Original Article

Central Obesity and Metabolic Risk Factors in Middle-aged Chinese*

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Abstract

Objective Central obesity is considered to be a central component of metabolic syndrome. Waist circumference (WC) has been widely used as a simple indicator of central obesity. This study is aimed to evaluate the sensitivity of WC cut-off values for predicting metabolic risk factors in middle-aged Chinese.

Methods The study involved 923 subjects aged 40-65 years. The metabolic risk factors were defined according to the Chinese Joint Committee for Developing Chinese Guidelines on Prevention and Treatment of Dyslipidemia in Adults. WC cut-off 85-90 cm and ≥90 cm were used as cut-off values of central pre-obesity and central obesity in males, respectively, while WC 80-85 cm and ≥85 cm were used as cut-off values of central pre-obesity and central obesity in females.

Results First, WC values corresponding to body mass index (BMI) 24 kg/m^2 and visceral fat area (VFA) 80 cm^2 were 88.55 cm and 88.51 cm in males, and 81.46 cm and 82.51 cm in females respectively. Second, receiver operating characteristic curves showed that the optimal WC cut-off of value was 88.75 cm in males, higher than that in females (81.75 cm). Third, the subjects with higher WC values were more likely to have accumulating metabolic risk factors. The prevalence of metabolic risk factors increased linearly and significantly in relation to WC levels.

Conclusion WC cut-off values of central pre-/central obesity are optimal to predict multiple metabolic risk factors.

Key words: Central obesity; Central pre-obesity; Metabolic syndrome; Middle-aged Chinese

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INTRODUCTION

Due to the improved life quality after rapid economic growth and ever increasing sedentary lifestyles, the prevalence of obesity increased dramatically over the past decade in China[1-2]. According to the most recent Chinese national chronic non-communicable diseases surveillance in 2010, the prevalence of obesity [body mass index (BMI)≥28 kg/m^2] and overweight (BMI in the range from 24 to 28 kg/m^2) in adults (>18 years) was 12.0% and 30.6%, respectively[3]. Increased high fat accumulation is generally associated with an elevated risk of the development of metabolic

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diseases, such as hypertension, dyslipidemia, and diabetes mellitus (DM), which have been recognized as essential components of metabolic syndrome (MetS)[4]. Previous studies have also indicated that the severity of metabolic disorders does not necessarily correspond to the amount of total body fat, and in fact it is closely associated with body fat distribution, especially visceral fat accumulation[5]. Compared with subcutaneous fat, visceral fat accumulation, known as releasing more proatherogenic and proinflammatory factors, leads to the exacerbation of insulin resistance and oxidative stress, and thus contributes to cardiovascular disease (CVD)[6-7].

Computed tomography (CT) and magnetic resonance imaging (MRI) are recognized as the standard method to measure visceral fat area (VFA)[8]. However, these techniques are costly and /or radioactive, and are not suitable for screening a large population. In contrast, anthropometric measurements are simple and noninvasive. Waist circumference (WC) is correlated well with VFA[9-10], and has been widely used as a simple indicator of central obesity in clinical practice. Several studies have proven that high values of WC may be used as an important predictor of metabolic risk factors, cardiovascular disease (CVD) and adverse outcomes[11-15]. Nevertheless, no criteria for central obesity across ethnic groups have been established. Various clinicians/groups in the world have established their own WC cut-off values based on their own clinical settings. For example, some WC cut-off values are corresponding to CT/MRI-evaluated visceral fat deposits[16] or BMI[17-18], whereas others are determined using receiver operating characteristic (ROC) curves for accumulating metabolic risk factors[19]. The International Diabetes Federation (IDF) has proposed 'Asian values' (90 cm in males and 80 cm in females). However, further studies revealed that these cut-off values do not apply to all Asian populations[20-22]. Recently, new WC cut-off values have been recommended as indicators of central obesity for Chinese, i.e., 90 cm and 85 cm for males and females, respectively. Furthermore, the WC cut-off values of central pre-obesity has been first proposed to, 85 cm and 80 cm for Chinese males and females, respectively[23].

