Comparison of Obesity-Related Parameters as Predictors of High Pulse Wave Velocity in Middle-Aged and Elderly People in China: A Multicenter Cross-Sectional Community-Based Study

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Research article

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Abstract

Background: The association between fat-related parameters and occurrence of high pulse wave velocity (PWV) in Chinese middle-aged and elderly people is unknown, especially when booy composition indicators are compared.

Methods: A total of 3219 middle-aged and elderly subjects who were recruited from 6 community health service centers located in Hefei, Bengbu, and Chuzhou met the inclusion criteria and had valid data. E-health promotion system was used to collect health basic data, and brachial-ankle pulse wave (baPWV) and body composition of each subject were measured. Partial correlation and binary logistic regression analyses were performed to identify associations between fat-related parameters and high PWV, and receiver operating characteristic curves were analyzed for optimal cutoff values and predictive capacity for high PWV.

Results: The highest partial correlation coefficients (adjusted for age) for waist-to-height ratio (WHtR) were in middle-aged women and elderly men (range, 0.1-0.31); and that for waist circumference (WC) were in elderly women and middle-aged men (range, 0.12-0.29). WHtR explained the largest proportion of variation for dependent variables, with an R^2 value ranging from 0.088 to 0.216 in Model 1; the beta of WC was slightly higher than that of WHtR in elderly women in Models 2 and 3. The predictive capacities of these parameters were lower in men. The area under the receiver operating characteristic curve was higher for WHtR (0.573–0.693) than for the other parameters in both men and women, with optimal cutoff values of 0.51-0.54.

Conclusions: WHtR and WC may be useful for community-based screening of women ≥40 years as a secondary preventative measure for high PWV. These 2 parameters can be used in conjunction with others (eg., body composition index) to predict the risk of high PWV based on region, age, and sex.

Introduction

The prevalence of overweight and obesity is increasing in China in line with the global trend; in 2016, there were more than 100 million obese people, making it the top-ranking country[1]. Compared to reference populations from 1992 to 2015, overweight and obesity have increased by 17% and 9%, respectively[2]. High body weight and inadequate body fat distribution are associated with chronic diseases such as hypertension, cardiovascular disease, metabolic syndrome, and type 2 diabetes mellitus [3, 4]. Physiologic changes caused by excess body fat include activation of the sympathetic nervous system and renin-angiotensin aldosterone system as well as endothelial dysfunction, which can lead to hypertension[5]; and increased insulin resistance, hypertriglyceridemia, decreased levels of high-density lipoprotein cholesterol, and changes in leptin levels and blood pressure are directly linked to a higher risk of cardiovascular disease[6-10].

Pulse wave velocity (PWV) is proportional to the rigidity of the arterial wall[11]and is a marker for increased risk of progressive organ dysfunction (e.g., hypertension and decreased renal function) and the prognosis of cardiovascular diseases[12]. According to the Japanese Guidelines for Noninvasive Vascular Function Test (JCS2013), a brachial-ankle baPWV of 1400 cm/s is considered as the moderate risk threshold at which lifestyle modification is recommended. This level corresponds to a moderate Framingham risk score and represents the threshold at which the risk for incident hypertension is increased in normotensive individuals[13].

How to explore the relationship between obesity-related indices and pulse wave? Perhaps the first step is to know how to evaluate these indicators. Body fatness and overweight have been widely studied using body mass index (BMI), which is body weight divided by the square of height (kg/m^2) [3, 14]. However, a well-known disadvantage of BMI is that it does not differentiate between fat mass (FM) and fat-free mass (FFM), and does not take fat distribution into account [4, 15]. Analysis of body composition based on bioelectric impedance is a more useful approach for measuring fat distribution (both FM and FFM) [4]. However, it remains unclear whether BMI or body composition index is the best predictor of vascular elasticity. Another disadvantage of BMI is that it is not closely related to abdominal obesity, which better reflects visceral obesity status. Abdominal fat—i.e., surrounding the heart, liver, and kidneys—is as pathogenic as overall obesity, but is associated with a higher disease burden[11]. Visceral fat accumulation has adverse health effects, and increases the risk of cardiovascular disease to a greater extent than subcutaneous fat[3, 14-16]. In fact, waist-to-height ratio (WHtR) and waist circumference (WC) may be better indicators of abdominal obesity as they can be easily measured and can also reflect overall obesity[4]. In fact, WHtR and WC may be superior to BMI for predicting the risk of diabetes, hypertension, dyslipidemia, metabolic syndrome, and cardiovascular diseases[15, 16], although this is controversial[10, 17, 18]. The best index for predicting the occurrence of high PWV is unclear.

