Impact of Screening Criterion of Waist Circumference on the Detection of Obesity among Chinese Adults

Tingting Du¹*, Xingxing Sun²*, Lixian Xu², Xuefeng Yu¹§

¹ Department of Endocrinology, Tongji Hospital, Tongji medical college of Huazhong university of science & technology, Wuhan 430000, PR China.
² Department of Anesthesiology, School of Stomatology, Fourth Military Medical University, Xi'an 710000, PR China.

*These authors contributed equally to this work
§Corresponding author

Email addresses:

TTD: aduttsxx@163.com
XXS: sunxx1984@gmail.com
LXX: fly.hippocampus@gmail.com
XFY: xuefengyu188@gmail.com
Abstract

Background
Central obesity is thought to be more pathogenic than overall obesity and studies have shown that the association between waist circumference (WC) and mortality was strongest in those with a normal BMI. The objective of our study is to determine the prevalence of central obesity (WC ≥ 90 cm for men and ≥ 80 cm for women) within the category of body mass index (BMI) < 25.0 kg/m² and to examine the impact of performance of combined BMI and WC on the prevalence of obesity in Chinese adults.

Methods
We used data from the China Health and Nutrition Surveys (CHNS), which was conducted from 1989 to 2009, from which we included a total of 52023 participants aged ≥18 years.

Results
The age-standardized prevalence of central obesity was 16.3% (7.6% among men, and 24.6% among women) within the category of BMI < 25.0 kg/m². Among all participants, BMI (9.4%) substantially underestimated the prevalence of obesity when central obesity was taken into account (33.8%) (P < 0.01). More than 60% of the total number of individuals with obesity would be missed if solely BMI was measured. Similar significant trends were observed in all age groups, rural/urban settings, and educational attainment groups for both men and women.

Conclusions
Our results emphasize the importance of WC as a measure to monitor the prevalence of obesity. Given the stronger association between WC and metabolic risk and
associated mortality, measuring WC in addition to BMI is helpful in more accurately predicting obesity-associated health burden.

**Keywords:**
Body mass index, Waist circumference, Central obesity, General obesity, CHNS.

**Background**
Despite the evidence that BMI is a key component of choice to provide a standardized definition of obesity for the purposes of national surveillance and international comparisons [1], the prevalence of obesity as defined by body mass index (BMI) should be interpreted cautiously as it is a poor indicator of body fat distribution [2]. Epidemiological studies have revealed that excess deposition of fat in the abdominal region seemed to be a risk factor for numerous adverse health outcomes independently of general adiposity reflected by BMI [3-5]. Since waist circumference (WC) is strongly correlated with abdominal fat localization [6], it is a sensitive measure of central-type obesity. The prevalence of general obesity and central obesity as measured by BMI and WC, respectively, are well-documented and both of them have increased dramatically worldwide [7-14]. However, the rates of such an increase in general obesity and central obesity are different. Interestingly, significant increase in the prevalence of central obesity seems to be more pronounced than that of general obesity at the same periods in both China and other countries [8-10, 13, 15]. As a result, the diagnostic use of WC may to some degree have a particularly significant impact on the current epidemiological landscape of obesity. Studies have also illustrated that a larger increase in abdominal obesity may not be related to the change in BMI [9]. Hence, it is very likely that a great number of subjects with normal
category of BMI suffer from central obesity. However, information on the prevalence of central obesity within normal category of BMI is scant [9, 10], particularly in China. US National Institutes of Health recommended that WC be measured to screen for increased disease risk only among individuals in the overweight and obese categories of BMI [16]. However, relatively few health care professionals in China routinely measure WC, particularly in individuals with normal category of BMI. However, it is useful to measure WC as it could provide meaningful information beyond that provided by BMI. Hence, our study aims to describe the prevalence of central obesity within the category of BMI < 25.0 kg/m$^2$ and to evaluate the impact on the prevalence of obesity if both BMI and WC are measured in Chinese adults. We used data from the China Health and Nutrition Surveys (CHNS), a nationally representative cross-sectional health and nutrition survey in China, for our analysis.

