Relationship of Body Mass Index, Waist Circumference and Cardiovascular Risk Factors in Chinese Adult[1]

SONG-MING DU[*, #], GUAN-SHENG MA[#, 2], YAN-PING LI[#], HONG-YUN FANG[#], XIAO-QI HU[#], XIAO-GUANG YANG[#], AND YONG-HUA HU[*, 2]

[*]*School of Public Health , Peking University Health Science Center, Beijing 100083, China; [#]National Institute for Nutrition and Food Safety, Chinese Center for Disease Control and Prevention, Beijing 100021, China*

Objective To compare the relative risk of waist circumference (WC) and/or BMI on cardiovascular risk factors. **Methods** A cross-sectional data of 41 087 adults (19 567 male and 21 520 female) from the 2002 China National Nutrition and Health Survey were examined. According to the obesity definition of WGOC (BMI, 24 kg/m^2 and 28 kg/m^2; WC, male 85 cm and 95 cm for male, 80 cm and 90 cm for female), the study population were divided into 9 groups. The prevalence and odds ratio (ORs) of cardiovascular disease (CVD) risk factors (hypertension, high fasting plasma glucose and dyslipidemia) were compared among these 9 groups. Stepwise linear regression analyses were used to compare the likelihood of BMI and/or WC on CVD risk factors. **Results** Both the indexes levels and the odds ratios of CVD risk factors were significantly increased (decreased for HDL-C levels) along with the increase of WC and/or BMI, even when the effect of age, sex, income, education, sedentary activity and dietary factors were adjusted. The variances (R^2) in CVD risk factors explained by WC only and BMI only were quite similar, but a little bit larger when WC and BMI were combined. The standard β was higher of BMI when predicting systolic BP and was higher of WC when predicting TG, TC and HDL. **Conclusions** BMI and WC had independent effects on CVD risk factors and combination of BMI and WC would be more predictive. Findings from the present study provided substantive evidence for the WGOC recommendation of a combined use of BMI and WC classifications.

Key words: obesity; central obesity; cardiovascular disease risk factors; multivariate regression

INTRODUCTION

Obesity has become one of the most prevalent conditions making a significant impact on public health worldwide[1-2]. The overall prevalence of overweight and obesity of Chinese people was increased by 38.6% and 80.6%, respectively, from 1992 to 2002. It is estimated that 70 million overweight and 30 million obese Chinese people emerged in China during the period of 1992-2002[3].

Obesity is defined by the World Health Organization (WHO) as a condition of excessive fat accumulation in the body to the extent that health and well-being are adversely affected[1] and leads to considerable health care expenditure[4-5]. The most common measure of excess body weight in clinical practice and population surveys are the body mass index (BMI) and waist circumference (WC). BMI is thought to be an indicator of overall body fat because it is highly correlated with percentage body fat[6-7] which has a strong association with the development of obesity-related metabolic disorders[8-9]. Thus, BMI is widely used to evaluate obesity and assess risk for cardiovascular disease and diabetes.

However, BMI is not a direct measure of fat mass and does not always accurately reflect the degree of body fat and body fat distribution. There is focus as to whether fat distribution and central obesity and overall body fat are more closely associated with CVD risk[10]. WC has been advocated as an indicator of abdominal fat content. An increasing number of papers indicate that the degree of abdominal fat distribution may be more closely tied to metabolic risks than BMI[11-12]. But someone also reported that the predictive effect of WC was equal to BMI[13]. These findings suggested

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[2]Correspondence should be addressed to: Yong-Hua HU. Tel: 86-10-82801518. E-mail: yhhu@bjmu.edu.cn; Guan-Sheng MA. Tel: 86-10-67776285. E-mail: mags@chinacdc.net.cn

Biographical note of the first author: Song-Ming DU, female, born in 1970, post doctoral fellow at the School of Public Health, Peking University, majoring in nutrition and related chronic diseases.

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that not only BMI but also WC should be taken into account for the association between obesity and diseases risks. Thus, further researches are required to determine the combined effect of BMI and WC for CVD.

In 2005, the Working Group on Obesity in China (WGOC) recommended a combination of BMI and WC to be used to classify obesity-related CVD risk in adults[14-15]. The disease risks were assessed based on both the BMI and WC categories. The objective of this investigation was to verify the WGOC classification of the combined influence of WGOC BMI and WC cutoff points predicting disease risk, using the national representative data of Chinese population. The specific aims were: firstly, to study whether the prevalence of hypertension, diabetes, dyslipidemia, and a clustering of metabolic risk factors was greater in individuals with higher WC values and/or higher BMI compared with individuals with normal WC and BMI values; secondly, to determine whether BMI and WC had independent effects on CVD risk factors among Chinese population.