The purposes of this study were 1) to test the new WC cut-off values with different statistical analyses, and 2) to identify the relationship between the WC cut-off values and the detection rates of multiple MetS risk factors in a group of middle-aged Chinese adults.

METHODS

Study Design

A population-based cross-sectional survey was conducted from March to May 2010 in Caihe community in Hangzhou, Zhejiang Province of China. The study subjects were 923 local residents aged 40-65 years; 380 males (57.14±7.31 years) and 543 females (57.16±7.60 years). The study was approved by the ethics review committee of Sir Run Run Shaw Hospital, and written informed consents were obtained from all subjects.

Face-to-face interviews were conducted among the subjects by trained medical staffs using a standardized questionnaire to collect the information about their education background, health status, disease history, and lifestyle behaviors, including alcohol use and smoking during the check-up interval.

Anthropometric Measurements

Body weight and body height of the subjects were measured to the nearest 0.1 kg and 0.1 cm, respectively. BMI was calculated with dividing weight by square of height (kg/m^2). Subjects with BMI 24 kg/m^2 -28 kg/m^2 were classified as overweight and BMI≥28 kg/m^2 were classified as obesity[24-25]. WC was measured at the horizontal plane between the inferior costal margin and the iliac crest on midaxillary line. Hip measurements were also done while subjects were standing, from the widest point of the hip. And a waist-hip ratio (WHR) was calculated and recorded for each subject. Body fat percentage (Fat%) was measured by a bioelectrical impedance analysis system (BIA) (TBF-300, Tanita Co, Japan). Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured for three times by using mercury sphygmomanometer, and the averages of three measurements were recorded.

Abdominal adipose tissue was determined using a whole-body imaging system (SMT-100, Shimadzu Co, Japan) with TR-500 and TE-200 of spin-echo sequences. MRI scans were obtained at the level of the umbilicus in the prone position. VFA and abdominal subcutaneous fat area (SFA), were calculated using the software provided by the manufacturer. VFA≥80 cm^2 was defined as high

VFA[26].

Laboratory Measurements

Subjects arrived at the local community health care centers at 7:00-8:00 am following an overnight fast. Subjects without a validated history of DM received a 75 g oral glucose tolerance test (OGTT), whereas a 100 g carbohydrate (steamed bread meal) test was conducted on subjects with DM[27]. Blood samples were immediately centrifuged and stored at -80 °C. Fasting plasma glucose (FPG) and 2-h post-OGTT plasma glucose (2 h PG), triglyceride (TG), total cholesterol (TC), low density lipoprotein-c (LDL-c) and high density lipoprotein-c (HDL-c) were measured with a automated instrument analyzer (Aeroset, Chicago, IL, USA). Glycosylated hemoglobin A_1c (HbA_1c) was measured using ion-exchange high-performance liquid chromatography (Hemglobin Testing System; Bio-Rad, Hercules, CA, USA). Serum insulin levels were measured with radioimmuno-assay using the insulin detection kit (Beijing North Institute of Biological Technology, China). Homeostatic model assessment of insulin resistance (HOMA-IR) was calculated using the formulas: HOMA-IR=fasting serum insulin (FINS, mU/L) × fasting plasma glucose (FPG, mmol/L)/22.5[28].

Definition

(1) Central pre-/Central Obesity Sex-specific cut-off values were 85-90 cm and 80-85 cm for central pre-obesity in males and females respectively, and ≥90 cm and ≥85 cm for central obesity in males and females respectively[29].