**Methods**

**Study design**

The China Health and Nutrition Surveys (CHNS), an ongoing international collaborative project between the Carolina Population Center at the University of North Carolina at Chapel Hill and the National Institute of Nutrition and Food Safety at the Chinese Center for Disease Control and Prevention, are a series of large-scale, national cross-sectional surveys representative of the Chinese population that were designed to explore how the social and economic transformation of Chinese society is affecting the health and nutritional status of the Chinese population. They were conducted in 1989, 1991, 1993, 1997, 2000, 2004, 2006, 2009 and 2011. For each survey, the CHNS employed a stratified multistage, random cluster process to draw study sample from nine provinces (Liaoning, Heilongjiang, Jiangsu, Shandong, Henan, Hubei, Hunan, Guangxi and Guizhou) that vary significantly in terms of
geography, economic development, and health status. Counties in the nine provinces were stratified by income (low, middle and high) and a weighted sampling scheme was used to select randomly four counties in each province. Full details of the CHNS have been described elsewhere [17]. Each participant provided a written informed consent and the study was approved by institutional review board from the University of North Carolina at Chapel Hill and the National Institute for Nutrition and Food Safety, China Center for Disease Control and Prevention.

**Study population**
Since WC was collected initially in 1993, this study examined data from CHNS: 1993, 1997, 2000, 2004, 2006, and 2009. For the purposes of this article, data from the six surveys were pooled together. There were 64308 participants included in these six surveys. All participants were asked to complete a structured questionnaire which provided information on age, sex, degree of urbanization (urban vs. rural), educational attainment, a history of diabetes and so on. They also underwent detailed physical examinations that included weight, height, WC and blood pressure (BP). Participants were included in the present analysis if they were 18 years or older. Pregnant women or participants with missing information on age, WC, BMI, or BP, extreme or implausible WC (51 cm or 190 cm), BMI, or BP values were excluded from analysis. The remaining available 52023 subjects were included in our analysis.

**Measurements**
Weight, height, WC and BP were measured following standardized protocols from the World Health Organization (WHO) [18, 19]. Weight was measured with the participants wearing light clothing on a calibrated beam scale and height was measured without shoes using a portable stadiometer. BMI was calculated as weight (kilogram) divided by squared height (meter), rounded to the nearest tenth. WC was
measured with an inelastic tape to the nearest 0.1 cm at a midpoint between the bottom of the rib cage and the top of the iliac crest at the end of exhalation. BP was measured by trained examiners using a mercury sphygmomanometer at three different consecutive times at 3 – 5 min intervals on one visit. The three readings were averaged as the BP values in our data analysis. All physical examinations were performed at the same location and followed the same protocol at each study visit.

**Definitions**
According to WHO suggestions for Chinese adults [20], normal weight is defined as BMI < 25 kg/m², obesity is defined as BMI >= 27.5 kg/m², and central obesity is defined as WC >= 90 cm for men and >= 80 cm for women. According to the Seventh Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure guidelines (21), pre-hypertension is defined as systolic blood pressure (SBP) of 120-139 mmHg and/or diastolic blood pressure (DBP) of 80-89 mmHg, and hypertension is defined as SBP >= 140 mm Hg, DBP >= 90 mm Hg, and/or self-reported treatment of hypertension with antihypertensive medication in the last 2 weeks.

**Statistical analysis**
All statistical analyses were conducted using SPSS software (version 16.0 for windows; SPSS, Chicago, IL, USA). Continuous variables were presented as means and standard deviations (SD), and categorical variables were expressed as percentages. Individuals were grouped by age at the interview: 18-44 years, 45-65 years, and of 65 years or older. Analyses were stratified by sex, age group, degree of urbanization (urban vs. rural), and educational attainment. One-way ANOVA was applied to compare differences of continuous variables across groups. A Chi-square test was performed to assess differences of proportions across groups. The estimated
prevalence was age-standardized to 2000 census of the Chinese adult population by the direct method. Venn diagram was constructed as a visual display of central obesity based on WC and general obesity based on BMI. A two-tailed $P$ value of $< 0.05$ was considered to be statistically significant.