The relationship between fat-related parameters and risk of arteriosclerosis or hypertension varies according to sex and age. Aging reduces arterial elasticity and causes biochemical and histologic changes in arteries, resulting in increased internalization of visceral fats[6, 11, 19, 20]. Fat is differentially distributed in men and women[21], such that the prevalence of obesity is higher in the latter.

Despite the increasing rates of obesity in China, few studies to date have examined the association between fat-related parameters and incidence of high PWV in Chinese adults, especially by comparing all indicators. The present study was carried out in order to identify the parameter that best predicts high PWV in middle-aged and elderly Chinese subjects stratified by age and sex.

Methods

Study design

We used cross-sectional data obtained from a community-based study which in order to identify factors that influence non-communicable chronic diseases and investigate the effects of health promotion through artificial intelligence. Data (anthropometric and biochemical parameters, cardiovascular function, lifestyle, disease status, family history of disease, and mental health) were collected each year using an e-health promotion system.

Participants

We invited local residents to participate in the study through 6 community health service centers located in Anhui province (Hefei, Bengbu, and Chuzhou). A total of 4529 participants aged >18 years were surveyed between June 2018 and January 2020. Exclusion criteria were age <40 years (n=800); ankle-brachial index >1.4 or <0.89; cardiovascular diseases (n=350); insufficient data for baPWV (n=28) or body composition analysis (n=132). A total of 3219 subjects (1951 women and 1264 men; mean age±SD, 61.32±9.81 years) were ultimately included in the analysis. All subjects provided written, informed consent for their data to be used in the study, and the study protocol was approved by the Ethics Committee of Bengbu Medical College (Anhui, China; no. 2018045).

Data collection

All physical examinations were performed by trained medical staff or medical postgraduate students according to standardized procedures. Participants were questioned regarding health-related behaviors including cigarette and alcohol consumption and amount of physical activity. For cigarette consumption, total smoking during the subject's lifetime was calculated based on the quantity of cigarettes that were smoked and the weekly frequency; this was extended to consumption before quitting in the case of former smokers. The amounts of alcohol in one bottle of the most popular alcoholic beverages in Anhui province are as follows: beer (500 ml, 3.2% alcohol), 17.5 g; white liquor (450 ml, 42% alcohol), 210 g; and wine (750 ml, 13.5%–14% alcohol), 97.5 g. Daily alcohol consumption was calculated using these values. When data for cigarette and alcohol consumption were missing, a value of zero was assigned. Subjects were questioned about the type of physical activities in which they engaged, the duration of activity (minutes), and the frequency (per week). According to activity codes and metabolic equivalent (MET) intensities in the Compendium of Physical Activities[22], physical activity time was determined as minutes/MET/day and missing values were assigned the median value. Data on sleep disorder, kidney disease, diabetes, dietary salt preferences, and dietary fat content were collected through self-report questionnaires, and missing values were assigned a value of zero.

Anthropometric data

Anthropometric measurements including body height, weight, and WC were obtained while subjects were standing and wearing light clothing. Height was measured with steel tape, and weight was measured with a bioelectric impedance analyzer (Model BX-BCA-100; Institute of Intelligent Machines, Hefei, China). WC was measured above the iliac crest and below the lowest rib margin at minimum respiration using flexible leather tape as subjects were in the standing position. After obtaining the measurements, BMI and WHtR were calculated as the ratio of weight (kg)/height $(m)^2$ and WC (cm)/height (cm), respectively. There were no missing values in the anthropometric data.

Body composition measurements

Body composition parameters were measured using bioelectric impedance analyzer. The participants refrained from eating and drinking 3 h before measurements were performed, and were instructed to remove their socks and stand on the machine; electrodes were placed on both hands and feet, and the subjects were instructed to lift both arms upright and touch the electrodes with their hands. Fat-free mass(FFM), including lean tissue mass, total body water, were derived from the impedance data, and fat-free tissue index (FFTI; FFM/height^2), fat tissue index (FTI; FM/height^2), FFTI/FTI, and ratio of trunk fat to free mass (RTFFM; trunk FFM/trunk weight) were calculated.

Measurement of baPWV and definition of high PWV

BaPWV (m/s) was measured using an IIM-AS-100 system (Institute of Intelligent Machines), which recorded bilateral brachial and posterior tibial-artery pressure waveforms by an oscillometric method by means of cuffs placed on subjects' arms and ankles. baPWV was calculated automatically for each arterial segment as the path length divided by the corresponding time interval.

High PWV was defined according to the Japanese Guidelines for Noninvasive Vascular Function Test, which recommend lifestyle modifications for a baPWV value >14 m/s on one side, which indicates a high risk of hypertension onset in untreated normotensive individuals [13].

Statistical analysis

Data were analyzed using SPSS v23.0 software (IBM, Armonk, NY, USA). Continuous variables are expressed as mean±SD. The Student's t test for independent samples and Pearson's chi-squared test were used to assess the significance of differences in baseline characteristics between groups according to baPWV level stratified by sex and age.

