	1.353 (1.299–1.409)
ABSI	1.329 (1.280–1.380)	1.182 (1.135–1.230)	1.176 (1.130–1.224)

ABSI indicates A Body Shape Index; BMI, body mass index; HC, hip circumference; OR, odds ratio; WC, waist circumference; WHR, waist-to-hip ratio; WHtR, waist-to-height ratio.

*Model 1: crude model.

†Model 2: adjusted for sociodemographic characteristics (age, sex, regions, location, and education levels).

‡Model 3: adjusted for sociodemographic (age, sex, regions, location, and education levels), lifestyle (physical activity and daily energy intake), and medical history characteristics (family history of coronary heart disease or heart failure or other cardiovascular diseases [CVDs]).

§Dyslipidemia: total cholesterol ≥5.2 mmol/L or low-density lipoprotein cholesterol ≥3.4 mmol/L or high-density lipoprotein cholesterol ≤1.0 mmol/L or triglycerides ≥1.7 mmol/L.

‖Abnormal blood pressure (BP): self-reported hypertension or systolic BP ≥120 mm Hg and/or diastolic BP ≥80 mm Hg.

¶Hyperglycemia: self-reported diabetes or fasting blood glucose level ≥5.6 mmol/L.

41%, cutoff point: 0.52). WC showed the best prediction for abnormal BP (AUCs: 0.671, sensitivity: 66%, specificity: 40%, cutoff point: 78.20 cm). In this study, because of its higher specificity (from 39% to 57%) than other indices, the ABSI did not show better prediction (AUCs: from 0.540 to 0.597, cutoff point: from 0.75 to 0.77 $m^{7/6}/kg^{2/3}$), even if its sensitivity was similar to that of the other indices (from 53% to 64%).

Table 4 compares the standardized ORs for each anthropometric measurement stratified by sex and age groups. For each index, the standardized OR for men was higher than for women. WHtR still showed a higher standardized OR than that of BMI, WC, HC, WHR, and ABSI for each cardiometabolic risk factor and CVDs for both men and women. For each anthropometric index, the ORs for middle-aged people were higher than for the elderly except for HC in the association

Table 3. AUCs and Optimal Cut Points for Anthropometric Measurements in Relation to Cardiometabolic Risk Factors and CVDs (N=44 048)

Outcomes	AUC (95% CI)*	Cutoff Point	Sensitivity	Specificity	Youden Index
Dyslipidemia[†]					
BMI	0.627 (0.622–0.633)	23.55	0.68	0.49	0.19
WC	0.642 (0.636–0.647)	79.50	0.65	0.44	0.21
HC	0.607 (0.602–0.612)	94.35	0.56	0.41	0.16
WHR	0.618 (0.612–0.623)	0.85	0.62	0.45	0.18
WHtR	0.646 (0.641–0.651)	0.49	0.65	0.44	0.22
ABSI	0.589 (0.583–0.594)	0.75	0.63	0.49	0.14
Abnormal BP[‡]					
BMI	0.653 (0.647–0.659)	23.58	0.64	0.41	0.23
WC	0.671 (0.665–0.677)	78.20	0.66	0.40	0.26
HC	0.624 (0.618–0.629)	94.60	0.52	0.33	0.19
WHR	0.649 (0.643–0.656)	0.84	0.67	0.44	0.23
WHtR	0.664 (0.658–0.669)	0.50	0.60	0.36	0.24
ABSI	0.597 (0.591–0.603)	0.75	0.59	0.44	0.15
Hyperglycemia[§]					
BMI	0.591 (0.586–0.596)	23.87	0.64	0.50	0.14
WC	0.588 (0.582–0.593)	80.40	0.60	0.46	0.13
HC	0.555 (0.549–0.560)	92.05	0.66	0.58	0.08
WHR	0.582 (0.577–0.588)	0.90	0.35	0.22	0.12
WHtR	0.595 (0.590–0.600)	0.50	0.60	0.45	0.15
ABSI	0.540 (0.535–0.546)	0.75	0.64	0.57	0.07
CVDs					
BMI	0.576 (0.565–0.587)	25.56	0.47	0.36	0.11
WC	0.601 (0.590–0.612)	82.50	0.59	0.43	0.15
HC	0.590 (0.579–0.602)	95.05	0.58	0.44	0.13
WHR	0.570 (0.559–0.581)	0.87	0.57	0.47	0.10
WHtR	0.619 (0.608–0.630)	0.52	0.59	0.41	0.18
ABSI	0.591 (0.580–0.602)	0.77	0.53	0.39	0.14

ABSI indicates A Body Shape Index; AUC, area under the receiver operating characteristic curve; BMI, body mass index; CVDs, coronary heart disease or heart failure or other cardiovascular diseases (arrhythmia, valvular heart disease, cardiomyopathy, and myocarditis); HC, hip circumference; WC, waist circumference; WHR, waist-to-hip ratio; WHtR, waist-to-height ratio.

*Models adjusted for sociodemographic (age, sex, regions, location, and education levels), lifestyle (physical activity and daily energy intake), and medical history characteristics (family history of coronary heart disease or heart failure or other CVDs).

[†]Dyslipidemia: total cholesterol ≥5.2 mmol/L or low-density lipoprotein cholesterol ≥3.4 mmol/L or high-density lipoprotein cholesterol ≤1.0 mmol/L or triglycerides ≥1.7 mmol/L.

[‡]Abnormal blood pressure (BP): self-reported hypertension or systolic BP ≥120 mm Hg and/or diastolic BP ≥80 mm Hg.

[§]Hyperglycemia: self-reported diabetes or fasting blood glucose level ≥5.6 mmol/L.

with abnormal BP. WHtR showed the highest OR for each cardiometabolic risk factor and CVDs in both middle-aged and elderly people.

AUCs for men and women and cutoff points for each parameter are demonstrated in Table 5. For men, WHtR is likely the best predictor for dyslipidemia (AUCs: 0.636, sensitivity: 70%, specificity: 45%, cutoff point: 0.49) and CVDs (AUCs: 0.622, sensitivity: 58%, specificity: 39%, cutoff point:

0.52) and BMI for abnormal BP (AUCs: 0.656, sensitivity: 61%, specificity: 38%, cutoff point: 23.71 kg/m^2) and hyperglycemia (AUCs: 0.595, sensitivity: 59%, specificity: 44%, cutoff point: 24.28 kg/m^2). However, in women, WC was superior for dyslipidemia (AUCs: 0.669, sensitivity: 63%, specificity: 43%, cutoff point:78.0 cm) and WHtR for abnormal BP (AUCs: 0.674, sensitivity: 62%, specificity: 36%, cutoff point: 0.50), hyperglycemia (AUCs: 0.601, sensitivity: 61%,

Table 4. Adjusted ORs (Per 1-SD Increase) for Cardiometabolic Risk Factors in Relation to Anthropometric Measurements, Stratified by Sex and Age Groups (N=44 048)