**Results**

Detailed information on the prevalence of central obesity in subjects with BMI $< 25$ kg/m$^2$ was shown for overall and by sex, age, degree of urbanization, and educational attainment in Figure 1. Among participants with BMI $< 25$ kg/m$^2$, the age-standardized prevalence of central obesity was 16.3% (7.6% among men, and 24.6% among women) (Figure 1a). The age-specific prevalence of central obesity increased with age, from 11.1% in the 18- to 44-year age group to 29.7% in the 65 years or older group. The observed trend was similar for the subgroup of both men and women, although the prevalence among women approximately tripled those of men in each corresponding age group. The rate of central obesity among women in the 45- to 64-year age group was 38.0%, which was double that of in the 18- to 44-year age group (15.8%). However, the proportion of men with central obesity increased moderately from 5.8% in the 18- to 44-year age group to 9.8% in the 45- to 64-year age group. Both men (13.5%) and women (44.7%) with central obesity reached their highest rates in the 65 years or older group (Figure 1b). Urban residents (17.1%) had higher prevalence of central obesity than their rural counterparts (14.9%) ($P < 0.05$); This was also the case in the subgroups of men and women (Figure 1c). However, the prevalence among women considerably exceeded those among men in each corresponding subgroup. There was a direct association between prevalence of central obesity and educational attainment among men, with 13.4% in the highest education category (university) and 6.4% in the lowest education category (less than high
school). However, there was no clear direct or reverse association between prevalence of central obesity and educational attainment among women, with 24.7% in the lowest education category, 26.2% in the middle education category (high), and 25.9% in the highest education category (Figure 1d).

The demographic and clinical characteristics of the participants with BMI < 25 kg/m² as stratified by waist circumference were listed in table 1. Compared with subjects with acceptable BMI (< 25 kg/m²) and WC (< 90/80 cm), individuals with central obesity experienced higher values of BMI, WC, SBP, and DBP, higher percentage of age >= 45 years, prehypertension, hypertension, and self-reported diabetes (all \( P < 0.01 \)).

The prevalence of obesity based on BMI (\( \geq 27.5 \text{ kg/m}^2 \)) alone and based on a combination of BMI and WC (BMI \( \geq 27.5 \text{ kg/m}^2 \) or WC \( \geq 90/80 \text{ cm} \)) were displayed for overall and by sex, age, degree of urbanization, and educational attainment in table 2. The age-standardized prevalence of obesity based on combined BMI and WC was 25.2% higher among all participants, 18.8% higher among men, and 31.2% higher among women than those based on BMI alone. The similar pattern was present among all age groups, urban and rural settings, and all educational attainment groups for both men and women. The gap of prevalence of obesity between based on a combination of BMI and WC and based on BMI alone was more evident in each female subgroup. Among those identified to have general obesity or central obesity based on a combination of BMI and WC, most individuals who were identified with general obesity according to BMI criterion (24.5%) were also with central obesity according to WC criterion and the remainder (3.3%) was diagnosed exclusively with general obesity based on BMI. In contrast, central obesity detected by WC occupied a great larger number (96.7%) of the group. A considerable 72.2%
was diagnosed exclusively with central obesity according to WC (Figure 2). This trend was similar in both genders, all age and educational attainment groups, and both urban and rural settings (Table 3). Of note, was that the proportions of exclusive central obesity based on WC surpassed 60% in each subgroup.