Partial correlations (adjusted for age) between obesity-related parameters and baPWV were examined. Binary logistic regression models were used to identify obesity-related parameters that were independently associated with high PWV after adjusting for age, heart rate, systolic blood pressure (SBP), cigarette consumption, physical activity, and diabetes status.

Receiver operating characteristic (ROC) curves were analyzed to identify the optimal cutoff points and assess the predictive capacity of obesity-related parameters for occurrence of high PWV by age (40–59 years and ≥60 years) and sex, with sensitivity and specificity values reported. Optimal cutoff points for the parameters were determined according to the largest Youden's index value (sensitivity+specificity−1).

Results

Participant characteristicsaccording to baPWV stratified by age and sex

The characteristics of the study population are presented in Table 1. The mean age of the 3219 subjects was 61.32 years (range, 40–94 years), and 61.7% (n=1951) were women. Mean age, heart rate, SBP, and diastolic blood pressure were higher in subjects of both sexes and age categories with high PWV value (≥14 m/s) as well as those with self-reported diabetes, except in men aged ≥60 years (all P<0.05). The amount of physical activity was lower in women aged ≥60 years with high PWV (P<0.05). Statistically significant differences were observed between high and low PWV groups for WC, BMI, WHtR, FTI, and RTFFM in both age categories of women and men (≥60 years), and all of these values were higher in subjects with high PWV stratified by age and sex except for RTFFM, which was lower (all *P*<0.05).

Partial correlation between obesity-related parameters and PWV

Partial correlations (adjusted for age) between obesity-related parameters and baPWV are shown in Figure 1. WC, BMI, WHtR, FFTI, and FTI were positively correlated with PWV in women (both age groups) and men (aged ≥60 years) whereas RTFFM and FFTI/FTI were negatively correlated, with the latter only showing this trend in women (all *P*<0.05). The range of partial correlation coefficients of obesity-related parameters for the 4 groups were as follows: WC, 0.12 to 0.29; BMI, −0.04 to 0.22; WHtR, 0.1 to 0.31; FFTI, 0.06 to 0.22; FTI, −0.09 to 0.21; FFTI/FTI, −0.1 to 0.04; and RTFFM, −0.17 to 0.03. The partial correlation coefficients for WHtR were highest in women aged 40–59 years and men ≥60 years while the coefficients for WC were highest in the other 2 groups. Notably, the partial correlation coefficient for WC was slightly higher than that for WHtR in women aged ≥60 years.

Regression analyses

Associations between all obesity-related parameters and high PWV value were significant after adjusting for age in all subjects except for men aged 40–59 years; in this group, only WC and WHtR were significant (Table 2, Model 1). After adjusting for age, heart rate, and SBP (Model 2) and for age, heart rate, SBP, smoking status, amount of physical activity, and diabetes status (Model 3), the associations remained significant for WC and WHtR in women (both age groups), while only FFTI/FTI was significantly correlated with high PWV in men aged 40–59 years. In all statistically significant correlations, WHtR explained the largest proportion of the variance for dependent variables; R^2 ranged from 0.088 to 0.216 (beta range, 3.624–10.064) in Model 1, whereas the beta of WC was slightly higher than that of WHtR in women aged ≥60 years in Models 2 and 3.

Association between obesity-related parameters and high PWV by ROC curve analysis

Table 3 shows the areas under the ROC curve (AUCs) of WC, BMI, WHtR, FFTI, and FTI for predicting high PWV. All of these obesity-related parameters showed a reasonable predictive capacity for high PWV in women (all with 95% confidence interval [CI]>0.5). However, this capacity decreased for middle-aged and elderly men (95% CI<0.5), except in the case of WC and WHtR (95% CI>0.5 for both groups). The discriminatory power of WHtR for high PWV was stronger in women, and was approximately 69.3% (AUC=0.693; 95% CI: 0.647–0.739) and 66.7% (AUC=0.667; 95% CI: 0.631–0.704) in middle-aged and elderly women, respectively. The AUC for WHtR was significantly higher than for other parameters in both men and women (Fig. 2).

The cutoff values of the 5 obesity-related parameters with high PWV predictive capacity by ROC curve analysis are shown in Table 3. For middle-aged and elderly men, the optimal cutoff values for WC for predicting high PWV were 95.5 and 88.5 cm, respectively; for women, the value was 83.5 in both age groups. The optimal cutoff values for WHtR were 0.54 in middle-aged men, 0.55 in elderly men, 0.51 in middle-aged women, and 0.52 in elderly women; and the optimal cutoff values for BMI in middle-aged and elderly women were 24.08 and 23.57, respectively.