(2) Metabolic Risk Factors In the study, subjects with two or more of the following four risk factors according to the criteria developed by the Chinese Joint Committee for Developing Chinese Guidelines on Prevention and Treatment of Dyslipidemia in Adults (JCDCG)[30] were defined as having multiple risk factors: (1) Hypertriglyceridemia (TG≥1.70 mmol/L); (2) Low HDL cholesterol (HDL-c<1.04 mmol/L); (3) Elevated BP (BP≥130/85 mmHg or under current treatment for hypertension); and (4) Hyperglycemia (FPG≥6.1 mmol/L or 2 h PG≥7.8 mmol/L or previously diagnosed DM and receiving treatment). Hypertension was defined as SBP≥140 mmHg and/or DBP≥90 mmHg, or previously diagnosed hypertension and receiving treatment. And DM was deemed present if the subjects had medical records of diabetes and were using hypoglycemic medication or insulin, or if the result of OGTT was FPG≥7.0 mmol/L and /or 2 h PG≥11.1 mmol/L.

Statistical Analyses

Normally distributed variables were expressed as mean±standard deviation (SD), while variables with a skewed distribution, including insulin, glucose, HOMA-IR, TG, SFA, and VFA underwent lg(x) transformation to achieve a normal distribution, and were reported as median value (inter-quartile range) [M(IQR)]. Categorical variables were represented by frequency and percentage. We performed the following statistical procedures to test the effectiveness of these WC cut-off values. First, we investigated the association between BMI and WC, as well as between VFA and WC using correlation analysis and linear regression analysis, and calculated WC associated with certain BMI and VFA levels. Second, we assessed the predictive power of WC using ROC curves for multiple risk factors. Third, we investigated the association between central pre-/central obesity and the risk of accumulating metabolic risk factors. In addition, we conducted a multivariate logistic regression analysis to determine the strength of the association between central pre-/central obesity and the metabolic disorders. All statistical analyses were performed with SPSS 20.0 (IBM, Armonk, NY, USA) and the results were considered statistically significant when 2-sided *P* was <0.05.

RESULTS

General Characteristics of Subjects

A total of 380 males and 543 females were surveyed. Their average WC and BMI were 88.47±9.72 cm and 23.96±2.86 kg/cm^2 in males, and 79.44±8.70 cm and 23.16±2.96 kg/cm^2 in females, respectively. The prevalence of hypertension and DM was 26.8% and 9.5% in males and 24.8% and 6.5% in females, respectively. VFA, TG, SBP, DBP, and HbA_1c were significantly higher in males than in females, while Fat%, SFA, 2 h insulin, TC, LDL, and HDL were significantly higher in females than in males (Table 1).

Correlation of Fat Accumulation with Anthropometric Markers

As shown in Table 2, VFA and SFA were both positively correlated with BMI, WC, WHR, Fat% (*P*<0.001). Among them, WC (*r*=0.73, *P*<0.001) had the closest correlation with VFA compared with BMI

(r=0.66, P<0.001), WHR (r=0.62, P<0.001), and Fat% (r=0.65, P<0.001) whereas BMI (r=0.73, P<0.001) was shown to correlate with SFA more strongly than WC (r=0.68, P<0.001), WHR (r=0.51, P<0.001), and Fat% (r=0.68, P<0.001).

Association between BMI, Visceral Adipose Tissue Area, and Waist Circumference

Figure 1A shows the association between WC and BMI. There was a strong correlation both in males (r=0.83, P<0.001) and in females (r=0.82, P<0.001). In our study, the prevalence of obesity and overweight in adults was 5.9% and 35.6%. Linear regression equations determined that WC values corresponding to BMI 24 kg/m^2 were 88.55 cm and 81.46 cm in males and females, and WC values corresponding to BMI 28 kg/m^2 were 99.77 cm and 91.08 cm in males and females, respectively.