**Discussion**
The present data provide evidence that among Chinese adults with BMI < 25 kg/m², more than one sixth (16.3%) suffered from central obesity and women were significantly more likely to be central obese compared with men; Adults aged 45 years and older saw dramatically higher prevalence of central obesity than their younger counterparts; Urban residents experienced a more serious central obesity epidemic than rural residents; Male subjects with the highest educational attainment were more likely to suffer from central obesity than those with the lowest educational attainment, whereas women displayed very high prevalence of central obesity in each educational attainment group. Among all participants, BMI substantially underestimated the prevalence of obesity when central obesity was taken into account. The similar trend was observed in all age groups, urban/rural settings, and educational attainment groups for both men and women. Notably, more than two thirds of the total number of individuals with obesity would be missed if screening by BMI alone. As regards the prevalence of central obesity in subjects with BMI < 25 kg/m², the findings from our present study are in line with the results obtained in the Pilot Study of the Fitness of Australians, where 6.5% of men and 22.0% of women with BMI < 25 kg/m² are in a risk category based on WC [15]. In addition, two available data suggest an independent increase in the prevalence of abdominal obesity based on WC over and above the prevalence of general obesity based on BMI in adults [9, 10].
Besides, a number of studies demonstrate a steeper rise in the prevalence of abdominal obesity based on WC than the prevalence of general obesity based on BMI although these studies do not indicate whether the abdominal obesity has moved independently further than the general obesity [8, 10, 13]. The exact comparison of data between countries is somewhat difficult due to differences in study methods, age ranges, cut-off points for WC or BMI adopted to define central obesity or general obesity, and methods of age adjustment. However, it is unlikely that this difficulty would affect the key finding of our study that a considerable number of subjects with BMI < 25 kg/m² are at risk due to excessive WC (≥ 90/80 cm). This emphasizes the huge potential for preventing an unexpectedly large burden of obesity that remains to be realized in Chinese adults with BMI < 25 kg/m² because central obesity, besides being an independent risk factor, is also related to several adverse health outcomes, and also a recent study shows that among women, the association between WC and mortality was strongest in those with a normal BMI [21].

Especially troubling is the statistic in our present study that more than two thirds of the total number of individuals with obesity would be missed if WC is not taken into account for identification of obesity. An understanding of this issue is important for clinical reasons as weight management is a key strategy to the treatment of people with metabolic disturbance [22, 23], which increases the risk for atherosclerotic cardiovascular disease [24], as well as mortality from cardiovascular disease [25]. Therefore, obese cases with metabolic disturbance deserve the highest priority in risk factor modification. Evidence from studies show that achieving healthy weight through controlling weight adequately in obese patients could decreases blood pressure levels, improve lipid profile and insulin resistance [22], and then potentially reduce obesity-related morbidity and mortality. It is of particular concern that most
individuals in China on a visit to a doctor undergo assessment of body composition only by BMI for convenience. Given that weight reduction has important implications to reduce the burden of obesity-related disease, it is necessary and crucial to make efforts to promote the measurement of WC in clinical practice and public health campaigns to determine the missed diagnosis of exclusive central obesity, so that these patients are not deprived of proper medical interventions and managements. In addition, evidence from studies show that a substantial number of subjects with metabolic disturbance do not always conform to general obesity assessed by BMI. The degree of adiposity associated with a given level of BMI varies by racial and ethnic group. Relative to blacks, a BMI of 20–25 kg/m², which would be considered lean within blacks, corresponds to an elevated body fat content in Asian populations as they tend to have higher body fat percentages at this BMI level and possible less favorable health [26-28]. Indeed, BMI may simply reflect increased muscle mass in athletes, which does not brought them less favorable health as lean body mass is inversely related to all-cause mortality [29]. Hence, measuring WC could provide additional meaningful information beyond that provided by BMI for accurately predicting obesity-associated complications and related mortality and morbidity and an opportunity for proper medical advice and treatment.

The finding from the current study that central obesity is observed more commonly in females than in males is similar to the results from other studies [8, 11]. For instance, the prevalence of central obesity was 16.1% in men and 37.6% in women in the study of InterASIA [11]. One possible explanation for our tripling of central obesity prevalence in women might be attributable to the fact that we adopted a threshold of 80 cm to diagnose central obesity in women and the mean WC of women is close to this cut-off point (data not shown), it is likely that women are more prone to exceed
this threshold to be defined as central obesity when their WC increases. However, the root causes that lead to differential prevalence of central obesity in men and women warrants further study. Given the higher prevalence of central obesity in women, it is of great concern that future obesity-associated complications are expected to be higher in women.