Discussion

The results of this study demonstrate that associations between obesity-related parameters and high PWV differed between sexes and age groups. In men of both age groups, WC and WHtR showed positive associations with PWV; in elderly men, all parameters showed positive associations except RTFFM. In women, the correlations between BMI, WC, WHtR, FFTI, and FTI and PWV were positive except FFTI/FTI and RTFFM. The correlation coefficients of WHtR and WC were higher than that of BMI. The binary logistic regression analysis adjusted for age showed similar associations between these parameters and the occurrence of high PWV; WHtR showed the strongest correlation with PWV. However, previous studies on the association between fat-related parameters and PWV, arteriosclerosis, or hypertension have reported conflicting findings. BMI showed the strongest association in adults [18] or only in one sex[10, 17, 18], while associations for 3 parameters were nonsignificant for men after adjustments[5]. However, others have reported results similar to ours[21, 23-27], including a cohort study in which subjects in the highest quartile of WHtR were 4.51 times more likely to have hypertension[28]. A systematic review also found that WHtR was the best parameter for predicting cardiometabolic risk factors, including hypertension[29]. Few studies have examined the relationship between body composition parameters and PWV, with only one in the last 5 years demonstrating a positive correlation between FFMI and PWV; nonetheless, this provides evidence for the value of FFMI as a predictor of arteriosclerosis[30].

In the present work, WHtR and WC had similarly modest capacities for predicting PWV occurrence in men, and BMI had no predictive value. WHtR, WC, and BMI had similar predictive capacities in women of both age groups, whereas WHtR had a slightly stronger predictive power in both men and woman. Significant sex differences were observed, with lower predictive capacities in men, especially those who were middle-aged. In contrast, BMI or WC was shown to have predictive value for the occurrence of hypertension[17, 31-33]. There were no significant differences in the predictive capacities of WC, BMI, and WHtR between men and women [31]; and the predictive values of BMI, WC, and WHtR were found to differ significantly between men and women[5], with a better performance in the latter[34]. WHtR has also been proposed as the best predictor of PWV or hypertension[25, 35-37].

The results of studies can vary according to whether the analysis is stratified by age or sex. BMI was shown to be more closely correlated with PWV in younger subjects than in older ones[10]. Our study population included a large number of subjects aged >40 years, with those over the age of 60 constituting the majority. Sex differences can also explain the discrepancies across reports. Because of metabolic adaptations during menopause, women are at greater risk than men for elevation of total and high low-density lipoprotein cholesterol after the age of 50, and are more likely to accumulate visceral fat[21]; thus, various indicators in women could show a strong association with PWV or hypertension. Additionally, study design, statistical methods, or selection of variables for adjustment can influence the degree of association.

The cutoff values with the best predictive capacity for high PWV in the present work based on sensitivity and specificity differed from those reported in studies of hypertension in Asian populations; the ranges were 82.70–85.2 for men and 77.5–83.5 for women [17, 31, 32, 35, 36]. The World Health Organization Working Group on Obesity recommends WC cutoff values of 85 cm for men and 80 cm for women, which are lower than those determined here (95.5 and 88.5 cm for middle-aged and elderly men, respectively; and 83.5 and 83.5 cm for middle-aged and elderly women, respectively). Our BMI ranges (23.86–24.01 for men and 24.08–23.57 for women) were similar to those in previous studies (22.65–24.12 for men and 23.53–27.7 for women) [17, 31, 32, 35], and the same was true for WHtR (0.54–0.55 for men and 0.51–0.52 for women in the present study vs 0.47–0.54 and 0.47–0.54, respectively, in previous reports) [17, 24, 31, 32, 35, 36, 38-40]. Notably, values obtained in a study conducted in Spain (WC, 90.5 cm; BMI, 26.6; WHtR, 0.54 for both sexes) [34]were much higher than those in Asian cohorts. Thus, different countries/regions should develop their own WC and WHtR cutoff values based on local epidemiologic status.

This study had several limitations. Firstly, it had a cross-sectional design and did not evaluate changes in the measured parameters. Secondly, the total number of participants was small, particularly the proportion of men aged 40–59. Finally, the results may not be generalizable to populations outside of Anhui.

Conclusions And Implications

In conclusion, the results of this study have implications for the health of middle-aged and elderly people in China, especially those at risk for high PWV. We propose that WHtR and WC be used for community-based screening of women (≥40 years) as secondary prevention of high PWV. Moreover, using WHtR, WC in conjunction with other parameters to predict risk of high PWV based on region, age, and sex could increase their predictive value.

Declaration

Ethics approval and consent to participate

All subjects provided written, informed consent for their data to be used in the study, and the study protocol was approved by the Ethics Committee of Bengbu Medical College (Anhui, China; no. 2018045).