SUBJECT AND METHODS

Study Population

The 2002 China National Nutrition and Health Survey (2002 CNNHS) is a nationally representative cross-sectional survey. The method of multi-step cluster sampling was adopted in this survey[16]. Of the total sample aged 18 years or older, measures of the WC, height, weight, and metabolic variables were obtained and that fit the BMI categories examined. Informed consent form was obtained from all participants, and ethics approval was obtained from the Ethics Committee of National Institute for Nutrition and Food Safety, Chinese Centre for Disease Control and Prevention.

Survey Methods

Anthropometry Body weight and height were measured by trained investigators following a standardized protocol. Body weight and height were measured in duplicate, to the nearest 0.1 kg and 0.1 cm, respectively, and the average of the 2 measurements was used. Body mass index (BMI) was calculated as body weight (in kilograms) divided by height (in meters) squared. The WC measurement was made at minimal inspiration to the nearest 0.1 cm, midway between the lowest rib and the superior border of the iliac crest. The average of the 2 measurements was used.

Metabolic variables For each participant, blood pressure measurements were obtained by a standardized protocol. Blood pressure was measured by trained investigators with participants in a relaxed seated position after they had rested for at least 5 minutes. The mean of the 2 measures was used for analysis.

Blood samples were obtained after a whole night fasting for the measurement of serum cholesterol, triglyceride, lipoprotein, and glucose levels. Briefly, cholesterol and triglyceride levels were measured with enzymatic procedures. Plasma glucose levels were assayed using a hexokinase enzymatic method in 4h after the blood sample drawn. The standard methods were used in laboratory which met CDC internet quality control. Details of blood sampling, its storage, transportation, analyses, and quality control have been published previously[17].

Definition of Obesity

BMI categories The BMI cutoff points developed by WGOC were used[14]. Participants were classified as normal weight (18.5-23.9 kg/m^2), overweight (24.0-27.9 kg/m^2), or obese (≥28.0 kg/m^2) on the basis of their BMI.

WC categories The WGOC criteria were used to divide subjects into the 3 WC categories, normal WC, class I high WC and class II high WC.

Normal WC, class I high WC and class II high WC were defined as <80 cm, 80 cm to 90 cm, and ≥90 cm, respectively, in women; and <85 cm, 85 cm to 95 cm, and ≥95 cm, respectively, in men.

Elevated CVD Risk Factors

Metabolic syndrome was defined according to the International Diabetes Federation (IDF) definition[18].

Central obesity: defined as waist circumference ≥90 cm for Chinese men and ≥80 cm for Chinese women;

Plus any two of the following four factors:

Raised TG level (high TG): ≥1.7 mmol/L (150 mg/dL), or specific treatment for this lipid abnormality;

Reduced HDL cholesterol (low HDL-C): <1.03 mmol/L (40 mg/dL) in males and <1.29 mmol/L (50 mg/dL) in females, or specific treatment for this lipid abnormality;

Raised blood pressure (high BP): systolic BP≥130 mmHg or diastolic BP≥85 mmHg, or treatment of previously diagnosed hypertension;

Raised fasting plasma glucose (high FPG): 5.6 mmol/L (100 mg/dL), or previously diagnosed type 2 diabetes.

Dyslipidemia was defined according to the Third Report National Cholesterol Education Program(NCEP) Adult Treatment Panel(ATP III)[19] and having any one of high TC(total cholesterol level ⩾5.18 mmol/L), high TG(serum triglyceride level⩾ 1.7 mmol/L), low HDL-C (⩾3.37 mmol/L).

Statistical Analysis

Across the BMI and WC categories, the subjects were divided into nine mutually exclusive subgroups. Within each BMI category, there were 3 subgroups according to the WC cutoff which included normal WC, class I high WC, and class II high WC. Because all participants who were underweight (BMI<18.5 kg/m^2) had normal WC values, they were excluded from the data analysis.

Continuous variables were expressed as mean±SD. For comparison of means across subgroups, BMI, WC, and the metabolic variables values were adjusted for age with analysis of covariance (ANOVA) models analysis of covariance. We compared prevalence of high BP, high TC, high LDL-C, low HDL-C, high TG, and dyslipidemia in all groups across BMI and WC categories using χ^2 statistics.