Table 1. Characteristics of the Study Subjects (n=923)

Variables	Total	Males	Females	*P* for trend
n	923	380	543	
Age (years)	57.15±7.48	57.14±7.31	57.16±7.60	0.974
Current smoker, *n* (%)	236 (25.6)	229 (60.3)	7 (1.3)	<0.001
Alcohol user, *n* (%)	197 (21.3)	154 (40.5)	43 (7.9)	<0.001
Education backgrounds, *n* (%)				<0.001
Below high school	89 (9.6)	24 (6.3)	65 (12.0)	
High school	697 (75.5)	281 (73.9)	416 (76.6)	
Above high school	137 (14.8)	75 (19.7)	62 (11.4)	
BMI (kg/m^2)	23.48±2.94	23.96±2.86	23.16±2.96	<0.001
WC (cm)	83.07±10.14	88.47±9.72	79.44±8.70	<0.001
WHR	0.87±0.07	0.91±0.06	0.85±0.06	<0.001
Fat% (%)	29.08±7.07	24.85±5.61	31.93±6.51	<0.001
SBP (mm Hg)	124.20±16.65	127.61±16.69	121.91±16.24	<0.001
DBP (mm Hg)	80.95±9.95	84.19±9.77	78.77±9.48	<0.001
FPG (mmol/L)	4.90 (1.90)	4.90 (0.90)	4.80 (0.80)	0.069
2 h PG (mmol/L)	5.40 (2.30)	5.30 (2.90)	5.50 (2.10)	0.379
FINS (μU/mL)	17.78 (9.50)	17.76 (9.75)	17.80 (9.06)	0.320
2 h INS (μU/mL)	56.45 (48.75)	50.45 (45.71)	61.99 (49.64)	<0.001
HOMA-IR	3.85 (2.39)	3.90 (2.63)	3.84 (2.33)	0.868
HbA_1c (%)	5.72±0.70	5.82±0.84	5.65±0.59	<0.001
TC (mmol/L)	5.62±1.05	5.48±1.00	5.71±1.07	0.001
LDL-c (mmol/L)	2.43±0.59	2.32±0.56	2.49±0.60	<0.001
HDL-c (mmol/L)	1.46±0.37	1.30±0.32	1.56±0.34	<0.001
TG (mmol/L)	1.30 (0.89)	1.50 (1.15)	1.22 (0.79)	<0.001
SFA (cm^2)	153.60 (85.45)	124.20 (53.80)	182.25 (82.58)	<0.001
VFA (cm^2)	70.71 (65.10)	101.60 (76.51)	62.28 (42.22)	<0.001
Hypertension, *n* (%)	379 (41.1)	193 (50.8)	186 (34.3)	0.666
Diabetes, *n* (%)	186 (20.2)	88 (23.2)	98 (18.1)	0.650

***Note*.** Normally distributed variables were expressed as mean±standard deviation (SD), while variables with a skewed distribution, including insulin, glucose, HOMA-IR, TG, SFA, and VFA underwent lg(x) transformation to achieve a normal distribution, and were reported as median value (inter-quartile range) [M(IQR)]. Categorical variables were represented by frequency and percentage. BMI: body mass index; WC: Waist circumference; WHR: waist-hip ratio; Fat%: body fat percentage; SBP: systolic blood pressure; DBP: diastolic blood pressure; FPG: fasting plasma glucose; 2 h PG: 2 hour postprandial glucose; FINS: fasting insulin; 2 h INS: 2 hour insulin; HOMA-IR: homeostatic model assessment of insulin resistance; HbA_1c: glycosylated hemoglobin A_1c; TC: total cholesterol; LDL-c: low density lipoprotein-c; HDL-c: high density lipoprotein-c; TG: triglyceride; SFA: subcutaneous fat area; VFA: visceral fat area.

Furthermore, we investigated the association between WC and VFA. As shown in Figure 1B, WC was closely correlated with VFA both in males (r=0.79, P<0.001) and females (r=0.68, P<0.001). The sex-specific regression line analyzed by simple correlation indicated that the WC corresponding to 80 cm^2 of VFA was 88.51 cm in males and 82.51 cm in females.

ROC curves of Waist Circumference for Metabolic Risk Factors Clustering

Figure 2 shows the ROC curves of WC for the prediction of multiple risk factors; the area under the curves and their 95% CI were calculated to be 0.753 (0.690, 0.817) in males and 0.731 (0.670, 0.791) in females. According to the ROC curves, the cut-off values showing maximal sensitivity and specificity for predicting the presence of multiple risk factors was 88.75 cm in males and 81.75 cm in females. The sensitivity and specificity using these cut-off values were 76.9% and 66.1% in males and 70.4% and 64.2% in females, respectively.