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Authorship contribution statement

Ting Sun: data analysis, manuscript drafting. ZuChang Ma: supervision, manuscript revision and editing. Hui Xie: data analysis, manuscript revision and editing.

Declaration of Competing Interests

None declared.

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Tables

Table 1. Baseline characteristics of the study population according to baPWV stratified by age and sex*

	Men (N=1268)						Women (N=1951)				
Age, years	40–59			≥60			40–59			≥60	
baPWV, m/s	≥14 (N=301)	<14 (N=201)	$P^{\dagger}$	≥14 (N=693)	<14 (N=73)	$P^{\dagger}$	≥14 (N=395)	<14 (N=443)	$P^{\dagger}$	≥14 (N=976)	<14 (N=137)
Age, years	52.1 (5.13)	49.47 (5.6)	<0.0001	69.15 (6.04)	65.23 (4.03)	<0.0001	54.01 (4.22)	50.55 (5.55)	<0.0001	68.13 (5.58)	64.63 (3.44)
Weight, kg	72.82 (10.17)	72.66 (8.91)	0.855	70.07 (9.87)	68.49 (9.37)	0.191	62.35 (9.71)	59.31 (8.44)	<0.0001	61.28 (9)	57.66 (8.5)
Height, cm	169.94 (4.84)	170.99 (7.93)	0.066	169.12 (5.43)	169.89 (5.4)	0.249	159.61 (4.78)	160.32 (4.5)	0.029	158.11 (4.67)	158.26 (7.06)
WC, cm	89.89 (9.67)	88.39 (9.9)	0.092	91.15 (9.32)	87.78 (7.98)	0.003	86.04 (9.41)	81.55 (8.32)	<0.0001	88.63 (9.85)	82.65 (8.4)
BMI	25.21 (3.31)	25.09 (6)	0.771	24.48 (3.05)	23.72 (2.97)	0.043	24.45 (3.5)	23.05 (2.89)	<0.0001	24.5 (3.37)	23.12 (4.23)
WHtR	0.53 (0.06)	0.52 (0.07)	0.055	0.54 (0.05)	0.52 (0.05)	0.001	0.54 (0.06)	0.51 (0.05)	<0.0001	0.56 (0.06)	0.52 (0.07)
FFTI	19.92 (1.65)	19.8 (1.95)	0.458	19.43 (1.64)	19.15 (1.53)	0.158	16.44 (1.14)	16.02 (1.05)	<0.0001	16.4 (1.06)	15.98 (0.96)
FTI	5.25 (1.79)	5.31 (4.34)	0.828	5.11 (1.78)	4.55 (1.66)	0.01	8.03 (2.54)	7.03 (2.03)	<0.0001	8.16 (2.49)	7.17 (3.53)
FFTI/FTI	4.35 (2.13)	4.25 (1.43)	0.567	2.80 (1.65)	5.56 (0.6)	0.588	2.26 (0.84)	2.44 (0.62)	<0.0001	2.2 (0.73)	2.52 (0.84)
RTFFM	0.79 (0.06)	0.8 (0.06)	0.793	0.78 (0.06)	0.83 (0.07)	0.009	0.70 (0.07)	0.72 (0.06)	<0.0001	0.69 (0.07)	0.72 (0.08)
Heart rate, bp/min	72.83 (10.72)	68.74 (8.79)	<0.0001	69.65 (10.59)	65.76 (9.77)	0.003	71.06 (9.11)	68.22 (8.39)	<0.0001	69.81 (9.31)	66.02 (8.31)
SBP, mmHg	128.48 (14.27)	118.69 (10.78)	<0.0001	129.87 (15.39)	113.77 (10.14)	<0.0001	125.02 (15.43)	111.11 (11.58)	<0.0001	129.56 (15.77)	111.11 (11.38)
DBP, mmHg	82.4 (9.68)	75.32 (8.38)	<0.0001	76.14 (9.15)	69.8 (6.72)	<0.0001	77.25 (10.02)	69.53 (8.35)	<0.0001	73.55 (8.64)	66.1 (7.55)
Cigarette consumption, cigarettes/lifetime	52858.31 (5511.49)	47588.01 (6163.35)	0.532	62553 (4498.19)	104970 (19632.32)	0.006	1012.76 (547.65)	1239.19 (575.15)	0.777	3085.3 (1405.6)	2770.8 (1916.55)
Alcohol consumption, g/day	9.26 (22.27)	12.75 (37.56)	0.193	7.2 (21.34)	8.92 (16.99)	0.508	0.44 (4.66)	0.32 (2.79)	0.640	0.5 (4.12)	0.61 (4.17)
Physical activity time, min/MET/day	242.68 (152.47)	152.47 (181.41)	0.316	231.79 (154.87)	258.87 (177.22)	0.162	243.26 (160.30)	255.8 (180.69)	0.291	220.41 (130.83)	251.25 (136.06)
Sedentary time, min/day	69.87 (8.70)	74.42 (7.82)	0.619	44.01 (3.12)	43.08 (8.03)	0.925	41.48 (4.48)	47.09 (3.67)	0.330	35.65 (2.26)	27.42 (4.66)
Sleep disorder, n	19 (6.3)	9 (4.5)	0.380	72 (10.4)	8 (11)	0.880	56 (14.2)	40 (9)	0.02	182 (18.6)	22 (16.1)
Kidney disease, n (%)	2 (0.7)	0 (0)	0.359	5 (0.7)	1 (1.4)	0.453	5 (1.3)	1 (0.2)	0.084	7 (0.7)	1 (0.7)
Diabetes, n (%)	31 (10.3)	15 (7.5)	0.179	134 (19.3)	3 (4.1)	<0.0001	39 (9.9)	12 (2.7)	<0.0001	144 (12.8)	4 (2.9)
Dietary salt preference, n (%)			0.480			0.260			0.123		
Light	89 (29.6)	54 (26.9)		282 (40.7)	30 (41.1)		162 (41)	189 (42.7)		448 (45.9)	67 (48.9)
Moderate	99 (32.9)	73 (36.3)		231 (33.3)	22 (30.1)		128 (32.4)	146 (33)		290 (29.7)	37 (27)