Logistic regression analysis was used to examine the associations between WC classification and metabolic risk. High BP, high TC, high LDL-C, low HDL-C, high TG, and dyslipidemia were used as outcome and WC, BMI, age, gender as independent variables. BMI and WC were added to the regression models as categorical variables. A normal WC with normal weight was used as the reference category (OR, 1.00). ORs were also computed after adjusting for the potential influence of age, race, physical activity, smoking, alcohol intake, and the poverty-income ratio. Trend tests were used to show whether the ORs increased with WC categories within each BMI category, and similarly with BMI categories within each WC category.

Stepwise linear regression analysis was used to assess the effect of BMI and WC on CVD risk profiles and to estimate the explained variance of CVD risk profiles by BMI and WC. BMI and WC were added to the regression models as continuous variables Initially, the R^2 was determined for a base model based on region, age, sex, smoke, drink, family income, education, dietary fat and salt, sedentary activity. Then, BMI and/or WC were added to the base modelto determine the additional variance above the base model that was explained by BMI and/or WC and to compare the standard β explained by BMI and WC, respectively.

All statistical procedures were performed using SAS software (version 8.2; SAS Institute Inc). Level of statistical significance was set at $P<0.05$ (two-sided).

RESULTS

The Characteristics of Subjects

The information on age, anthropometric indices and means for SBP, DBP, FPG, TC, LDL-C, HDL-C and TG in the subjects was shown in Table 1. A total of 41 087 individuals aged ⩾18 years participated in the survey. Among these participants were 19 567 men (47.6 %) and 21 520 women (52.4 %). Men had higher height, weight and WC than women ($P<0.05$). The level of SBP, DBP, and TG was higher ($P<0.05$), and the level of HDL-C was lower ($P<0.05$) for men than that for women.

TABLE 1

The Characteristics and CVD Risk Factors of the Subjects

	Men(*n*=19 557)		Women (*n*=21 520)	
	Mean	SD	Mean	SD
Age (year)	44.5	14.5	44.0	13.9
Height (cm)	166.2*	6.6	155.0	6.2
Weight (kg)	62.5*	10.6	54.9	9.4
BMI (kg/m^2)	22.6	3.2	22.8	3.4
WC (cm)	78.6*	9.7	75.0	9.4
SBP (mmHg)	121*	18	119	19
DBP (mmHg)	78*	11	76	11
FPG (mmol/L)	4.85	0.91	4.82	0.97
TC (mmol/L)	3.86	0.87	3.88	0.90
LDL-C (mmol/L)	2.02	0.74	2.02	0.74
HDL-C (mmol/L)	1.28*	0.32	1.33	0.29
TG (mmol/L)	1.12*	0.62	1.06	0.54

Note: CVD, cardiovascular decease, BMI indicates body mass index; WC, waist circumference; SBP, systolic BP; DBP, diastolic BP; FPG, Fasting plasma glucose level; TC, total cholesterol level; LDL-C, LDL cholesterol level; HDL-C, HDL cholesterol level; TG, triglyceride level. *$P<0.05$. Significant differences from sex, age adjusted by analysis of covariance.

Distributions of Subjects across BMI and WC Categories

The subject distributions categorized across WC and BMI categories were shown in Table 2. Among adults whose BMI<24 kg/m^2, the WC of 6.0% men were equal to or above 85 cm and WC of 8.1% women were equal to or above 80 cm; while among adults with normal WC, 11.0% of men, and 13.9% of women were overweight or obese with BMI⩾24 kg/m^2.

TABLE 2

Distributions of Subjects Across BMI and WC Categories (%)

WC Categories	BMI Categories			Total
	Normal Weight	Overweight	Obesity	
Male				
Normal WC	12 982 (94.0)	1 558 (33.8)	41 (3.6)	14 581 (74.6)
Class I High WC	793 (5.7)	2 557 (55.5)	334 (29.1)	3 684 (18.8)
Class II High WC	29 (0.3)	489 (10.6)	774 (67.4)	1 292 (6.6)
All	13 804 (70.6)	4 604 (23.5)	1 149 (5.9)	19 557 (100.0)
Female				
Normal WC	13 312 (91.9)	2 077 (38.8)	80 (4.8)	15 469 (71.9)
Class I High WC	1 096 (7.6)	2 717 (50.7)	595 (35.3)	4 408 (20.5)
Class II High WC	70 (0.5)	564 (10.5)	1 009 (59.9)	1 643 (7.6)
All	14 478 (67.3)	5 358 (24.9)	1 684 (7.8)	21 520 (100.0)

Note. Normal WC described WC<85 cm for men or <80 cm for women; class high I WC described WC value is 85 cm to 95 cm for men or 80 cm to 90 cm for women; class II high WC described WC value ⩾95 cm for men or ⩾90 cm for women.