Waist Circumference and Metabolic Risk Factors

We divided the WC dataset into three groups for males and females respectively (non-central obese group, central pre-obese group, and central obese group) to evaluate the association between WC and the prevalence of metabolic risk factors. As shown in Figure 3, both male and female subjects with higher WC were more likely to have greater accumulating metabolic risk factors.

Table 2. Partial Spearman's Correlation Coefficients of Fat Accumulation with Anthropometric Markers

Items	Total[a] n=923		Male[b] n=380		Female[b] n=543	
	r	P value	r	P value	r	P value
VFA						
BMI	0.66	<0.001	0.72	<0.001	0.62	<0.001
WC	0.73	<0.001	0.79	<0.001	0.68	<0.001
WHR	0.60	<0.001	0.68	<0.001	0.54	<0.001
Fat%	0.65	<0.001	0.70	<0.001	0.63	<0.001
SFA						
BMI	0.73	<0.001	0.74	<0.001	0.73	<0.001
WC	0.68	<0.001	0.74	<0.001	0.62	<0.001
WHR	0.51	<0.001	0.60	<0.001	0.44	<0.001
Fat%	0.68	<0.001	0.69	<0.001	0.69	<0.001

***Note*.** SFA: subcutaneous fat area; VFA: visceral fat area; BMI: body mass index; WC: Waist circumference; WHR: waist-hip ratio; Fat%: body fat percentage. [a]Correlation coefficients were calculated after adjustment for sex, age, smoking, alcohol use and education. [b]Correlation coefficients were calculated after adjustment for age, smoking, alcohol drinking, and education.

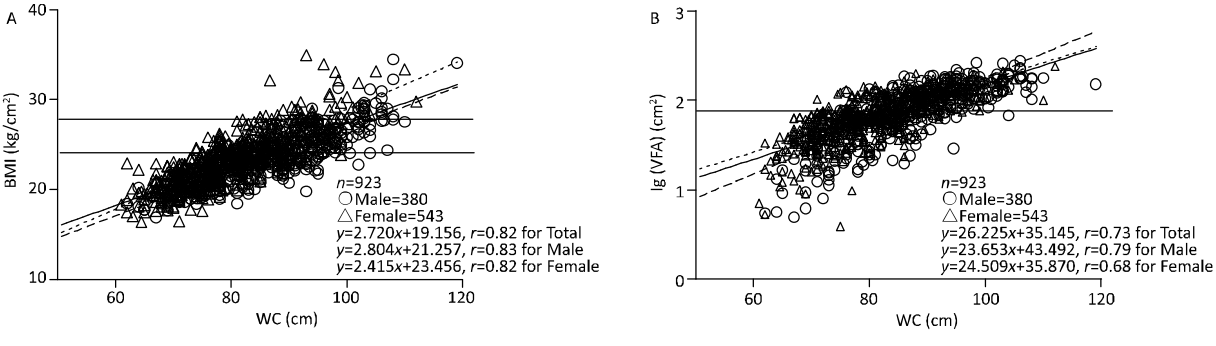

Figure 1. Correlations between body mass index (BMI) or visceral fat area (VFA) and waist circumference (WC). A: Sex-specific scatterplots of WC and BMI. B: Sex-specific scatterplots of WC and VFA. Bold solid lines represent regression lines, whereas bold and narrow dashed lines represent regression lines for male and female, respectively. Narrow solid lines show the correspondence of WC to BMI 24 and 28 kg/m^2 in A, and VFA to 80 cm^2 [lg(VFA) to 1.90 cm^2] in B.