Outcomes	Sex*		Age Groups*	
	Male (n=18 139)	Female (n=25 909)	35≤ Age <65 y (n=39 632)	Age ≥65 y (n=4416)
Dyslipidemia†				
BMI	1.723 (1.659–1.790)	1.374 (1.335–1.413)	1.558 (1.522–1.596)	1.321 (1.232–1.416)
WC	1.836 (1.771–1.903)	1.480 (1.441–1.521)	1.714 (1.675–1.753)	1.411 (1.323–1.505)
HC	1.593 (1.539–1.650)	1.307 (1.273–1.343)	1.453 (1.421–1.486)	1.348 (1.261–1.441)
WHR	1.690 (1.626–1.756)	1.392 (1.351–1.433)	1.603 (1.564–1.642)	1.335 (1.245–1.432)
WHtR	1.839 (1.775–1.904)	1.504 (1.462–1.548)	1.729 (1.690–1.770)	1.451 (1.358–1.552)
ABSI	1.361 (1.314–1.410)	1.192 (1.160–1.224)	1.338 (1.309–1.369)	1.176 (1.106–1.250)
Abnormal BP‡				
BMI	1.837 (1.756–1.923)	1.635 (1.582–1.690)	1.829 (1.781–1.879)	1.819 (1.628–2.033)
WC	1.863 (1.782–1.947)	1.721 (1.662–1.782)	1.870 (1.819–1.922)	1.805 (1.611–2.022)
HC	1.617 (1.549–1.688)	1.477 (1.430–1.525)	1.560 (1.520–1.601)	1.689 (1.508–1.892)
WHR	1.621 (1.547–1.699)	1.463 (1.413–1.515)	1.630 (1.585–1.676)	1.480 (1.319–1.661)
WHtR	2.047 (1.945–2.154)	1.758 (1.695–1.823)	2.296 (2.010–2.622)	1.892 (1.836–1.949)
ABSI	1.179 (1.131–1.230)	1.101 (1.068–1.134)	1.235 (1.205–1.265)	1.014 (0.919–1.118)
Hyperglycemia§				
BMI	1.382 (1.336–1.430)	1.253 (1.220–1.287)	1.336 (1.306–1.366)	1.206 (1.136–1.281)
WC	1.350 (1.306–1.395)	1.287 (1.253–1.322)	1.388 (1.358–1.420)	1.194 (1.122–1.271)
HC	1.255 (1.213–1.297)	1.161 (1.131–1.193)	1.235 (1.208–1.262)	1.107 (1.040–1.178)
WHR	1.265 (1.222–1.310)	1.248 (1.213–1.284)	1.328 (1.298–1.360)	1.201 (1.125–1.283)
WHtR	1.399 (1.350–1.450)	1.288 (1.253–1.325)	1.419 (1.388–1.450)	1.247 (1.168–1.331)
ABSI	1.050 (1.015–1.087)	1.045 (1.018–1.073)	1.137 (1.112–1.163)	0.978 (0.923–1.035)
CVDs				
BMI	1.237 (1.164–1.315)	1.150 (1.105–1.196)	1.206 (1.115–1.305)	1.189 (1.148–1.232)
WC	1.416 (1.317–1.523)	1.247 (1.189–1.308)	1.436 (1.375–1.500)	1.224 (1.124–1.332)
HC	1.371 (1.275–1.474)	1.274 (1.213–1.338)	1.342 (1.283–1.404)	1.264 (1.157–1.382)
WHR	1.246 (1.171–1.326)	1.128 (1.077–1.182)	1.239 (1.193–1.288)	1.107 (1.008–1.214)
WHtR	1.441 (1.343–1.546)	1.292 (1.229–1.359)	1.451 (1.387–1.517)	1.297 (1.187–1.417)
ABSI	1.254 (1.166–1.349)	1.131 (1.077–1.187)	1.330 (1.271–1.391)	1.055 (0.971–1.147)

ABSI indicates A Body Shape Index; BMI, body mass index; HC, hip circumference; OR, odds ratio; WC, waist circumference; WHR, waist-to-hip ratio; WHtR, waist-to-height ratio.
*Models adjusted for sociodemographic (age, sex, regions, location, and education levels), lifestyle (physical activity and daily energy intake), and medical history characteristics (family history of coronary heart disease or heart failure or other cardiovascular diseases [CVDs]).
†Dyslipidemia: total cholesterol ≥5.2 mmol/L or low-density lipoprotein cholesterol ≥3.4 mmol/L or high-density lipoprotein cholesterol ≤1.0 mmol/L or triglycerides ≥1.7 mmol/L.
‡Abnormal blood pressure (BP): self-reported hypertension or systolic BP ≥120 mm Hg and/or diastolic BP ≥80 mm Hg.
§Hyperglycemia: self-reported diabetes or fasting blood glucose level ≥5.6 mmol/L.

specificity: 46%, cutoff point: 0.50), and CVDs (AUCs: 0.614, sensitivity: 56%, specificity: 38%, cutoff point: 0.52).

Table 6 shows the predictive values for each parameter stratified by age group. WHtR had the highest predictive value in middle-aged people for dyslipidemia (AUCs: 0.647, sensitivity 64%, specificity 43%, cutoff point: 0.49), hyperglycemia (AUCs: 0.594, sensitivity 58%, specificity 44%, cutoff point: 0.50), and CVDs (AUCs: 0.614, sensitivity 57%, specificity 39%, cutoff point: 0.52). As for the elderly, BMI was superior for abnormal BP (AUCs: 0.696, sensitivity 64%, specificity 41%, cutoff point: 23.60 kg/m^2) and hyperglycemia (AUCs: 0.584, sensitivity 70%, specificity 56%, cutoff point: 23.22 kg/m^2).

Discussion

Using baseline data from a large prospective cohort study among Chinese participants, we found strong evidence for a

Table 5. AUCs and Optimal Cut Points for Anthropometric Measurements in Relation to Cardiometabolic Risk Factors and CVDs, Stratified by Sex

Outcomes	Men (n=18 139)					Women (n=25 909)				
	AUC (95% CI)*	Cutoff Point	Sensitivity	Specificity	Youden Index	AUC (95% CI)*	Cutoff Point	Sensitivity	Specificity	Youden Index
Dyslipidemia[†]										
BMI	0.607 (0.600–0.614)	23.51	0.71	0.47	0.24	0.657 (0.649–0.665)	23.87	0.63	0.47	0.16
WC	0.628 (0.622–0.635)	82.45	0.68	0.43	0.25	0.669 (0.661–0.677)	78.0	0.63	0.43	0.20
HC	0.585 (0.579–0.592)	94.15	0.61	0.41	0.20	0.638 (0.630–0.646)	94.3	0.54	0.41	0.13
WHR	0.614 (0.607–0.621)	0.87	0.71	0.49	0.22	0.643 (0.63 5–0.651)	0.84	0.59	0.42	0.17
WHtR	0.636 (0.629–0.642)	0.49	0.70	0.45	0.25	0.662 (0.654–0.670)	0.51	0.54	0.34	0.20
ABSI	0.590 (0.583–0.597)	0.76	0.70	0.55	0.14	0.592 (0.583–0.600)	0.74	0.63	0.50	0.14
Abnormal BP[‡]										
BMI	0.656 (0.646–0.666)	23.71	0.61	0.38	0.24	0.655 (0.648–0.663)	23.64	0.64	0.41	0.23
WC	0.653 (0.643–0.663)	81.95	0.63	0.39	0.23	0.668 (0.661–0.675)	77.85	0.61	0.35	0.26
HC	0.630 (0.620–0.640)	93.15	0.61	0.42	0.19	0.619 (0.612–0.626)	94.60	0.51	0.33	0.18
WHR	0.623 (0.613–0.634)	0.88	0.63	0.43	0.20	0.646 (0.638–0.653)	0.83	0.62	0.40	0.23
WHtR	0.654 (0.644–0.664)	0.48	0.70	0.47	0.23	0.674 (0.667–0.681)	0.50	0.62	0.36	0.26
ABSI	0.570 (0.560–0.580)	0.76	0.65	0.54	0.11	0.595 (0.587–0.603)	0.75	0.54	0.39	0.15
Hyperglycemia[§]										
BMI	0.595 (0.587–0.604)	24.28	0.59	0.44	0.15	0.589 (0.582–0.596)	23.87	0.64	0.50	0.14
WC	0.581 (0.573–0.590)	83.05	0.61	0.49	0.12	0.590 (0.583–0.597)	79.05	0.57	0.44	0.14
HC	0.557 (0.549–0.566)	92.05	0.68	0.59	0.09	0.552 (0.545–0.559)	91.25	0.69	0.62	0.07
WHR	0.579 (0.570–0.587)	0.90	0.47	0.32	0.14	0.585 (0.578–0.592)	0.87	0.40	0.27	0.13
WHtR	0.590 (0.581–0.598)	0.50	0.58	0.44	0.14	0.601 (0.593–0.608)	0.50	0.61	0.46	0.15
ABSI	0.522 (0.514–0.531)	0.76	0.63	0.58	0.04	0.548 (0.541–0.555)	0.75	0.57	0.49	0.08
CVDs										
BMI	0.586 (0.568–0.604)	25.92	0.44	0.31	0.13	0.569 (0.555–0.584)	25.57	0.47	0.36	0.11
WC	0.620 (0.602–0.638)	88.05	0.51	0.33	0.18	0.608 (0.594–0.621)	82.25	0.52	0.36	0.16
HC	0.604 (0.586–0.622)	95.05	0.61	0.46	0.15	0.584 (0.571–0.598)	95.15	0.55	0.42	0.13
WHR	0.595 (0.590–0.600)	0.90	0.58	0.44	0.14	0.586 (0.572–0.600)	0.85	0.53	0.40	0.13
WHtR	0.622 (0.604–0.640)	0.52	0.58	0.39	0.19	0.614 (0.601–0.628)	0.52	0.56	0.38	0.18
ABSI	0.603 (0.585–0.622)	0.78	0.59	0.43	0.16	0.600 (0.587–0.614)	0.76	0.54	0.38	0.16

ABSI indicates A Body Shape Index; AUC, area under the receiver operating characteristic curve; BMI, body mass index; CVDs, coronary heart disease or heart failure or other cardiovascular diseases (arrhythmia, valvular heart disease, cardiomyopathy, and myocarditis); HC, hip circumference; WC, waist circumference; WHR, waist-to-hip ratio; WHtR, waist-to-height ratio.