Salty	72 (23.9)	54 (26.9)		143 (20.6)	13 (17.8)		82 (20.8)	69 (15.6)		177 (18.1)	24 (17.5)
Dietary fat preference, n (%)			0.205			0.201			0.144		
Light	84 (27.9)	47 (23.4)		308 (44.4)	34 (46.6)		163 (41.3)	191 (43.1)		481 (49.3)	64 (46.7)
Moderate	121 (40.2)	85 (42.3)		261 (37.7)	22 (30.1)		163 (41.3)	177 (40)		348 (35.7)	52 (38)
Oily	55 (18.3)	49 (24.4)		87 (12.6)	9 (12.3)		46 (11.6)	36 (8.1)		86 (8.8)	12 (8.8)

*Continuous variables are presented as mean (standard deviation), and discontinuous variables are presented as a number followed by percentage value.

† *P* values for the difference between high and low baPWV groups stratified by sex and age were determined with the t test and Chi-squared test.

Abbreviations: baPWV, brachial-ankle pulse wave velocity; BMI, body mass index; DBP, diastolic blood pressure; FFTI, fat-free tissue index; FTI, fat tissue index; MET, metabolic equivalent; RTFFM, ratio of trunk fat-free mass; SBP, systolic blood pressure; WC, waist circumference; WHtR, waist-to-height ratio.

Table 2. Association between obesity-related parameters and incidence of high pulse wave velocity value, after adjusting for confounding factors*

	Model 1			Model 2			Model 3		
	R^2	Beta	*P*	R^2	Beta	*P*	R^2	Beta	*P*
Men (40–59 years)									
WC (cm)	0.084	0.020	0.045	0.242	0.005	0.671	0.245	0.004	0.689
BMI	0.075	0.123	0.523	0.248	0.059	0.115	0.253	−0.064	0.091
WHtR	0.088	3.624	0.025	0.244	1.752	0.284	0.247	1.638	0.321
FFTI	0.077	0.06	0.263	0.248	−0.113	0.101	0.252	0.119	0.085
FTI	0.074	0.005	0.861	0.246	0.08	0.22	0.251	−0.091	0.171
FFTI/FTI	0.074	0.022	0.668	0.275	0.15	0.016	0.262	0.162	0.011
RTFFM	0.074	−0.44	0.776	0.249	−3.386	0.068	0.255	3.822	0.042
Men (≥60 years)									
WC (cm)	0.121	0.045	0.003	0.317	0.016	0.339	0.377	0.008	0.669
BMI	0.111	0.1	0.02	0.315	0.008	0.867	0.378	−0.035	0.507
WHtR	0.127	9.024	0001	0.318	3.226	0.291	0.378	1.715	0.598
FFTI	0.109	0.172	0.034	0.315	0.015	0.872	0.377	0.004	0.969
FTI	0.115	0.196	0.01	0.315	0.028	0.751	0.379	−0.09	0.325
FFTI/FTI	0.112	−0.068	0.008	0.316	0.023	0.573	0.377	−0.01	0.836
RTFFM	0.108	−4.180	0.033	0.316	1.534	0.507	0.381	3.329	0.178
Women (40–59 years)									
WC (cm)	0.204	0.055	<0.0001	0.4	0.036	<0.0001	0.404	0.033	0.001
BMI	0.203	0.152	<0.0001	0.390	0.06	0.033	0.395	0.055	0.066
WHtR	0.216	10.064	<0.0001	0.404	6.668	<0.0001	0.407	6.282	<0.0001
FFTI	0.199	0.433	<0.0001	0.391	0.187	0.025	0.395	0.164	0.051
FTI	0.199	0.204	<0.0001	0.389	0.076	0.054	0.395	0.07	0.077
FFTI/FTI	0.164	−0.376	<0.0001	0.385	0.021	0.854	0.391	−0.015	0.9
RTFFM	0.179	−5.555	<0.0001	0.386	−1.288	0.33	0.392	−1.217	0.361
Women (≥60 years)									
WC (cm)	0.155	0.064	<0.0001	0.386	0.049	<0.0001	0.391	0.048	<0.0001
BMI	0.127	0.123	<0.0001	0.366	0.051	0.148	0.372	0.046	0.197
WHtR	0.146	9.101	<0.0001	0.38	6.434	<0.0001	0.385	6.238	0.002
FFTI	0.125	0.385	<0.0001	0.370	0.263	0.03	0.375	0.25	0.04
FTI	0.124	0.155	<0.0001	0.365	0.05	0.275	0.37	0.043	0.35
FFTI/FTI	0.128	−0.456	<0.0001	0.367	0.22	0.091	0.372	−0.198	0.126
RTFFM	0.128	−5.380	<0.0001	0.066	−2.279	0.128	0.372	−2.072	0.168