We subsequently designed male and female subgroups into one model and analyzed OR for each metabolic risk factor (Table 3). The prevalence of central pre-obesity and central obesity were 20.5% and 47.1% in males, and 18.2% and 26.7% in females, respectively. The most prevalent metabolic risk factor was elevated BP in both males and females. All metabolic risk factors and ≥2 metabolic risk factors were more prevalent in males than in females, and increased linearly and significantly in relation to WC levels. Compared with the non-central obese group, central pre-obesity and central obesity was associated with an OR of 3.46 (95% CI: 1.97-6.06) and 24.06 (95% CI: 12.10-47.84) in males, and 2.14 (95% CI: 1.24-3.68) and 9.02 (95% CI: 5.42-15.02) in females, respectively in predicting ≥2 metabolic risk factors, after adjustment for age, smoking, alcohol use, and education backgrounds.

DISCUSSION

It is recognized that the amount of visceral adipose tissue is critically corresponding to a cluster of metabolic risk factors. Based on a positive correlation between WC and VFA, WC has been widely accepted as a good indicator of abdominal visceral fat accumulation. Asian populations have been shown to have a higher visceral fat deposition at a lower BMI than Caucasians[31-33]. Therefore, it is difficult to apply the same WC criteria to different ethnic groups. Even among Asians, each ethnic group has their own anthropometric characteristics. Thus, it is particularly important to determine the appropriate WC cut-off values in Chinese subjects.

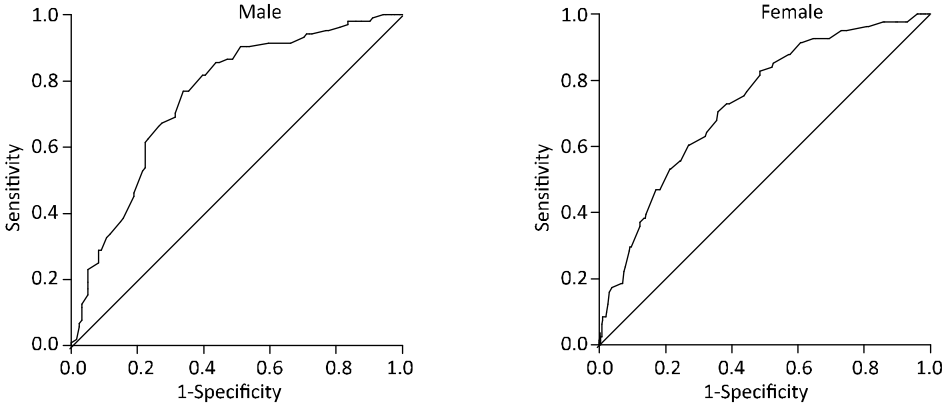

Figure 2. ROC curves of waist circumference for a cluster of metabolic risk factors.