*Models adjusted for sociodemographic (age, sex, regions, location, and education levels), lifestyle (physical activity and daily energy intake), and medical history characteristics (family history of coronary heart disease or heart failure or other CVDs).

[†]Dyslipidemia: total cholesterol ≥5.2 mmol/L or low-density lipoprotein cholesterol ≥3.4 mmol/L or high-density lipoprotein cholesterol ≤1.0 mmol/L or triglycerides ≥1.7 mmol/L.

[‡]Abnormal blood pressure (BP): self-reported hypertension or systolic BP ≥120 mm Hg and/or diastolic BP ≥80 mm Hg.

[§]Hyperglycemia: self-reported diabetes or fasting blood glucose level ≥5.6 mmol/L.

positive association between obesity-related anthropometric indices and cardiometabolic risk factors and CVDs, but these measures had only moderate discriminatory ability for predicting these cardiometabolic risk factors. The results of this study indicated that markers of central obesity measured by WHtR were more strongly related to dyslipidemia, hyperglycemia, and CVDs risk than BMI.

The strong associations shown in this study between obesity-related indices and cardiometabolic risk factors and CVDs were consistent with previous studies from both the developed and developing countries.[11–13,15,37–39] In this study, when calculating ORs that allow adjusting for further confounding factors, WHtR showed a slightly stronger association with all cardiometabolic risk factors and CVD risk than that of any other

Table 6. AUCs and Optimal Cut Points for Anthropometric Measurements in Relation to Cardiometabolic Risk Factors and CVDs, Stratified by Age Groups

Outcomes	35≤ Age <65 y (n=39 632)					Age ≥65 y (n=4416)				
	AUC (95% CI)*	Cutoff Point	Sensitivity	Specificity	Youden Index	AUC (95% CI)*	Cutoff Point	Sensitivity	Specificity	Youden Index
Dyslipidemia†										
BMI	0.630 (0.624–0.635)	24.34	0.59	0.40	0.20	0.609 (0.592–0.626)	23.43	0.68	0.50	0.17
WC	0.646 (0.640–0.651)	79.50	0.65	0.43	0.22	0.590 (0.573–0.607)	77.70	0.76	0.61	0.15
HC	0.609 (0.603–0.614)	94.10	0.58	0.42	0.16	0.588 (0.571–0.605)	96.65	0.45	0.32	0.13
WHR	0.622 (0.617–0.628)	0.85	0.62	0.43	0.18	0.553 (0.537–0.571)	0.86	0.66	0.57	0.08
WHtR	0.647 (0.642–0.653)	0.49	0.64	0.43	0.22	0.617 (0.600–0.634)	0.51	0.68	0.50	0.18
ABSI	0.591 (0.585–0.596)	0.74	0.68	0.54	0.14	0.543 (0.525–0.560)	0.75	0.77	0.70	0.07
Abnormal BP‡										
BMI	0.653 (0.647–0.659)	23.60	0.64	0.41	0.23	0.696 (0.670–0.721)	23.60	0.64	0.41	0.23
WC	0.668 (0.662–0.674)	78.20	0.65	0.40	0.25	0.665 (0.638–0.693)	77.70	0.72	0.46	0.26
HC	0.622 (0.616–0.628)	94.20	0.54	0.36	0.19	0.654 (0.627–0.680)	93.0	0.62	0.39	0.23
WHR	0.647 (0.641–0.653)	0.84	0.66	0.43	0.23	0.608 (0.578–0.638)	0.83	0.78	0.57	0.21
WHtR	0.658 (0.652–0.664)	0.49	0.62	0.38	0.23	0.674 (0.647–0.702)	0.49	0.72	0.44	0.28
ABSI	0.590 (0.583–0.596)	0.75	0.61	0.47	0.14	0.546 (0.516–0.576)	0.78	0.52	0.42	0.10
Hyperglycemia§										
BMI	0.592 (0.587–0.598)	23.87	0.64	0.50	0.14	0.584 (0.567–0.601)	23.22	0.70	0.56	0.15
WC	0.589 (0.583–0.595)	80.80	0.57	0.44	0.13	0.549 (0.532–0.566)	80.10	0.67	0.58	0.09
HC	0.556 (0.550–0.562)	92.05	0.66	0.58	0.08	0.532 (0.515–0.549)	90.05	0.76	0.70	0.07
WHR	0.583 (0.577–0.589)	0.90	0.34	0.21	0.12	0.545 (0.528–0.562)	0.87	0.60	0.52	0.08
WHtR	0.594 (0.589–0.600)	0.50	0.58	0.44	0.15	0.561 (0.544–0.578)	0.50	0.67	0.57	0.10
ABSI	0.539 (0.533–0.545)	0.75	0.62	0.56	0.07	0.515 (0.498–0.532)	0.76	0.63	0.56	0.07
CVDs										
BMI	0.574 (0.561–0.587)	25.65	0.46	0.35	0.12	0.585 (0.562–0.609)	23.08	0.76	0.63	0.14
WC	0.597 (0.584–0.610)	82.05	0.59	0.44	0.15	0.578 (0.554–0.602)	85.60	0.52	0.34	0.13
HC	0.585 (0.572–0.597)	95.05	0.57	0.44	0.12	0.600 (0.576–0.623)	95.10	0.61	0.46	0.16
WHR	0.571 (0.558–0.583)	0.88	0.49	0.38	0.11	0.519 (0.494–0.543)	0.85	0.69	0.63	0.06
WHtR	0.614 (0.601–0.626)	0.52	0.57	0.39	0.18	0.580 (0.557–0.604)	0.52	0.63	0.50	0.13
ABSI	0.587 (0.575–0.599)	0.77	0.50	0.37	0.13	0.525 (0.500–0.549)	0.78	0.58	0.51	0.07

ABSI indicates A Body Shape Index; AUC, area under the receiver operating characteristic curve; BMI, body mass index; CVDs, coronary heart disease or heart failure or other cardiovascular diseases (arrhythmia, valvular heart disease, cardiomyopathy, and myocarditis); HC, hip circumference; WC, waist circumference; WHR, waist-to-hip ratio; WHtR, waist-to-height ratio.

*Models adjusted for sociodemographic (age, sex, regions, location, and education levels), lifestyle (physical activity and daily energy intake), and medical history characteristics (family history of coronary heart disease or heart failure or other CVDs).

†Dyslipidemia: total cholesterol ≥5.2 mmol/L or low-density lipoprotein cholesterol ≥3.4 mmol/L or high-density lipoprotein cholesterol ≤1.0 mmol/L or triglycerides ≥1.7 mmol/L.

‡Abnormal blood pressure (BP): self-reported hypertension or systolic BP ≥120 mm Hg and/or diastolic BP ≥80 mm Hg.

§Hyperglycemia: self-reported diabetes or fasting blood glucose level ≥5.6 mmol/L.

indices. Possibly, WHtR takes height into account, which is more sensitive to muscle mass distribution and has a better interpretation on the whole body shape. Men showed higher ORs than women in this study, which is similar to that found in previous studies[21,40] on the association between obesity-related indices and cardiometabolic risk factors and CVDs. This could be partially explained by other modified risk factors (ie,

smoking or drinking) and the diversity of fat and muscle distributions. We found that in middle-aged people, anthropometric indices had stronger associations with cardiometabolic risk factors and CVDs. The gain of fat mass and loss of lean mass with increasing age may interpret the differences.[41,42]

Two previous reviews of meta-analyses combining 30 and 31 studies indicated that WHtR was a better predictor for

cardiometabolic risk factors and CVD risk than BMI and WC.[16,17] Our results also indicate that WHtR may be the best index to predict dyslipidemia, hyperglycemia, and CVD risk compared with all other anthropometric parameters. This may be explained by the fact that WHtR does not misclassify muscular but low body fat individuals as BMI does. However, we found WC was a slightly better predictor for abnormal BP. WC is regarded as a visceral fat indicator and reflects both lean and fat mass, which has been shown to be more closely related to high BP than BMI. ABSI as a new body shape index has been used to predict CVD mortality in 4 European populations with HRs (95% CIs) per SD increase of 1.34 (1.26–1.44).[20] In this study, a positive association was also observed between ABSI and all cardiometabolic risk factors and CVDs both in univariate and multivariable models ($P<0.001$). However, in this study, ABSI did show this superiority over any other traditional obesity-related indices, which may be related to the distinct difference in body figures between Chinese and white people. Based on previous studies, the cutoff value of ≈0.5 for WHtR was considered properly for the Asian population.[40,43,44] Our study suggests a similar cutoff value (range, 0.49–0.52).