Similar to the study of ENRICA [8], the frequency of central obesity increases with age in our study. Evidence from a study demonstrates that aging is associated with an increased accumulation of central fat [30]. China has experienced extremely rapid increases in economic development and national wealth over the last 20 years, the consequence of which is that lifestyle and the inhabitant environment in China have changed dramatically. Old populations within this transitional country, who have traditionally suffered from facing famine and extreme food shortages, may eventually come to experience the highest risk of central obesity. Simultaneously, China has been experiencing rapidly ageing population, which is expected to drastically increase the frequency of central obesity, too. The combined effects of the obesity epidemic and aging population suggest that urgent implementation of both weight control and obesity prevention programs in old adults should be prioritized.

Variations in the prevalence of central obesity between urban and rural settings in our study is also a characteristic observed in other population-based studies in China [11, 13, 31]. In China, usually urban residents have better living standards and higher income and have easier access to a high degree of westernization of dietary and more sedentary lifestyle than rural residents. The environmental, economic and social factors that follow urbanization might inevitably increase the prevalence of central obesity. Besides, studies indicate that the proportion of the Chinese population living in urban areas increased from 26% in 1990 to 36% in 2000 and this increasing
urbanization is expected to continue [32]. The higher prevalence of central obesity in urban residents represents significant public health implications in China.

Finally, our direct relationship between the prevalence of central obesity and educational level among men is in keeping with the results from the previous studies in China and the USA [9, 33]. However, the relationship between the prevalence of central obesity and educational attainment among women presented in our study is somewhat different from other studies [8, 9, 33]. It is unclear why men and women show the divergent patterns. However, women experience high prevalence of central obesity in each educational attainment group. Our results, together with those of previous studies [10, 11, 13], provide evidence that the burden of obesity also affects the lower social classes in China as educational attainment reflects socioeconomic status to some extent.

Our study has several limitations. First, it is a cross-sectional study that we cannot establish causal associations between obesity and sociodemographic factors (including gender, age group, degree of urbanization, and educational attainment). Second, the sample is partial nationally representative as only nine of China’s 31 provinces are included, and therefore, extrapolating results to the whole of China should be interpreted cautiously. Third, other social and environmental variables such as dietary habits and sedentary lifestyle, which would have impact on obesity, were not considered. However, our study has several strengths. Firstly, our study maintains a large sample size and includes individuals from urban and rural settings in China, which allows for exploring the prevalence of obesity over a range of demographic groups. Secondly, all study measurements are made by trained staff following a standard protocol. A vigorous quality assurance program and the same strict
methodology are used to ensure the quality of the data collection over the entire study period.

Conclusions
Nearly 1 in 6 Chinese adults with BMI < 25 kg/m^2 suffer from central obesity, which is more striking in women. The prevalence of obesity based on a combination of BMI and WC is significantly higher than that based on BMI alone among all participants. About 2 in 3 Chinese obese adults would be missed if solely BMI was adopted to define obesity. Results from our present study emphasize the importance of WC as a measure to monitor the prevalence of obesity. Given the stronger association between WC and metabolic risk, which underlie the obesity-related morbidity and mortality, Measuring both BMI and WC, besides being useful in more accurately describing the epidemiology of obesity, is also helpful in more accurately predicting obesity-associated health burden. In addition, the findings of our study have implications for detecting the prevalence of central obesity in adults with BMI < 25 kg/m^2 and for public health action directed toward controlling weight to prevent deleterious obesity-associated health outcomes.

Authors' contributions
XFY, TTD conceived of the study and drafted the manuscript. XXS and LXX completed all statistical analyses, draft the manuscript and helped to revise the manuscript. All authors have read and approved the final manuscript.

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Food Safety, China Center for Disease Control and Prevention, Carolina Population Center, the University of North Carolina at Chapel Hill and the Fogarty International Center for providing the data used here. We also thank the China-Japan Friendship Hospital and Ministry of Health for support for CHNS 2009 survey. All errors are the authors’ alone.

Competing interests
The authors declare that they have no competing interests.