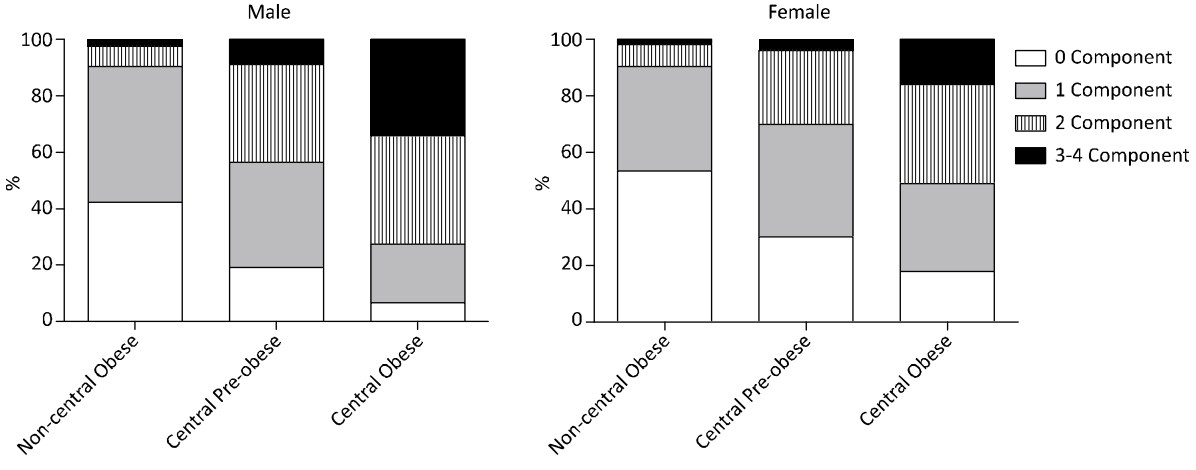

Figure 3. The number of accumulating metabolic risk factors in relation with central pre- and central obesity.

Table 3. Risk of Having an Altered Metabolic Profile among the Study Subjects

Items	Non-central Obese	Central Pre-obese	Central Obese	*P* for Trend
Elevated BP				
Male	123	78	179	
Prevalence (%)	53 (43.1)	45 (57.7)	146 (81.6)$^{\#\#}$	
Adjusted model	1	3.17 (1.72-5.84)	5.95 (3.43-10.31)	<0.001
Female	299	99	145	
Prevalence (%)	107 (35.8)	51 (51.5)	94 (64.8)	
Adjusted model	1	1.55 (0.92-2.61)	2.93 (1.92-4.45)	<0.001
Hyperglycemia				
Male	123	78	179	
Prevalence (%)	17 (13.8)	11 (14.1)	61 (34.1)$^{\#\#}$	
Adjusted model	1	2.96 (1.44-6.09)	3.16 (1.71-5.85)	<0.001
Female	299	99	145	
Prevalence (%)	28 (9.4)	22 (22.2)	48 (33.1)	
Adjusted model	1	1.56 (0.87-2.82)	4.34 (2.57-7.34)	<0.001
Hypertriglyceridemia				
Male	123	78	179	
Prevalence (%)	13 (10.6)	35 (44.9)	109 (60.9)$^{\#}$	
Adjusted model	1	1.99 (1.14-3.45)	13.19 (6.82-25.52)	<0.001
Female	299	99	145	
Prevalence (%)	36 (12.0)	27 (27.3)	65 (44.8)$^{\#\#}$	
Adjusted model	1	1.99 (1.15-3.44)	5.60 (3.47-9.04)	<0.001
Low HDL cholesterol				
Male	123	78	179	
Prevalence (%)	4 (3.3)	14 (17.9)	50 (27.9)$^{\#}$	
Adjusted model	1	2.06 (1.04-4.11)	14.40 (4.91-42.20)	<0.001
Female	299	99	145	
Prevalence (%)	3 (1.0)	3 (3.0)	11 (7.6)	
Adjusted model	1	3.06 (0.83-11.27)	9.42 (2.70-36.58)	<0.001
≥2 metabolic risk factors				
Male	123	78	179	
Prevalence (%)	12 (9.8)	34 (43.6)	130 (72.6)$^{\#\#}$	
Adjusted model	1	3.46 (1.97-6.08)	24.06 (12.10-47.84)	<0.001
Female	299	99	145	
Prevalence (%)	28 (9.4)	30 (30.3)	74 (51.0)$^{\#\#}$	
Adjusted model	1	2.14 (1.24-3.68)	9.02 (5.42-15.02)	<0.001

***Note*.** Values of adjusted model denoted odds ratio (95% confidence interval). Model adjusted for age, smoking, alcohol drinking and education level. $^{\#}P<0.05$ and $^{\#\#}P<0.01$ compared with pre-obese group.