Study Strengths

The main strengths of the present study are the large size of the study population and standardized measures and high quality of data. We measured and compared detailed information of different anthropometric measurements of both the traditional and new-built indices in the same population, which presented a whole picture of the predictive values of all anthropometric parameters in a single Chinese population.

Study Limitations

Several limitations of the present study should be considered. First, our study used only baseline data from the PURE-China cohort, and cause and effect may not be inferred from this study alone. Our results only assessed the predictive abilities of anthropometric indices on prevalence and did not directly predict the prospective risk of cardiovascular events. Therefore, the results of the current study should be verified by further follow-up studies. In addition, we recognize that misclassification of disease diagnoses is a concern, as they were self-report and not further verified by medical record or available laboratory tests. This misclassification, however, was likely to be nondifferential, which led to an underestimation of reported associations.

Conclusions

This study suggests that there is a positive association of obesity-related anthropometric indices with cardiometabolic

risk factors and CVDs. WHtR appeared to be a better indicator of dyslipidemia, hyperglycemia, and CVD risk than BMI, WC, HC, WHR, and ABSI. A growing body of evidence supports that avoidance of abdominal obesity is the prioritized primary prevention strategy for CVDs, along with control of other major CVD risk factors.

Appendix

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References

1. Murray C, Lopez A. Alternative projections of mortality and disability by cause 1990–2020: Global Burden of Disease Study. *Lancet*. 1997;349:1498–1504.

2. Flegal KM, Graubard BI, Williamson DF, Gail MH. Cause-specific excess deaths associated with underweight, overweight, and obesity. *JAMA*. 2007;298:2028–2037.

3. Roth GA, Johnson C, Abajobir A, Abd-Allah F, Abera SF, Abyu G, Ahmed M, Aksut B, Alam T, Alam K, Alla F, Alvis-Guzman N, Amrock S, Ansari H, Ärnlöv J, Asayesh H, Atey TM, Avila-Burgos L, Awasthi A, Banerjee A, Barac A, Bärnighausen T, Barregard L, Bedi N, Belay Ketema E, Bennett D, Berhe G, Bhutta Z, Bitew S, Carapetis J, Carrero JJ, Malta DC, Castañeda-Orjuela CA, Castillo-Rivas J, Catalá-López F, Choi JY, Christensen H, Cirillo M, Cooper L Jr, Criqui M, Cundiff D, Damasceno A, Dandona L, Dandona R, Davletov K, Dharmaratne S, Dorairaj P, Dubey M, Ehrenkranz R, El Sayed Zaki M, Faraon EJA, Esteghamati A, Farid T, Farvid M, Feigin V, Ding EL, Fowkes G, Gebrehiwot T, Gillum R, Gold A, Gona P, Gupta R, Habtewold TD, Hafezi-Nejad N, Hailu T, Hailu GB, Hankey G, Hassen HY, Abate KH, Havmoeller R, Hay SI, Horino M, Hotez PJ, Jacobsen K, James S, Javanbakht M, Jeemon P, John D, Jonas J, Kalkonde Y, Karimkhani C, Kasaeian A, Khader Y, Khan A, Khang YH, Khera S, Khoja AT, Khubchandani J, Kim D, Kolte D, Kosen S, Krohn KJ, Kumar GA, Kwan GF, Lal DK, Larsson A, Linn S, Lopez A, Lotufo PA, El Razek HMA, Malekzadeh R, Mazidi M, Meier T, Meles KG, Mensah G, Meretoja A, Mezgebe H, Miller T, Mirrakhimov E, Mohammed S, Moran AE, Musa KI, Narula J, Neal B, Ngalesoni F, Nguyen G, Obermeyer CM, Owolabi M, Patton G, Pedro J, Qato D, Qorbani M, Rahimi K, Rai RK, Rawaf S, Ribeiro A, Safiri S, Salomon JA, Santos I, Santric Milicevic M, Sartorius B, Schutte A, Sepanlou S, Shaikh MA, Shin MJ, Shishehbor M, Shore H, Silva DAS, Sobngwi E, Stranges S, Swaminathan S, Tabarés-Seisdedos R, Tadele Atnafu N, Tesfay F, Thakur JS, Thrift A, Topor-Madry R, Truelsen T, Tyrovolas S, Ukwaja KN, Uthman O, Vasankari T, Vlassov V, Vollset SE, Wakayo T, Watkins D, Weintraub R, Werdecker A, Westerman R, Wiysonge CS, Wolfe C, Workicho A, Xu G, Yano Y, Yip P, Yonemoto N, Younis M, Yu C, Vos T, Naghavi M, Murray C. Global, regional, and national burden of cardiovascular diseases for 10 causes, 1990 to 2015. *J Am Coll Cardiol*. 2017;70:1–25.

4. Global, regional, and national incidence, prevalence, and years lived with disability for 328 diseases and injuries for 195 countries, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet*. 2017;390:1211–1259.

5. Hubert HB, Feinleib M, McNamara PM, Castelli WP. Obesity as an independent risk factor for cardiovascular disease: a 26-year follow-up of participants in the Framingham Heart Study. *Circulation*. 1983;67:968–977.

6. Gregg EW, Shaw JE. Global health effects of overweight and obesity. *N Engl J Med*. 2017;377:80–81.

7. GBD 2015 Obesity Collaborators, Afshin A, Forouzanfar MH, Reitsma MB, Sur P, Estep K, Lee A, Marczak L, Mokdad AH, Moradi-Lakeh M, Naghavi M, Salama JS, Vos T, Abate KH, Abbafati C, Ahmed MB, Al-Aly Z, Alkerwi A, Al-Raddadi R, Amare AT, Amberbir A, Amegah AK, Amini E, Amrock SM, Anjana RM, Ärnlöv J, Asayesh H, Banerjee A, Barac A, Baye E, Bennett DA, Beyene AS, Biadgilign S, Biryukov S, Bjertness E, Boneya DJ, Campos-Nonato I, Carrero JJ, Cecilio P, Cercy K, Ciobanu LG, Cornaby L, Damtew SA, Dandona L, Dandona R, Dharmaratne SD, Duncan BB, Eshrati B, Esteghamati A, Feigin VL, Fernandes JC, Fürst T, Gebrehiwot TT, Gold A, Gona PN, Goto A, Habtewold TD, Hadush KT, Hafezi-Nejad N, Hay SI, Horino M, Islami F, Kamal R, Kasaeian A, Katikireddi SV, Kengne AP, Kesavachandran CN, Khader YS, Khang YH, Khubchandani J, Kim D, Kim YJ, Kinfu Y, Kosen S, Ku T, Defo BK, Kumar GA, Larson HJ, Leinsalu M, Liang X, Lim SS, Liu P, Lopez AD, Lozano R, Majeed A, Malekzadeh R, Malta DC, Mazidi M, McAlinden C, McGarvey ST, Mengistu DT, Mensah GA, Mensink GBM, Mezgebe HB, Mirrakhimov EM, Mueller UO, Noubiap JJ, Obermeyer CM, Ogbo FA, Owolabi MO, Patton GC, Pourmalek F, Qorbani M, Rafay A, Rai RK, Ranabhat CL, Reinig N, Safiri S, Salomon JA, Sanabria JR, Santos IS, Sartorius B, Sawhney M, Schmidhuber J, Schutte AE, Schmidt MI, Sepanlou SG, Shamsizadeh M, Sheikhbahaei S, Shin MJ, Shiri R, Shiue I, Roba HS, Silva DAS, Silverberg JI, Singh JA, Stranges S, Swaminathan S, Tabarés-Seisdedos R, Tadese F, Tedla BA, Tegegne BS, Terkawi AS, Thakur JS, Tonelli M, Topor-Madry R, Tyrovolas S, Ukwaja KN, Uthman OA, Vaezghasemi M, Vasankari T, Vlassov VV, Vollset SE, Weiderpass E, Werdecker A, Wesana J, Westerman R, Yano Y, Yonemoto N, Yonga G, Zaidi Z, Zenebe ZM, Zipkin B, Murray CJL. Health effects of overweight and obesity in 195 countries over 25 years. *N Engl J Med*. 2017;377:13–27.

8. Epidemiology Report of Chronic Diseases in Ministry of Health of China. 2012.

9. Obesity: preventing and managing the global epidemic. Report of a WHO Consultation. *World Health Organ Tech Rep Ser*. 2000;894:i–xii, 1-253.

10. Choo V. WHO reassesses appropriate body-mass index for Asian populations. *Lancet*. 2002;360:235.

11. Schneider H, Glaesmer H, Klotsche J, Böhler S, Lehnert H, Zeiher A, März W, Pittrow D, Stalla GK, Wittchen HU. Accuracy of anthropometric indicators of obesity to predict cardiovascular risk. *J Clin Endocrinol Metab*. 2007;92:589–594.