*Standardized beta coefficients are given for each measurement in Model 1 (age), Model 2 (age, heart rate, SBP), and Model 3 (age, heart rate, SBP, cigarette consumption, physical activity, diabetes status).

BMI, body mass index; FFTI, fat-free tissue index; FTI, fat tissue index; RTFFM, ratio of trunk fat-free mass; WC, waist circumference; WHtR, waist-to-height ratio.

Table 3. Cutoff points for adiposity indices that predict the incidence of high pulse wave velocity value

	Cutoff	Sensitivity (%)	Specificity (%)	*P*	AUC (95% CI)
Men (40–59 years)					
WC (cm)	95.5	0.256	0.856	0.047	0.522 (0.502–0.603)
BMI	23.86	0.691	0.398	0.131	0.54 (0.487–0.591)
WHtR	0.54	0.359	0.781	0.006	0.573 (0.522–0.623)
FFTI	19.62	0.551	0.537	0.178	0.535 (0.484–0.587)
FTI	5.48	0.449	0.672	0.16	0.537 (0.486–0.588)
Men (≥60 years)					
WC (cm)	88.5	0.595	0.589	0.004	0.603 (0.538–0.667)
BMI	24.01	0.569	0.589	0.05	0.57 (0.503–0.636)
WHtR	0.55	0.371	0.836	0.001	0.62 (0.557–0.683)
FFTI	19.73	0.421	0.74	0.115	0.556 (0.49–0.622)
FTI	5.6	0.378	0.808	0.022	0.581 (0.517–0.646)
Women (40–59 years)					
WC (cm)	83.5	0.628	0.614	<0.0001	0.65 (0.613–0.687)
BMI	24.08	0.514	0.704	<0.0001	0.63 (0.592–0.667)
WHtR	0.51	0.704	0.567	<0.0001	0.667 (0.631–0.704)
FFTI	15.94	0.661	0.517	<0.0001	0.611 (0.573–0.649)
FTI	7.56	0.557	0.661	<0.0001	0.629 (0.591–0.666)
Women (≥60 years)					
WC (cm)	83.5	0.731	0.547	<0.0001	0.678 (0.631–0.726)
BMI	23.57	0.576	0.657	<0.0001	0.645 (0.596–0.694)
WHtR	0.52	0.733	0.591	<0.0001	0.693 (0.647–0.739)
FFTI	15.99	0.651	0.577	<0.0001	0.62 (0.571–0.67)
FTI	7.34	0.611	0.65	<0.0001	0.648 (0.598–0.697)

AUC, area under the receiver operating characteristic curve; BMI, body mass index; FFTI, fat-free tissue index; FTI, fat tissue index; WC, waist circumference; WHtR, waist-to-height ratio.