Prevalence of CVD Risk Factors across BMI and WC Categories

The metabolic variables and disease prevalence in 9 subgroups were presented in Table 3 and Table 4.

With a few exceptions, the metabolic variables levels increased across normal WC, class I high WC and class II high WC categories within BMI categories in both men and women (P<0.05). In additionwith few exceptions in both sexes and in all BMI categories, the prevalence of high BP, high FPG, high TC, high LDL-C, low HDL-C, high TG, and dyslipidemia tended to be higher in subjects with higher WC values compared with those with normal WC values (P<0.05).

Within each of the 3 WC categories, the metabolic variables levels increased across normal weight, overweight, and obesity in both men and women (P<0.05); with few exceptions in both sexes and in all WC categories, the prevalence of high BP, high FPG, high TC, high LDL-C, low HDL-C, high TG, and dyslipidemia tended to be higher in subjects with higher BMI category compared with those with normal BMI values (P<0.05).

Odds Ratios of CVD Risk according to BMI and WC Categories

Results from the logistic regression were presented in Fig. 1.

Along with the increase of WC categories, the risk of high BP, high FPG, high TC, high LDL-C, low HDL-C, high TG, and dyslipidemia increased within each of the 3 BMI categories (P_{trend}<0.0001) except for high FPG, high TC, high LDL-C, high TG, and dyslipidemia in normal weight group, as well as high TC in obese group.

Along with the increase BMI categories, the risk of high BP, high FPG, high TC, high LDL-C, low HDL-C, high TG and dyslipidemia increased within each of the 3 WC categories (P_{trend}<0.0001) with few exceptions.

For blood pressure, compared with those with the normal-weight and normal WC, the normal-weight group with class I high WC and the overweight group with normal WC had a 1.84-1.90 fold increased risk. The ORs for the normal-weight group with class II high WC, the overweight group with class I high WC and the obesity group with class I high WC and class II high WC is 2.17-2.97; The ORs for the overweight and obesity group with class II high WC is 3.46-5.22. Similar results were found in the group with high FPG, high TC, high LDL-C, low HDL-C, high TG, and dyslipidemia within each of the 9 groups (Fig. 1, A-G).

TABLE 3

Comparison of Metabolic Variables and Disease Prevalence in Men with WC Categories within BMI Categories

	BMI Categories								
	Normal Weight			Overweight			Obesity		
	Normal WC	Class I High WC	Class II High WC	Normal WC	Class I High WC	Class II High WC	Normal WC	Class I High WC	Class II High WC
Age	43.7±14.9	48.3±13.7†	49.6±13.2†	43.9±13.3	46.0±13.2†	49.5±13.3†	47.4±15.5*	42.5±13.2†,*	46.3±13.7†
BMI	20.8±1.8	22.8±1.2†	22.2±1.6†	25.1±0.9*	25.8±1.1†,*	26.7±0.9†,*	31.3±4.7*	29.0±1.0*	30.2±1.9*
WC	73.2±5.5	87.6±2.2†	99.8±6.9†	80.6±3.7*	89.3±2.7†	97.7±2.8†	76.5±6.6*	91.4±2.5*	101.1±4.7*
Variables									
SBP	119±17	125±18†	126±25†	124±17*	126±17†,*	130±19†,*	128±23*	128±17†,*	133±19†,*
DBP	76±10	81±10†	83±14†	80±10*	82±10†,*	84±11†	81±12*	84±12†,*	87±11†,*
FPG	4.7±0.8	5.0±1.0†	5.1±0.7†	4.9±0.9*	5.1±1.1*	5.3±1.6†,*	4.9±0.6*	5.2±1.2†,*	5.3±1.3†,*
TC	3.74±0.84	4.06±0.92†	4.10±0.97†	3.95±0.89*	4.12±0.88†,*	4.11±0.84†*	4.08±0.86*	4.11±0.96†,*	4.28±0.87†,*
LDL-C	1.92±0.70	2.19±0.78†	2.23±0.85†	2.12±0.76*	2.24±0.78†,*	2.23±0.77†	2.19±0.78*	2.23±0.80†,*	2.32±0.79†,*
HDL-C	1.33±0.33	1.24±0.30†	1.23±0.26†	1.22±0.28*	1.18±0.27†,*	1.14±0.25†,*	1.20±0.28*	1.13±0.23†,*	1.11±0.23†,*
TG	0.98±0.50	1.27±0.65†	1.29±0.76†	1.22±0.65*	1.42±0.73†,*	1.50±0.77†,*	1.37±0.84*	1.53±0.75†,*	1.73±0.80†,*
Prevalence, %									
High BP	27.2	44.6†	41.0†	40.1*	48.3†,*	57.7†,*	41.5*	51.2†,*	65.6†,*
High FPG	4.6	9.7†	15.4†	8.6*	12.9†,*	20.0†	7.3*	15.0†,*	19.1†,*
High TC	5.0	11.7†	12.8†	7.4*	11.4†	10.8†	9.8*	12.0†,*	14.6†,*
High LDL-C	2.9	7.7	10.3†	5.5*	7.2†	6.7†	4.9*	7.5†	9.4†
Low HDL-C	15.7	23.8†	15.4†	25.4*	29.4†,*	33.5†,*	34.1*	35.3†,*	41.0†,*
High TG	7.5	19.0†	15.4†	17.3	27.1†	26.8†	22.0*	34.0†,*	43.7†,*
Dyslipidemia	24.9	43.5†	30.8†	40.6*	50.9†,*	55.4†,*	51.2*	59.6†,*	67.3†,*