12. Kelishadi R, Gheiratmand R, Ardalan G, Adeli K, Mehdi Gouya M, Mohammad Razaghi E, Majdzadeh R, Delavari A, Shariatinejad K, Motaghian M, Heshmat R, Heidarzadeh A, Barekati H, Sadat Mahmoud-Arabi M, Mehdi Riazi M. Association of anthropometric indices with cardiovascular disease risk factors among children and adolescents: CASPIAN Study. *Int J Cardiol*. 2007;117:340–348.

13. Kidy F, Dhalwani N, Harrington D, Gray L, Bodicoat D, Webb D, Davies MJ, Khunti K. Associations between anthropometric measurements and cardiometabolic risk factors in white European and South Asian adults in the United Kingdom. *Mayo Clin Proc*. 2017;92:925–933.

14. Newby P, Dickman P, Adami H, Wolk A. Early anthropometric measures and reproductive factors as predictors of body mass index and obesity among older women. *Int J Obes (Lond)*. 2005;29:1084–1092.

15. Carlsson A, Risérus U, Engström G, Ärnlöv J, Melander O, Leander K, Gigante B, Hellénius ML, de Faire U. Novel and established anthropometric measures and the prediction of incident cardiovascular disease: a cohort study. *Int J Obes (Lond)*. 2013;37:1579–1585.

16. Ashwell M, Gunn P, Gibson S. Waist-to-height ratio is a better screening tool than waist circumference and BMI for adult cardiometabolic risk factors: systematic review and meta-analysis. *Obes Rev*. 2012;13:275–286.

17. Lo K, Wong M, Khalechelvam P, Tam W. Waist-to-height ratio, body mass index and waist circumference for screening paediatric cardio-metabolic risk factors: a meta-analysis. *Obes Rev*. 2016;17:1258–1275.

18. Krakauer NY, Krakauer JC. A new body shape index predicts mortality hazard independently of body mass index. *PLoS One*. 2012;7:e39504.

19. Song X, Jousilahti P, Stehouwer CD, Soderberg S, Onat A, Laatikainen T, Yudkin JS, Dankner R, Morris R, Tuomilehto J, Qiao Q. Cardiovascular and all-cause mortality in relation to various anthropometric measures of obesity in Europeans. *Nutr Metab Cardiovasc Dis*. 2015;25:295–304.

20. Song X, Jousilahti P, Stehouwer CD, Soderberg S, Onat A, Laatikainen T, Yudkin JS, Dankner R, Morris R, Tuomilehto J, Qiao Q. Comparison of various surrogate obesity indicators as predictors of cardiovascular mortality in four European populations. *Eur J Clin Nutr*. 2013;67:1298–1302.

21. Dhana K, Ikram M, Hofman A, Franco O, Kavousi M. Anthropometric measures in cardiovascular disease prediction: comparison of laboratory-based versus non-laboratory-based model. *Heart*. 2015;101:377–383.

22. Cheung YB. "A Body Shape Index" in middle-age and older Indonesian population: scaling exponents and association with incident hypertension. *PLoS One*. 2014;9:e85421.

23. Wang H, Liu A, Zhao T, Gong X, Pang T, Zhou Y, Xiao Y, Yan Y, Fan C, Teng W, Lai Y, Shan Z. Comparison of anthropometric indices for predicting the risk of metabolic syndrome and its components in Chinese adults: a prospective, longitudinal study. *BMJ Open*. 2017;7:e016062.

24. Sardarinia M, Ansari R, Azizi F, Hadaegh F, Bozorgmanesh M. Mortality prediction of a body shape index versus traditional anthropometric measures in an Iranian population: Tehran Lipid and Glucose Study. *Nutrition*. 2017;33:105–112.

25. Corsi DJ, Subramanian SV, Chow CK, McKee M, Chifamba J, Dagenais G, Diaz R, Iqbal R, Kelishadi R, Kruger A, Lanas F, López-Jaramilo P, Mony P, Mohan V, Avezum A, Oguz A, Rahman MO, Rosengren A, Szuba A, Li W, Yusoff K, Yusufali A, Rangarajan S, Teo K, Yusuf S. Prospective Urban Rural Epidemiology (PURE) study: baseline characteristics of the household sample and comparative analyses with national data in 17 countries. *Am Heart J*. 2013;166:636–646.e4.

26. Chow CK, Teo KK, Rangarajan S, Islam S, Gupta R, Avezum A, Bahonar A, Chifamba J, Dagenais G, Diaz R, Kazmi K, Lanas F, Wei L, Lopez-Jaramillo P, Fanghong L, Ismail NH, Puoane T, Rosengren A, Szuba A, Temizhan A, Wielgosz A, Yusuf R, Yusufali A, McKee M, Liu L, Mony P, Yusuf S. Prevalence, awareness, treatment, and control of hypertension in rural and urban communities in high-, middle-, and low-income countries. *JAMA*. 2013;310:959–968.

27. Teo K, Lear S, Islam S, Mony P, Dehghan M, Li W, Rosengren A, Lopez-Jaramillo P, Diaz R, Oliveira G, Miskan M, Rangarajan S, Iqbal R, Ilow R, Puone T, Bahonar A, Gulec S, Darwish EA, Lanas F, Vijaykumar K, Rahman O, Chifamba J, Hou Y, Li N, Yusuf S. Prevalence of a healthy lifestyle among individuals with cardiovascular disease in high-, middle- and low-income countries: the Prospective Urban Rural Epidemiology (PURE) study. *JAMA*. 2013;309:1613–1621.

28. Li W, Gu H, Teo KK, Bo J, Wang Y, Yang J, Wang X, Zhang H, Sun Y, Jia X, He X, Zhao X, Cheng X, Li J, Rangarajan S, Chen C, Yusuf S, Liu L. Hypertension prevalence, awareness, treatment, and control in 115 rural and urban communities involving 47 000 people from China. *J Hypertens*. 2016;34:39–46.

29. Yan R, Li W, Yin L, Wang Y, Bo J; PURE-China Investigators. Cardiovascular diseases and risk-factor burden in urban and rural communities in high-, middle-, and low-income regions of China: a large community-based epidemiological study. *J Am Heart Assoc*. 2017;6:e004445. DOI: 10.1161/JAHA.116.004445

30. Yan R, Wang Y, Bo J, Li W. Healthy lifestyle behaviors among individuals with chronic obstructive pulmonary disease in urban and rural communities in China: a large community-based epidemiological study. *Int J Chron Obstruct Pulmon Dis*. 2017;12:3311–3321.

31. Craig CL, Marshall AL, Sjostrom M, Bauman AE, Booth ML, Ainsworth BE, Ainsworth BE, Pratt M, Ekelund U, Yngve A, Sallis JF, Oja P. International physical activity questionnaire: 12-country reliability and validity. *Med Sci Sports Exerc*. 2003;35:1381–1395.

32. Kelemen LE, Anand SS, Vuksan V, Yi Q, Teo KK, Devanesen S, Yusuf S; SHARE Investigators. Development and evaluation of cultural food frequency questionnaires for South Asians, Chinese, and Europeans in North America. *J Am Diet Assoc*. 2003;103:1178–1184.

33. Dehghan M, Ilow R, Zatonska K, Szuba A, Zhang X, Mente A, Regulska-Ilow B. Development, reproducibility and validity of the food frequency questionnaire in the Poland arm of the Prospective Urban and Rural Epidemiological (PURE) study. *J Hum Nutr Diet*. 2012;25:225–232.

34. Liu LS. [2016 Chinese guideline for the management of dyslipidemia in adults]. *Zhonghua Xin Xue Guan Bing Za Zhi*. 2016;44:833–853.

35. Liu LS. [2010 Chinese guidelines for the management of hypertension]. *Zhonghua Xin Xue Guan Bing Za Zhi*. 2011;39:579–615.

36. Alberti KG, Zimmet PZ. Definition, diagnosis and classification of diabetes mellitus and its complications. Part 1: diagnosis and classification of diabetes mellitus provisional report of a WHO consultation. *Diabet Med*. 1998;15:539–553.

37. Yang L, Kuper H, Weiderpass E. Anthropometric characteristics as predictors of coronary heart disease in women. *J Intern Med*. 2008;264:39–49.

38. de Koning L, Gerstein H, Bosch J, Diaz R, Mohan V, Dagenais G, Yusuf S, Anand SS. Anthropometric measures and glucose levels in a large multi-ethnic cohort of individuals at risk of developing type 2 diabetes. *Diabetologia*. 2010;53:1322–1330.