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**Figures**

**Figure 1** - Age-standardized prevalence of central obesity among Chinese adults with BMI < 25 kg/m²

Age-standardized prevalence of central obesity by sex (a), age and sex (b), degree of urbanization and sex (c), and educational attainment and sex (d).
Figure 2 - Venn Diagram for obesity based on either WC and BMI criteria.
WC criterion for obesity: waist circumference (WC) $\geq 80$ cm for women. BMI criterion for obesity: body mass index (BMI) $\geq 27.5$ kg/m$^2$.

### Tables

**Table 1 - Demographic and clinical characteristics of the participants with BMI $< 25$ kg/m$^2$.**

<table>
<thead>
<tr>
<th></th>
<th>WC $&lt; 90/80$ cm</th>
<th>WC $\geq 90/80$ cm</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>44.2 (15.9)</td>
<td>51.5 (14.2)</td>
<td>$&lt;0.001$</td>
</tr>
<tr>
<td>Age $\geq 45$ y (%)</td>
<td>45.6</td>
<td>66.8</td>
<td>$&lt;0.001$</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>161.0 (8.7)</td>
<td>159.9 (8.8)</td>
<td>$&lt;0.001$</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>56.1 (10.0)</td>
<td>66.0 (12.1)</td>
<td>$&lt;0.001$</td>
</tr>
<tr>
<td>BMI (kg/m$^2$)</td>
<td>21.6 (3.0)</td>
<td>25.7 (3.6)</td>
<td>$&lt;0.001$</td>
</tr>
<tr>
<td>WC (cm)</td>
<td>74.7 (6.9)</td>
<td>90.5 (7.7)</td>
<td>$&lt;0.001$</td>
</tr>
<tr>
<td>SBP (mmHg)</td>
<td>117.4 (16.7)</td>
<td>125.1 (20.1)</td>
<td>$&lt;0.001$</td>
</tr>
<tr>
<td>DBP (mmHg)</td>
<td>75.3 (11.4)</td>
<td>81.4 (12.1)</td>
<td>$&lt;0.001$</td>
</tr>
<tr>
<td>Prehypertension (%)</td>
<td>45.2</td>
<td>61.4</td>
<td>$&lt;0.001$</td>
</tr>
<tr>
<td>Hypertension (%)</td>
<td>15.4</td>
<td>35.6</td>
<td>$&lt;0.001$</td>
</tr>
<tr>
<td>Self-reported diabetes (%)</td>
<td>0.7</td>
<td>3.1</td>
<td>$&lt;0.001$</td>
</tr>
</tbody>
</table>

Data are presented as means (SD) or percentages. WC, waist circumference; BMI, body mass index. SBP, systolic blood pressure; DBP, diastolic blood pressure. Prehypertension is defined as systolic blood pressure (SBP) of 120-139 mmHg and/or diastolic blood pressure (DBP) of 80-89 mmHg; Hypertension is defined as SBP $\geq 140$ mm Hg, DBP $\geq 90$ mm Hg, and/or self-reported treatment of hypertension with antihypertensive medication in the last 2 weeks.
### Table 2 - Age-standardized prevalence of obesity based on BMI alone or based on combined BMI and WC