Note. Unless otherwise indicated, data are given as mean±SD. BMI indicates body mass index; WC, waist circumference; SBP, systolic BP; DBP, diastolic BP; FPG, fasting plasma glucose level; TC, total cholesterol level; LDL-C, LDL cholesterol level; HDL-C, HDL cholesterol level; TG, triglyceride level. The unit of variables: age, year; BMI, kg/m^2; WC, cm; SBP and DBP, mmHg; FPG, TC, LDL-C, HDL-C and TG, mmol/L. $^{\dagger}P<0.05$, compared with the normal WC group within the same BMI category. $^{*}P<0.05$, compared with the normal weight group within the same WC category. All P values were adjusted for age.

TABLE 4

Comparison of Metabolic Variables and Disease Prevalence in Women with WC Categories within BMI Categories

	BMI categories								
	Normal weight			Overweight			Obesity		
	Normal WC	Class I High WC	Class II High WC	Normal WC	Class I High WC	Class II High WC	Normal WC	Class I High WC	Class II High WC
Age	41.8±14.1	51.6±13.7†	56.9±15.8†	41.9±11.6	48.1±11.9†	54.1±11.9†	41.7±11.0	45.6±11.2†,*	50.3±12.2†,*
BMI	20.8±1.9	22.6±1.2	22.2±1.9	25.0±0.9	25.8±1.1†	26.6±1.0†	30.5±3.4*	29.2±1.3	30.7±2.3
WC	69.5±5.3	82.8±2.5†	93.4±3.7†	75.6±3.5	84.1±2.7†	93.2±3.1†	72.9±6.8	85.9±2.6†,*	96.7±5.4†
Variables									
SBP	115±18	124±21†	132±27†	119±18	126±21†	130±21†,*	121±20*	127±19†,*	134±22†,*
DBP	73±10	78±10†	79±11†	77±10*	80±11†,*	81±10†	78±12*	81±10†,*	84±11†,*
FPG	4.7±0.8	4.9±1.0†	5.0±1.1†	4.8±0.9	5.0±1.1†	5.3±1.5†,*	4.9±0.7	5.0±0.9†	5.3±1.3†,*
TC	3.76±0.85	4.05±0.92†	3.99±0.83†	3.9±0.9*	4.11±0.94†,*	4.29±0.96†,*	3.87±0.84*	4.13±0.92†,*	4.27±0.97†,*
LDL-C	1.91±0.69	2.17±0.76†	2.1±0.69†	2.05±0.74	2.21±0.8†,*	2.35±0.83†,*	2.03±0.66	2.22±0.79*	2.34±0.82*
HDL-C	1.37±0.3	1.29±0.29†	1.3±0.29†	1.3±0.28*	1.27±0.27†,*	1.23±0.27†,*	1.27±0.26*	1.25±0.26*	1.23±0.27*
TG	0.95±0.46	1.19±0.61†	1.18±0.52†	1.11±0.57*	1.26±0.62†,*	1.41±0.68†,*	1.14±0.56*	1.33±0.67†,*	1.40±0.65†,*
Prevalence, %									
High BP	19.5	39.3†	55.7†	28.1*	41.2†,*	52.1†	35.0*	47.2†,*	60.9†,*
High FPG	4.0	8.4†	5.7†	6.2*	10.9†,*	16.8†,*	6.3*	10.8†,*	16.8†,*
High TC	5.7	11.7†	8.6†	8.1	12.7†,*	18.1†,*	6.3	14.5†,*	16.3†,*
High LDL-C	3.2	7.0†	4.3†	4.5*	8.1†,*	11.3†,*	3.8*	8.7†,*	10.6†,*
Low HDL-C	41.6	51.8†	54.3†	52.0*	56.7†,*	59.2†,*	57.5*	60.5†,*	64.1†,*
Hyper TG	5.9	15.5†	11.4†	11.8*	17.6†,*	23.0†,*	12.5*	21.7†,*	24.1†,*
Dyslipidemia	48.0	63.0†	62.9†	60.3*	67.6†,*	74.5†,*	62.5*	73.3†,*	77.7†,*