39. Jiang J, Deng S, Chen Y, Liang S, Ma N, Xu Y, Chen X, Cao X, Song C, Nie W, Wang K. Comparison of visceral and body fat indices and anthropometric measures in relation to untreated hypertension by age and gender among Chinese. *Int J Cardiol*. 2016;219:204–211.

40. Hadaegh F, Zabetian A, Sarbakhsh P, Khalili D, James W, Azizi F. Appropriate cutoff values of anthropometric variables to predict cardiovascular outcomes: 7.6 years follow-up in an Iranian population. *Int J Obes (Lond)*. 2009;33:1437–1445.

41. Cai L, Liu A, Zhang Y, Wang P. Waist-to-height ratio and cardiovascular risk factors among Chinese adults in Beijing. *PLoS One*. 2013;8:e69298.

42. Jian S, Su-Mei N, Xue C, Jie Z, Xue-Sen W. Association and interaction between triglyceride-glucose index and obesity on risk of hypertension in middle-aged and elderly adults. *Clin Exp Hypertens*. 2017;39:732–739.

43. Hsieh SD, Yoshinaga H. Waist/height ratio as a simple and useful predictor of coronary heart disease risk factors in women. *Intern Med*. 1995;34:1147–1152.

44. Hsieh SD, Yoshinaga H. Abdominal fat distribution and coronary heart disease risk factors in men-waist/height ratio as a simple and useful predictor. *Int J Obes Relat Metab Disord*. 1995;19:585–589.

SUPPLEMENTAL MATERIAL

Table S1. Crude and adjusted ORs (per 1 SD increase) for cardiometabolic risk factors and cardiovascular diseases in relation to anthropometric indices.

Outcomes[*]	Model 1 OR (95% CI) [†] (N=44048)	Model 2 OR (95% CI) [‡] (N= 43940)	Model 3 OR (95% CI) [§] (N= 40543)
Dyslipidemia[‖]			
BMI	1.556 (1.522, 1.591)	1.529 (1.495, 1.564)	1.529 (1.494, 1.566)
WC	1.671 (1.637, 1.705)	1.651 (1.616, 1.687)	1.660 (1.623, 1.698)
HC	1.454 (1.425, 1.483)	1.434 (1.404, 1.464)	1.441 (1.409, 1.473)
WHR	1.513 (1.482, 1.546)	1.553 (1.517, 1.589)	1.560 (1.523, 1.599)
WHtR	1.699 (1.665, 1.735)	1.678 (1.642, 1.715)	1.687 (1.649, 1.726)
ABSI	1.333 (1.307, 1.360)	1.285 (1.259, 1.313)	1.294 (1.265, 1.323)
Abnormal BP[#]			
BMI	1.842 (1.797, 1.888)	1.736 (1.691, 1.783)	1.751 (1.703, 1.800)
WC	1.893 (1.846, 1.940)	1.808 (1.760, 1.858)	1.823 (1.772, 1.876)
HC	1.523 (1.488, 1.559)	1.552 (1.513, 1.592)	1.561 (1.520, 1.604)
WHR	1.721 (1.678, 1.765)	1.554 (1.511, 1.597)	1.566 (1.521, 1.612)
WHtR	1.842 (1.791, 1.894)	1.883 (1.828, 1.939)	1.876 (1.819, 1.935)
ABSI	1.340 (1.310, 1.371)	1.150 (1.122, 1.178)	1.159 (1.130, 1.189)
Hyperglycemia[**]			
BMI	1.321 (1.293, 1.348)	1.323 (1.295, 1.351)	1.313 (1.284, 1.342)
WC	1.356 (1.330, 1.383)	1.335 (1.307, 1.363)	1.333 (1.304, 1.363)
HC	1.206 (1.183, 1.230)	1.210 (1.186, 1.236)	1.208 (1.182, 1.235)
WHR	1.317 (1.290, 1.344)	1.279 (1.251, 1.307)	1.280 (1.251, 1.309)

WHtR	1.384 (1.357, 1.412)	1.345 (1.318, 1.374)	1.343 (1.314, 1.372)
ABSI	1.136 (1.114, 1.158)	1.065 (1.043, 1.087)	1.070 (1.047, 1.094)
CVDs			
BMI	1.215 (1.178, 1.253)	1.186 (1.148, 1.226)	1.183 (1.143, 1.224)
WC	1.412 (1.360, 1.467)	1.316 (1.265, 1.368)	1.321 (1.267, 1.377)
HC	1.369 (1.317, 1.422)	1.323 (1.271, 1.377)	1.324 (1.268, 1.382)
WHR	1.204 (1.164, 1.245)	1.181 (1.139, 1.225)	1.186 (1.141, 1.232)
WHtR	1.495 (1.441, 1.552)	1.363 (1.309, 1.419)	1.371 (1.314, 1.431)
ABSI	1.329 (1.280, 1.380)	1.183 (1.137, 1.231)	1.190 (1.141, 1.242)

* BMI: body mass index; WC: waist circumference; HC: hip circumference; WHR: waist-to-hip ratio;

WHtR: waist-to-height ratio; ABSI: a body shape index; Abnormal BP: abnormal blood pressure; CVDs:

coronary heart disease or heart failure or other cardiovascular diseases (arrhythmia, valvular heart disease,

cardiomyopathy and myocarditis).

† Model 1: Crude model;

‡Model 2: Adjusted for socio-demographic characteristics (age, sex, regions, location and education levels);

§ Model 3: Adjusted for socio-demographic (age, sex, regions, location and education levels), lifestyle

(physical activity and daily energy intake) and medical history characteristics (family history of coronary heart

disease or heart failure or other cardiovascular diseases);

||Dyslipidemia: total cholesterol≥5.2 mmol/L or low-density lipoprotein cholesterol≥3.4 mmol/L or high-density

lipoprotein cholesterol≤1.0 mmol/L or triglycerides≥1.7 mmol/L;

Abnormal blood pressure: Self-reported hypertension or SBP≥120 mmHg and/or DBP≥80 mmHg;

** Hyperglycemia: Self-reported diabetes or fasting blood glucose level≥ 5.6 mmol/L.

Table S2. AUCs* and optimal cut points for anthropometric measurements in relation to cardiometabolic risk factors and cardiovascular diseases (N=40543).

Outcomes[†]	AUC[‡] (95% CI)	Cut-off point	Sensitivity	Specificity	Youden Index
Dyslipidemia[§]					
BMI	0.628(0.622, 0.633)	23.55	0.68	0.49	0.19
WC	0.642(0.637, 0.647)	79.50	0.65	0.44	0.21
HC	0.607(0.601, 0.612)	94.35	0.56	0.41	0.16
WHR	0.618(0.613, 0.623)	0.85	0.62	0.45	0.18
WHtR	0.647(0.641, 0.652)	0.49	0.65	0.44	0.22
ABSI	0.589(0.583, 0.594)	0.75	0.63	0.49	0.14
Abnormal BP[‖]					
BMI	0.652(0.646, 0.659)	23.58	0.64	0.41	0.23
WC	0.672(0.666, 0.678)	78.20	0.66	0.40	0.26
HC	0.623(0.617, 0.629)	94.60	0.52	0.33	0.19
WHR	0.650(0.644, 0.657)	0.84	0.67	0.44	0.23
WHtR	0.664(0.658, 0.670)	0.50	0.60	0.36	0.24
ABSI	0.599(0.592, 0.605)	0.75	0.59	0.44	0.15
Hyperglycemia[#]					
BMI	0.588(0.583, 0.594)	23.87	0.64	0.50	0.14
WC	0.585(0.580, 0.591)	80.40	0.60	0.46	0.13
HC	0.552(0.546, 0.558)	92.05	0.66	0.58	0.08
WHR	0.582(0.577, 0.588)	0.90	0.35	0.22	0.12

WHtR	0.593(0.588, 0.599)	0.50	0.60	0.45	0.15
ABSI	0.540(0.535, 0.546)	0.75	0.64	0.57	0.07
CVDs					
BMI	0.577(0.565, 0.589)	25.56	0.47	0.36	0.11
WC	0.603(0.591, 0.615)	82.50	0.59	0.43	0.15
HC	0.590(0.579, 0.602)	95.05	0.58	0.44	0.13
WHR	0.570(0.560, 0.584)	0.87	0.57	0.47	0.10
WHtR	0.622(0.611, 0.634)	0.52	0.59	0.41	0.18
ABSI	0.594(0.582, 0.601)	0.77	0.53	0.39	0.14

*AUC = area under the receiver operating characteristic curve;

† BMI: body mass index; WC: waist circumference; HC: hip circumference; WHR: waist-to-hip ratio; WHtR: waist-to-height ratio; ABSI: a body shape index; Abnormal BP: abnormal blood pressure; CVDs: coronary heart disease or heart failure or other cardiovascular diseases (arrhythmia, valvular heart disease, cardiomyopathy and myocarditis);

‡Models adjusted for socio-demographic (age, sex, regions, location and education levels), lifestyle (physical activity and daily energy intake) and medical history characteristics (family history of coronary heart disease or heart failure or other cardiovascular diseases);

§ Dyslipidemia: total cholesterol≥5.2 mmol/L or low-density lipoprotein cholesterol≥3.4 mmol/L or high-density lipoprotein cholesterol≤1.0 mmol/L or triglycerides≥1.7 mmol/L;

|| Abnormal blood pressure: Self-reported hypertension or SBP≥120 mmHg and/or DBP≥80 mmHg;

Hyperglycemia: Self-reported diabetes or fasting blood glucose level≥ 5.6 mmol/L.