<table>
<thead>
<tr>
<th></th>
<th>BMI &gt;= 27.5 kg/m^2 (%)</th>
<th>BMI &gt;= 27.5 kg/m^2 or WC &gt;= 90/80 cm (%)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>8.2</td>
<td>33.4</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Age &lt; 45 y</td>
<td>6.5</td>
<td>25.9</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>45 y ≤ Age &lt; 65 y</td>
<td>11.3</td>
<td>46.3</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Age &gt;= 65 y</td>
<td>11.3</td>
<td>47.5</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Urban</td>
<td>9.0</td>
<td>35.4</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Rural</td>
<td>7.5</td>
<td>31.0</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Less than high school</td>
<td>8.4</td>
<td>30.1</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>High school or similar</td>
<td>7.7</td>
<td>26.3</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>University or similar</td>
<td>8.7</td>
<td>28.4</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Men</td>
<td>8.1</td>
<td>26.9</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Age &lt; 45 y</td>
<td>7.5</td>
<td>23.1</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>45 y ≤ Age &lt; 65 y</td>
<td>9.3</td>
<td>33.4</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Age &gt;= 65 y</td>
<td>9.2</td>
<td>34.1</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Urban</td>
<td>9.3</td>
<td>30.3</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Rural</td>
<td>7.5</td>
<td>24.4</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Less than high school</td>
<td>7.4</td>
<td>18.7</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>High school or similar</td>
<td>9.5</td>
<td>24.0</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>University or similar</td>
<td>9.1</td>
<td>29.7</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Age/City/Level of Education</td>
<td>Overlap of Obesity</td>
<td>Either WC &gt;= 90/80 cm or BMI &gt;= 27.5 kg/m²</td>
<td>Exclusive WC &gt;= 90/80 cm</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>---------------------</td>
<td>---------------------------------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>Women Overall</td>
<td>8.3</td>
<td>39.5</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Age &lt; 45 y</td>
<td>5.5</td>
<td>28.4</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>45 y ≤ Age &lt; 65 y</td>
<td>13.2</td>
<td>58.3</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Age &gt;= 65 y</td>
<td>13.0</td>
<td>59.3</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Urban</td>
<td>8.8</td>
<td>40.2</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Rural</td>
<td>7.5</td>
<td>37.0</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Less than high school education</td>
<td>9.2</td>
<td>39.5</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>High school or similar education</td>
<td>5.5</td>
<td>28.4</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>University or similar education</td>
<td>4.3</td>
<td>25.9</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

BMI, body mass index; WC, waist circumference.

Table 3 - Overlap of obesity by BMI and WC criterion among Chinese adults

<table>
<thead>
<tr>
<th>Age/City/Level of Education</th>
<th>Overlap of Obesity</th>
<th>Either WC &gt;= 90/80 cm or BMI &gt;= 27.5 kg/m²</th>
<th>Exclusive WC &gt;= 90/80 cm</th>
<th>Exclusive BMI &gt;= 27.5 kg/m²</th>
<th>Both WC &gt;= 27.5 kg/m²</th>
</tr>
</thead>
</table>

Men 5745 62.4 (3586) 6.8 (390) 30.8 (1769)

Women 11836 77.0 (9108) 1.6 (187) 21.5 (2541)

Age < 45 y 5957 70.0 (4171) 5.2 (309) 24.8 (1477)

45 y ≤ Age < 65 y 8265 72.8 (6014) 2.5 (203) 24.8 (2048)

Age >= 65 y 3359 74.7 (2509) 1.9 (65) 23.4 (785)

Urban 6641 71.0 (4712) 3.3 (219) 25.7 (1710)

Rural 10940 73.0 (7982) 3.3 (358) 23.8 (2600)

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<table>
<thead>
<tr>
<th>Education Level</th>
<th>N</th>
<th>WC (%) (SD)</th>
<th>BMI (%) (SD)</th>
<th>PWC (%) (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than high school</td>
<td>13782</td>
<td>72.6 (10002)</td>
<td>3.0 (417)</td>
<td>24.4 (3363)</td>
</tr>
<tr>
<td>High school or similar</td>
<td>2360</td>
<td>71.1 (1677)</td>
<td>4.2 (99)</td>
<td>24.7 (584)</td>
</tr>
<tr>
<td>University or similar</td>
<td>1364</td>
<td>69.9 (954)</td>
<td>4.4 (60)</td>
<td>25.7 (350)</td>
</tr>
</tbody>
</table>

WC, waist circumference; BMI, body mass index. Proportions of exclusive central obesity is calculated as the number of exclusive central obesity divided by the number of obesity based on either WC $\geq 90/80$ cm or BMI $\geq 27.5$ kg/m$^2$. Likewise, proportions of exclusive general obesity and proportions of obesity based on both WC $\geq 90/80$ cm and BMI $\geq 27.5$ kg/m$^2$ are calculated by the similar procedure. All the prevalence in this table is not age-standardized to 2000 census of the Chinese adult population.
exclusive general obesity (3.3%, n=577)
both general obesity and central obesity (24.5%, n=4310)
exclusive central obesity (72.2%, n=12694)