Note: Unless otherwise indicated, data are given as mean ± SD. BMI indicates body mass index; WC, waist circumference; SBP, systolic BP; DBP, diastolic BP; FPG, fasting plasma glucose level; TC, total cholesterol level; LDL-C, LDL cholesterol level; HDL-C, HDL cholesterol level; TG, triglyceride level. The unit of variables: age, years; BMI, kg/m^2; WC, cm; SBP and DBP, mmHg; FPG, TC, LDL-C, HDL-C and TG, mmol/L. $^{\dagger}P<0.05$, compared with the normal WC group within the same BMI category. $^{*}P<0.05$, compared with the normal weight group within the same WC category. All P values were adjusted for age.

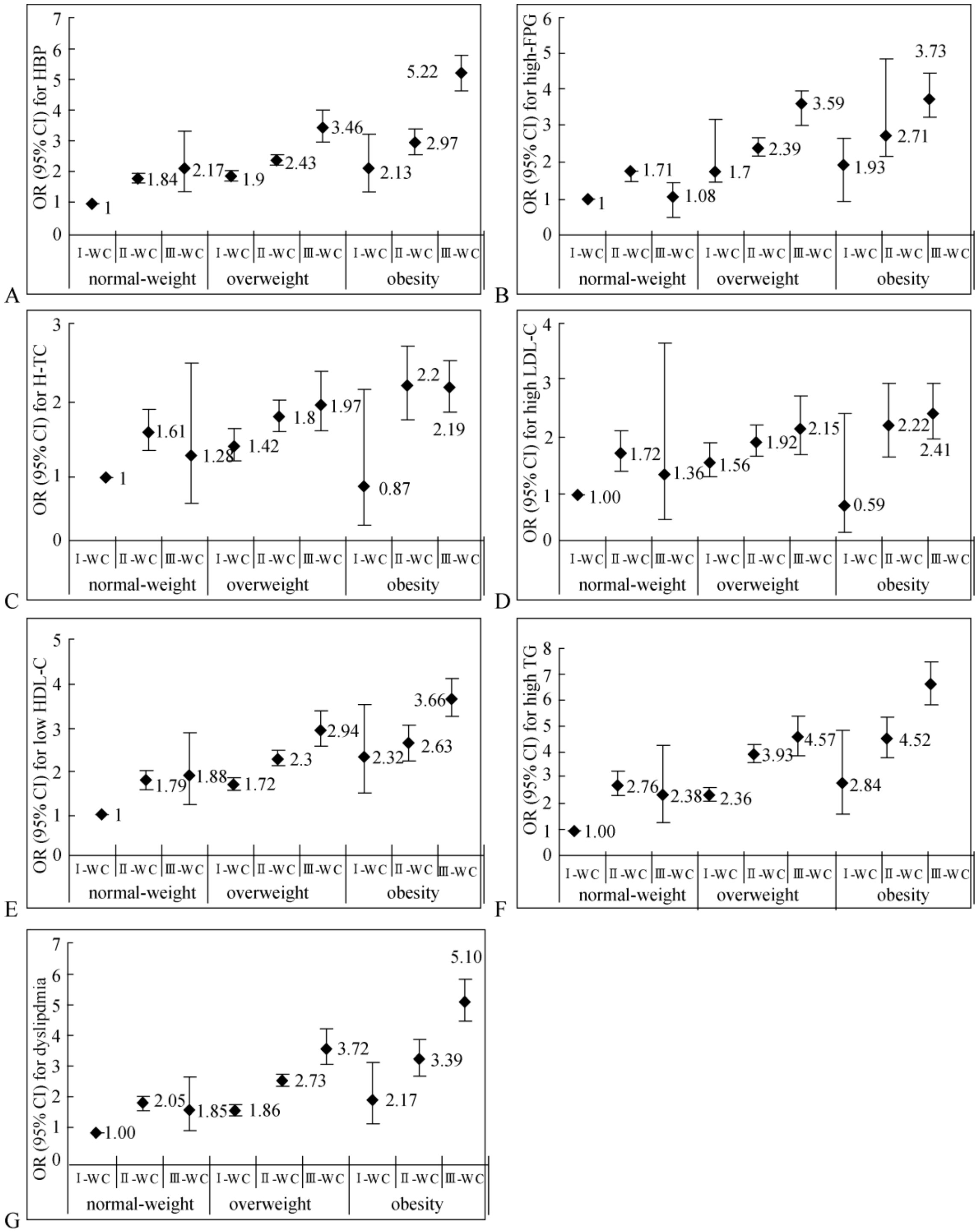

FIG. 1. Adjusted odds ratios (OR) for having high BP (A), high FPG (B), high TC (C), high LDL-C (D), low HDL-C (E), high TG (F) and dyslipemia (G) from logistic regression models for 9 subgroups.Subjects with a normal WC value within normal weight were used for the reference category (OR, 1.00). OR (95% CI) adjusted for region, age, sex, smoke, drink, family income, education, dietary fat and salt, sedentary activity. Ⅰ-WC: normal WC,WC<M85/F80 cm; Ⅱ-WC: class I high WC, WC M85-95/F80-90 cm; Ⅲ-WC: class II high WC, WC≥M95/F90 cm. The *P* values are <0.05 compared with the 1-WC within the normal weight, except for the normal weight group in Figs. B,C,D,F and obesity group in fig. G.The BMI and WC categories are described in “subjects and Methods” section.

Explained Variance of CVD Risk Profiles by BMI and WC

Using models of stepwise multivariate regression analysis, the variances in CVD risk factors explained by BMI and WC were listed in Table 5. The base model included region, age, sex, smoke, drink, family income, education, dietary fat, and salt, sedentary activity. The