Table S3. Adjusted ORs (per 1 SD increase) for cardiometabolic risk factors in relation to anthropometric measurements, stratified by sex and age groups (N=40543).

Outcomes*	Sex[†]		Age groups [†]	
	Male(N=16729)	Female (N=23814)	35≤Age<65 years(N=36520)	Age≥65 years (N=4023)
Dyslipidemia[‡]				
BMI	1.740 (1.673, 1.811)	1.374 (1.334, 1.416)	1.550 (1.512, 1.589)	1.321 (1.228, 1.420)
WC	1.861 (1.792, 1.932)	1.487 (1.445, 1.530)	1.686 (1.646, 1.726)	1.429 (1.335, 1.529)
HC	1.618 (1.559, 1.678)	1.310 (1.274, 1.348)	1.449 (1.415, 1.483)	1.383 (1.288, 1.484)
WHR	1.700 (1.633, 1.769)	1.404 (1.361, 1.449)	1.582 (1.542, 1.623)	1.329 (1.235, 1.430)
WHtR	1.859 (1.792, 1.928)	1.512 (1.467, 1.558)	1.711 (1.670, 1.752)	1.470 (1.370, 1.576)
ABSI	1.383 (1.332, 1.436)	1.194 (1.161, 1.228)	1.306 (1.275, 1.337)	1.201 (1.126, 1.281)
Abnormal BP[§]				
BMI	1.834 (1.749, 1.924)	1.660 (1.604, 1.719)	1.839 (1.636, 2.067)	1.742 (1.693, 1.792)
WC	1.863 (1.778, 1.951)	1.749 (1.686, 1.814)	1.821 (1.769, 1.875)	1.812 (1.607, 2.042)
HC	1.618 (1.547, 1.693)	1.497 (1.447, 1.549)	1.555 (1.512, 1.598)	1.676 (1.485, 1.892)
WHR	1.629 (1.551, 1.711)	1.480 (1.427, 1.535)	1.564 (1.518, 1.612)	1.533 (1.357, 1.733)
WHtR	2.021 (1.916, 2.131)	1.766 (1.700, 1.835)	2.261 (1.969, 2.597)	1.859 (1.801, 1.919)
ABSI	1.192 (1.141, 1.246)	1.108 (1.073, 1.144)	1.164 (1.134, 1.195)	1.025 (0.924, 1.138)
Hyperglycemia[‖]				
BMI	1.377 (1.329, 1.426)	1.245 (1.211, 1.280)	1.315 (1.284, 1.346)	1.197 (1.124, 1.275)
WC	1.344 (1.299, 1.391)	1.291 (1.255, 1.327)	1.348 (1.317, 1.380)	1.183 (1.108, 1.263)
HC	1.256 (1.213, 1.301)	1.160 (1.128, 1.193)	1.219 (1.192, 1.248)	1.103 (1.033, 1.178)

WHR	1.259 (1.214, 1.306)	1.257 (1.220, 1.295)	1.286 (1.255, 1.318)	1.192 (1.112, 1.277)
WHtR	1.396 (1.345, 1.448)	1.292 (1.254, 1.330)	1.358 (1.327, 1.390)	1.249 (1.167, 1.337)
ABSI	1.055 (1.026, 1.085)	1.050 (1.013, 1.088)	1.087 (1.062, 1.113)	0.965 (0.908, 1.026)
CVDs				
BMI	1.271 (1.192, 1.356)	1.141 (1.094, 1.189)	1.204 (1.107, 1.309)	1.175 (1.130, 1.220)
WC	1.473 (1.363, 1.593)	1.245 (1.183, 1.309)	1.341 (1.279, 1.406)	1.237 (1.130, 1.353)
HC	1.418 (1.312, 1.533)	1.269 (1.205, 1.337)	1.324 (1.261, 1.390)	1.284 (1.169, 1.411)
WHR	1.275 (1.195, 1.361)	1.128 (1.075, 1.185)	1.195 (1.146, 1.246)	1.123 (1.017, 1.240)
WHtR	1.507 (1.398, 1.625)	1.289 (1.222, 1.359)	1.391 (1.325, 1.460)	1.308 (1.190, 1.437)
ABSI	1.286 (1.190, 1.390)	1.137 (1.080, 1.196)	1.231 (1.172, 1.293)	1.086 (0.994, 1.186)

*BMI: body mass index; WC: waist circumference; HC: hip circumference; WHR: waist-to-hip ratio;

WHtR: waist-to-height ratio; ABSI: a body shape index; Abnormal BP: abnormal blood pressure; CVDs: coronary

heart disease or heart failure or other cardiovascular diseases (arrhythmia, valvular heart disease, cardiomyopathy

and myocarditis);

† Models adjusted for socio-demographic (age, sex, regions, location and education levels), lifestyle (physical

activity and daily energy intake) and medical history characteristics (family history of coronary heart disease or

heart failure or other cardiovascular diseases);

‡ Dyslipidemia: total cholesterol≥5.2 mmol/L or low-density lipoprotein cholesterol≥3.4 mmol/L or high-density

lipoprotein cholesterol≤1.0 mmol/L or triglycerides≥1.7 mmol/L;

§ Abnormal blood pressure: Self-reported hypertension or SBP≥120 mmHg and/or DBP≥80 mmHg;

|| Hyperglycemia: Self-reported diabetes or fasting blood glucose level≥ 5.6 mmol/L.

Table S4. AUCs[*] and optimal cut points for anthropometric measurements in relation to cardiometabolic risk factors and cardiovascular diseases, stratified by sex.

Outcomes[†]	Male (N=16729)					Female (N=23814)				
	AUC[‡] (95% CI)	Cut-off point	Sensitivity	Specificity	Youden Index	AUC[‡] (95% CI)	Cut-off point	Sensitivity	Specificity	Youden Index
Dyslipidemia[§]										
BMI	0.607 (0.600,0.614)	23.51	0.71	0.47	0.24	0.658 (0.650,0.666)	23.87	0.63	0.47	0.16
WC	0.628 (0.621,0.635)	82.45	0.68	0.43	0.25	0.670 (0.662,0.678)	78.0	0.63	0.43	0.20
HC	0.584 (0.577,0.592)	94.15	0.61	0.41	0.20	0.639 (0.631,0.647)	94.3	0.54	0.41	0.13
WHR	0.615 (0.608,0.622)	0.87	0.71	0.49	0.22	0.645 (0.636,0.653)	0.84	0.59	0.42	0.17
WHtR	0.635 (0.628,0.642)	0.49	0.70	0.45	0.25	0.664 (0.656,0.672)	0.51	0.54	0.34	0.20
ABSI	0.589 (0.582,0.596)	0.76	0.70	0.55	0.14	0.592 (0.584,0.601)	0.74	0.63	0.50	0.14
Abnormal BP[‖]										
BMI	0.656 (0.648,0.663)	23.71	0.61	0.38	0.24	0.653 (0.642,0.663)	23.64	0.64	0.41	0.23

WC	0.652 (0.641,0.662)	81.95	0.63	0.39	0.23	0.669 (0.662,0.677)	77.85	0.61	0.35	0.26
HC	0.629 (0.618,0.639)	93.15	0.61	0.42	0.19	0.620 (0.612,0.627)	94.60	0.51	0.33	0.18
WHR	0.623 (0.612,0.634)	0.88	0.63	0.43	0.20	0.647 (0.639,0.655)	0.83	0.62	0.40	0.23
WHtR	0.652 (0.642,0.663)	0.48	0.70	0.47	0.23	0.675 (0.668,0.683)	0.50	0.62	0.36	0.26
ABSI	0.571 (0.560,0.582)	0.76	0.65	0.54	0.11	0.596 (0.588,0.604)	0.75	0.54	0.39	0.15