BMI is most widely used to determine nutritional status. It has been demonstrated to be correlated with morbidity, mortality and longevity[34-35]. The overall correlation coefficients between BMI and WC were nearly identical in males and females (r=0.83 for males and r=0.82 for females) in our study. Western countries usually derived their WC cut-off values from the association with BMI[17-18]. The reliability of these cut-off values was latter supported by their provision of statistically significant OR for accumulating metabolic risk factors[36-37]. In our study, WC values corresponding to BMI 24 kg/m^2 were 88.55 cm and 81.46 cm in males and females, respectively. In addition, we used the MRI scan to investigate the relationship between fat accumulation and BMI, WC and WHR, and found that WC (r=0.73, P<0.001) had the closest correlation with the VFA, whereas the BMI (r=0.73, P<0.001) was shown to correlate with SFA more strongly than other anthropometric markers. And similar results were obtained in other studies[38-39]. Therefore, it has been suggested that WC is a better marker of visceral fat accumulation than BMI. In our study, we also measured the Fat% using a BIA. Interestingly, the correlation between Fat% and VFA (r=0.65, P<0.001) was much weaker than that reported in other studies[40], which might be partially explained by the superiority of the 4-limb BIA device over the conventional foot-to-foot or handheld devices.

The Japan Society for the Study of Obesity first used VFA≥100 cm^2 to define central obesity[16]. It has been reported that approximately 70% of patients with CVD had a VFA≥100 cm^2 in Japan. Despres et al.[41] also demonstrated that the subjects with VFA≥ 100 cm^2 were at higher risks than those with VFA< 100 cm^2. Despite this standard is applied to many Asian countries, there are still many controversies[22,42]. Recently, Bao et al.[26] found that the best VFA cut-off was 80 cm^2 in the Chinese people in identifying two or more metabolic risk factors, and the corresponding cut-off of WC was around 88 cm in males before and after age of 50 years, while WC values were different with 81.5 cm for females <50 years and 86.3 cm for those ≥50 years. In our study, the WC corresponding to 80 cm^2 of VFA was 88.51 cm in males and 82.51 cm in females.

In search of the optimal WC cut-off value, we also analyzed ROC curves for metabolic risk factors and, found that the best trade-off between the sensitivity and the specificity was 88.75 cm in males and 81.75 cm in females. The cut-off values of WC described in the present study for males is very close to, but for females is lower than the new criteria proposed. It should be taken into consideration that there was a difference in the age distribution. The subjects of our study were all middle-aged Chinese, and their mean age of our study was much lower than that in other studies. Previous studies have demonstrated that the peak frequency distribution of WC was increased with aging, which was more obvious in females[26,43]. Given that the aging process brings about many changes in body composition, including an increased body fat accumulation, these observations are not surprising. Thus, appropriate WC cut-off values for younger females would be a little lower than older females. In the present study, compared with non-central obesity group, the subjects with central obesity had higher risk for MetS (OR=24.06, 95% CI: 12.10-47.84 for males and OR=9.02, 95% CI: 5.42-15.02 for females). Even in the central pre- obese group, the risk of Mets significantly increased as compared with the non-obese population (OR=3.46, 95% CI: 1.97-6.08 for males and OR=2.14, 95% CI: 1.24-3.68). Furthermore, when increasing the WC based on the new cut-off value, larger numbers of components of MetS were seen. Primary prevention of central obesity should be stressed.

There are some limitations to our study. First, the cross-sectional design does not determine the cause-and-effect relationship. Further larger prospective epidemiologic studies are necessary to support our findings. Second, the dietary intake and work-related physical activity were not assessed in our study. Therefore, we were not able to determine the association between these factors and the prevalence of MetS. Third, the recall bias still occurred during the sociodemographic characteristic data collection with questionnaire.

In conclusion, this study has identified WC (central pre-obesity: WC≥85 cm for males and ≥80 cm for females and central obesity: WC≥90 cm for males and ≥85 cm for females) as an effective indicator to predict metabolic risk factors for developing MetS. Based on the findings of the present study, we recommend that WC measure-ment should be a routine practice in local clinical settings. Males and females with central pre-obesity should strengthen their lifestyle management, and peoples with central obesity should be screened for MetS to prevent or delay CVD and DM in a more effective way. Further large prospective studies are

needed to validate our findings and to develop more effective and easier methods for early diagnosis of central obesity and MetS.

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