R^2 values for BMI and WC represent the additional variance (above the base model) explained by the 2 anthropometric variables. BMI explained from 1.5% to 7.8% of the variation in the CVD risk factors, while WC explained from 1.5% to 9.0% of the variation in the CVD risk factors. The combination of BMI and WC explained from 1.7% to 9.4% of the variation in the CAD risk factors. The variances in CVD risk factors explained by WC only and BMI only were quite similar, but a little bit larger (0.1-1.6 higher R^2 values) when combined WC and BMI.

For SBP and DBP, BMI had the higher standardized β value than other variables. For HDL-C and TG, WC had the higher standardized β value than other variables. The standardized β coefficients of WC slightly exceeded the values of BMI for all variables expect SBP.

TABLE 5

Variation (R^2) in CVD Risk Factors Explained by BMI and WC†

Dependent Variable	Variation(R^2) Explained by Base Model¶, %	Additional Variation(R^2) Explained by, %			Standardized β	
		BMI	WC	BMI and WC	BMI	WC
SBP	18.2	4.8	4.7	5.2	0.129	0.123
DBP	9.3	6.6	6.5	7.2	0.146	0.151
FPG	4.2	2.2	2.4	2.5	0.070	0.106
TC	11.7	1.5	1.5	1.7	0.053	0.092
LDL-C	10.0	1.7	1.8	1.9	0.064	0.091
HDL-C	4.2	5.5	6.1	6.4	-0.102	-0.179
TG	3.1	7.8	9.0	9.4	0.104	0.235

Note: BMI indicates body mass index; WC, waist circumference; SBP, systolic BP; DBP, diastolic BP; FPG, fasting plasma glucose level; TC, total cholesterol level; LDL-C, LDL cholesterol level; HDL-C, HDL cholesterol level; TG, triglyceride level. †Adjusted region, age, sex, smoke, drink, family income, education, dietary fat and salt, sedentary activity. ¶The base model included region, age, sex, smoke, drink, family income, education, dietary fat and salt, sedentary activity.