Hyperglycemia[#]

BMI	0.593 (0.585,0.602)	24.28	0.59	0.44	0.15	0.585 (0.578,0.593)	23.87	0.64	0.50	0.14
WC	0.579 (0.570,0.587)	83.05	0.61	0.49	0.12	0.588 (0.581,0.596)	79.05	0.57	0.44	0.14
HC	0.555 (0.546,0.564)	92.05	0.68	0.59	0.09	0.549 (0.542,0.557)	91.25	0.69	0.62	0.07
WHR	0.577 (0.568,0.586)	0.90	0.47	0.32	0.14	0.586 (0.579,0.593)	0.87	0.40	0.27	0.13
WHtR	0.587 (0.579,0.596)	0.50	0.58	0.44	0.14	0.599 (0.592,0.607)	0.50	0.61	0.46	0.15
ABSI	0.521 (0.512,0.530)	0.76	0.63	0.58	0.04	0.549 (0.542,0.557)	0.749	0.57	0.49	0.08

CVDs

	AUC (95% CI)					AUC (95% CI)				
BMI	0.594 (0.574,0.613)	25.92	0.44	0.31	0.13	0.568 (0.553,0.582)	25.57	0.47	0.36	0.11
WC	0.630 (0.611,0.649)	88.05	0.51	0.33	0.18	0.608 (0.594,0.622)	82.25	0.52	0.36	0.16
HC	0.608 (0.588,0.627)	95.05	0.61	0.46	0.15	0.582 (0.568,0.597)	95.15	0.55	0.42	0.13
WHR	0.606 (0.586,0.625)	0.90	0.58	0.44	0.14	0.588 (0.573,0.602)	0.85	0.53	0.40	0.13
WHtR	0.632 (0.612,0.650)	0.52	0.58	0.39	0.19	0.615 (0.601,0.629)	0.52	0.56	0.38	0.18
ABSI	0.611 (0.591,0.631)	0.78	0.59	0.43	0.16	0.602 (0.588,0.617)	0.76	0.54	0.38	0.16

*AUC = area under the receiver operating characteristic curve;

† BMI: body mass index; WC: waist circumference; HC: hip circumference; WHR: waist-to-hip ratio;

WHtR: waist-to-height ratio; ABSI: a body shape index; Abnormal BP: abnormal blood pressure; CVDs: coronary heart disease or heart failure or other cardiovascular diseases (arrhythmia,

valvular heart disease, cardiomyopathy and myocarditis);

‡ Models adjusted for socio-demographic (age, sex, regions, location and education levels), lifestyle (physical activity and daily energy intake) and medical history characteristics (family history of

coronary heart disease or heart failure or other cardiovascular diseases);

§ Dyslipidemia: total cholesterol≥5.2 mmol/L or low-density lipoprotein cholesterol≥3.4 mmol/L or high-density lipoprotein cholesterol≤1.0 mmol/L or triglycerides≥1.7 mmol/L;

|| Abnormal blood pressure: Self-reported hypertension or SBP≥120 mmHg and/or DBP≥80 mmHg;

Hyperglycemia: Self-reported diabetes or fasting blood glucose level≥ 5.6 mmol/L.

Table S5. AUCs* and optimal cut points for anthropometric measurements in relation to cardiometabolic risk factors and cardiovascular diseases, stratified by age groups.

	35≤Age<65 years (N=36520)					Age≥65 years (N=4023)				
	AUC‡	Cut-off			Youden	AUC‡	Cut-off			Youden
Outcomes†	(95% CI)	point	Sensitivity	Specificity	Index	(95% CI)	point	Sensitivity	Specificity	Index
Dyslipidemia§										
BMI	0.630 (0.625,0.636)	24.34	0.59	0.40	0.20	0.607 (0.589,0.625)	23.43	0.68	0.50	0.17
WC	0.646 (0.640,0.651)	79.50	0.65	0.43	0.22	0.593 (0.575,0.611)	77.70	0.76	0.61	0.15
HC	0.608 (0.602,0.614)	94.10	0.58	0.42	0.16	0.591 (0.572,0.608)	96.65	0.45	0.32	0.13
WHR	0.623 (0.618,0.629)	0.85	0.62	0.43	0.18	0.555 (0.537,0.573)	0.86	0.66	0.57	0.08
WHtR	0.648 (0.642,0.653)	0.49	0.64	0.43	0.22	0.619 (0.602,0.637)	0.51	0.68	0.50	0.18
ABSI	0.590 (0.585,0.596)	0.74	0.68	0.54	0.14	0.547 (0.529,0.565)	0.75	0.77	0.70	0.07
Abnormal BP‖										
BMI	0.653 (0.647,0.659)	23.60	0.64	0.41	0.23	0.692 (0.664,0.719)	23.60	0.64	0.41	0.23

WC	0.669 (0.663,0.675)	78.20	0.65	0.40	0.25	0.664 (0.635,0.693)	77.70	0.72	0.46	0.26
HC	0.622 (0.616,0.628)	94.20	0.54	0.36	0.19	0.648 (0.620,0.676)	93.0	0.62	0.39	0.23
WHR	0.648 (0.642,0.655)	0.84	0.66	0.43	0.23	0.610 (0.578,0.642)	0.83	0.78	0.57	0.21
WHtR	0.658 (0.652,0.665)	0.49	0.62	0.38	0.23	0.675 (0.647,0.704)	0.49	0.72	0.44	0.28
ABSI	0.592 (0.585,0.598)	0.75	0.61	0.47	0.14	0.545 (0.514,0.577)	0.78	0.52	0.42	0.10

Hyperglycemia[#]

BMI	0.590 (0.584,0.600)	23.87	0.64	0.50	0.14	0.583 (0.565,0.600)	23.22	0.70	0.56	0.15
WC	0.587 (0.581,0.593)	80.80	0.57	0.44	0.13	0.544 (0.526,0.562)	80.10	0.67	0.58	0.09
HC	0.554 (0.548,0.560)	92.05	0.66	0.58	0.08	0.528 (0.511,0.546)	90.05	0.76	0.70	0.07
WHR	0.583 (0.577,0.589)	0.90	0.34	0.21	0.12	0.541 (0.524,0.559)	0.87	0.60	0.52	0.08
WHtR	0.593 (0.587,0.599)	0.50	0.58	0.44	0.15	0.558 (0.540,0.575)	0.50	0.67	0.57	0.10
ABSI	0.540 (0.534,0.546)	0.75	0.62	0.56	0.07	0.520 (0.502,0.538)	7.46	0.63	0.56	0.07

CVDs

	AUC (95% CI)	Cut-off				AUC (95% CI)	Cut-off			
BMI	0.576 (0.562,0.589)	25.65	0.46	0.35	0.12	0.587 (0.562,0.612)	23.08	0.76	0.63	0.14
WC	0.600 (0.586,0.612)	82.05	0.59	0.44	0.15	0.583 (0.558,0.608)	85.60	0.52	0.34	0.13
HC	0.584 (0.570,0.597)	95.05	0.57	0.44	0.12	0.603 (0.579,0.628)	95.10	0.61	0.46	0.16
WHR	0.574 (0.560,0.587)	0.88	0.49	0.38	0.11	0.522 (0.496,0.548)	0.85	0.69	0.63	0.06
WHtR	0.617 (0.604,0.630)	0.52	0.57	0.39	0.18	0.587 (0.561,0.612)	0.52	0.63	0.50	0.13
ABSI	0.590 (0.577,0.603)	0.77	0.50	0.37	0.13	0.530 (0.504,0.556)	0.78	0.58	0.51	0.07

*AUC = area under the receiver operating characteristic curve;

† BMI: body mass index; WC: waist circumference; HC: hip circumference; WHR: waist-to-hip ratio;

WHtR: waist-to-height ratio; ABSI: a body shape index; Abnormal BP: abnormal blood pressure; CVDs: coronary heart disease or heart failure or other cardiovascular diseases (arrhythmia,

valvular heart disease, cardiomyopathy and myocarditis);

‡ Models adjusted for socio-demographic (age, sex, regions, location and education levels), lifestyle (physical activity and daily energy intake) and medical history characteristics (family history

of coronary heart disease or heart failure or other cardiovascular diseases);

§ Dyslipidemia: total cholesterol≥5.2 mmol/L or low-density lipoprotein cholesterol≥3.4 mmol/L or high-density lipoprotein cholesterol≤1.0 mmol/L or triglycerides≥1.7 mmol/L;

|| Abnormal blood pressure: Self-reported hypertension or SBP≥120 mmHg and/or DBP≥80 mmHg;

Hyperglycemia: Self-reported diabetes or fasting blood glucose level≥ 5.6 mmol/L.