Figures

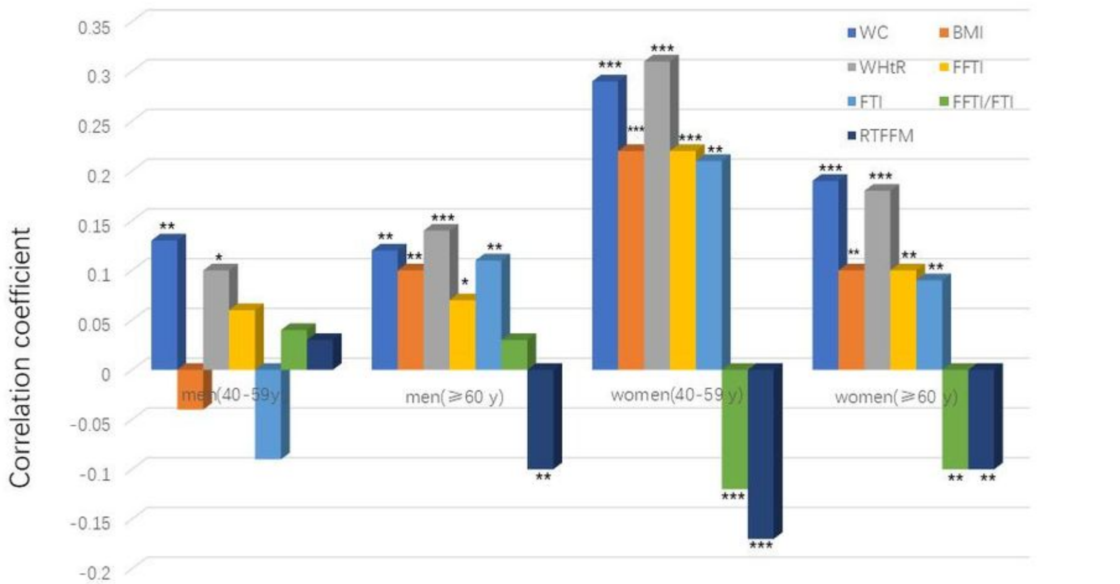

Figure 1. Partial correlation (adjusted for age) between obesity-related parameters and brachial-ankle pulse wave velocity. WC: waist circumference, BMI body mass index; WHtR: waist–height ratio; FFTI: fat-free tissue index; FTI: fat tissue index; RTFFM: ratio of trunk fat-free mass.
* p<0.05,** p<0.01,*** p<0.001

Figure 1

Figure 1

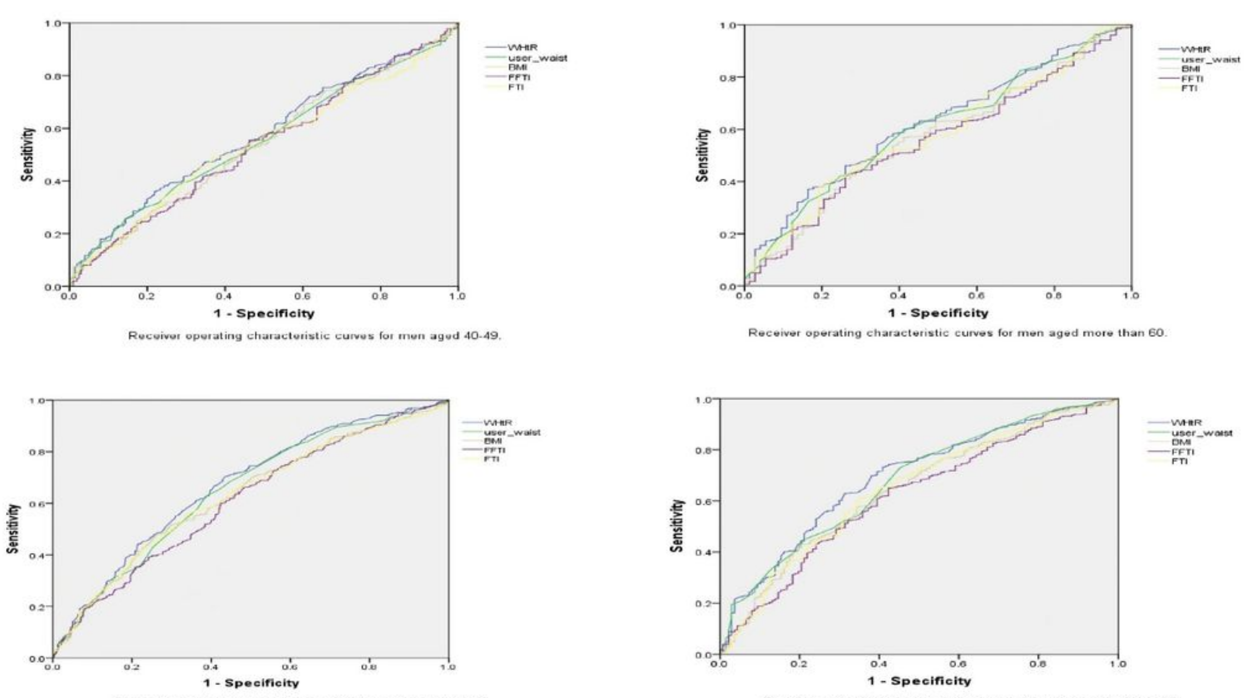

Figure 2. Receiver operating characteristic curves for incidence of arteriosclerosis risk and adiposity indices.

Figure 2

Figure 2