DISCUSSION

Primary result from this study indicated that those with WC values above the WGOC WC cutoff points and/or BMI value above the WGOC BMI cutoff points had higher risks for high BP, high FPG, and dyslipidemia compared with those below the WC and BMI cutoff points of WGOC.

Although the results from the previous report were developed on the basis of a meta-analysis on the relation between BMI, WC, and risk factors of related chronic diseases enrolled 13 population studies in the 1990s in the Chinese population[15], no new evidence confirmed that the influence of using combined WGOC BMI and WC cutoff points on predicting diseases risk in Chinese adults. In the present study and compared with those with the normal-weight and normal WC, both the indices levels and the odds ratios of CVD risk factors were significantly increased (decreased for HDL-C levels) along with the increase of WC and/or BMI, even when the effect of age, sex, income, education, sedentary activity and dietary factors were adjusted. Similar results were found in a representative sample of US adults[20] and Canadian women[21]. These studies provided useful information for predicting individuals at elevated risk. Clearly, obtaining a WC measurement in addition to a BMI provided important information on a person's diseases risk and gave the widespread use of the WGOC classification.

One concern is whether there is difference in the abilities of BMI and WC in predicting CVD risk factors. WC correlates with visceral fat mass and visceral adipose tissue is associated with metabolic disorders and CVD risk factors, after controlling for BMI[22-23]. These studies highlighted the role of WC in predicting increased CVD risk. In contrast, data from our study did not support the ideas. The result of this study indicated both BMI and WC were independent predictors of CVD risk factors when both BMI and WC were included in the regression model. From the stepwise liner regression analysis, the variation in CVD risk factors explained by WC only (1.5-9.0 R^2 values) and BMI only (1.5-7.8 R^2

values) were quite similar. The data suggested that, in Chinese adults, BMI and WC may provide the same predictive abilities for CVD risk.

Our observation is in consistent with a recent study which compared the impact of differences in waist circumference (WC) defined according to the International Diabetes Federation (IDF) and the Adult Treatment Panel III (ATP III) and body mass index (BMI) on cardiovascular disease risk factors in 402 apparently healthy volunteers of European[24]. This study showed BMI identified increased cardiovascular disease risk as effectively as determination of WC. The close relation between BMI and WC was in consistent with the findings by Ford *et al*.[25] using data from the National Health and Nutrition Examination Survey. The disagreement of these results might be due to the difference from race[26], age[27], study design, measurement method of WC, continuous or dichotomized variable for WC in the same regression model[28] and so on.

Another relevant question iswhether BMI coupled with WC predicts an increase in CVD risk factors better than does WC alone or BMI alone. Result from this present study indicated that the variation in CVD risk factors explained by WC only (1.5-9.0 R^2 values) and BMI only (1.5-7.8 R^2 values) were quite similar, but a little bit large(0.1-1.6 higher R^2 values)when combined WC and BMI, and showed the combination of BMI and WC provided the better prediction. The similar results were presented in other studies. Zhu *et al*.[29] have shown that using BMI and WC cutoff jointly, more individual at metabolic risk should be identified than using BMI or WC alone. In the present study, of men and women with normal weight, 7% had elevated levels in WC (>85 cm for men or >80 cm for women) while 12% Overweight/obese adults had normal WC. This indicated that some individual with risk of CVD might be missed if BMI or WC cutoff was used alone. Combinedmeasures of BMI and WC can help identify more adults who might have potentially elevations in CVD risk factors. Thus, results from our study have strengthened the fact that both BMI and WC are the screening CVD risk tools in China.

Our investigation has several limitations. Firstly, it was cross-sectional design which can be used to explore the associations between BMI and/or WC and disease but might not be used to explore the correlation of cause and effect. The prospective cohort study can better compare the prognostic value of BMI and WC in the prediction of CVD risk factors. Secondly, only CVD risk factors were considered in our analyses. There were data to suggest that knowledge of increased WC contributes to predicting other outcomes such as type 2 diabetes, coronary heart disease, stroke, certain types of cancer, even death, and so on.

In conclusion, *it was* found that the CVD risk was greater in individuals with higher WC and/or higher BMI values. The combined use of BMI and WC appeared to be more predictive of CVD risk factors. This finding underscored the importance of incorporating evaluation of the WC in addition to the BMI in clinical practice and provided substantive evidence for the WGOC recommendation of combined use of BMI and WC classifications.

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CONFLICT OF INTEREST STATEMENT

All authors declare no conflicts of interests.

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