Preventive Medicine 48 (2009) 272–278

Contents lists available at ScienceDirect

Preventive Medicine

journal homepage: www.elsevier.com/locate/ypmed

# Obesity related metabolic abnormalities: Distribution and geographic differences among middle-aged and older Chinese populations

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ARTICLE INFO

Available online 14 January 2009

*Keywords:*
Cross-sectional survey
Chinese
Overweight
Obesity
Metabolic syndrome
Dyslipidemias
Hypertension
Diabetes mellitus

ABSTRACT

*Objective.* To investigate geographic differences in obesity related metabolic abnormalities in middle-aged and older Chinese people with different levels of adiposity.

*Method.* Data from 3289 individuals aged 50–70 years who participated in a cross-sectional survey in 2005 (1641 from northern [Beijing] and 1648 from southern [Shanghai] China) were analyzed. Overweight or obesity and abdominal obesity were classified as body mass index ≥ 24 kg/m$^2$ and waist circumference ≥90 cm for men and ≥80 cm for women. Metabolic abnormalities (metabolic syndrome, dyslipidemia, hypertension and diabetes) were defined using the NCEP/ATPIII criteria.

*Results.* The overall prevalence of overweight and obesity was 53.4%, and the prevalence of abdominal obesity was 48.0%, respectively. The prevalence of the metabolic abnormalities was significantly higher among obese individuals than their normal weight counterparts. The association between obesity and the higher prevalence of the metabolic abnormalities was more pronounced among people who were overweight or obese in the north, especially for those living in rural areas.

*Conclusion.* The prevalence of obesity and associated metabolic abnormalities varies substantially among Chinese people in different geographic region. Individuals who were overweight or obese living in rural areas in the north contribute importantly to the north–south differences in obesity-related metabolic abnormalities among Chinese populations.



## Introduction

The prevalence of obesity is increasing and currently constitutes a major public health problem world wide (World Health Organization, 2000). Obesity is associated with leading causes of morbidity and mortality such as cardiovascular disease (CVD), cancer and type 2 diabetes mellitus (DM) (Willett et al., 1999) and related risk factors (Janssen et al., 2002). There is substantial evidence that individuals with different obesity phenotypes as defined by body mass index (BMI) or waist circumference (WC) have different levels of cardio-metabolic risk factors (Grundy et al., 2005). People who are overweight or obese have a more unfavorable metabolic profile than those with a normal weight (Huang et al., 2005; Janssen et al., 2002; Wildman et al., 2004, 2005). Although this also holds for people with abdominal obesity, these individuals have even worse metabolic profile than those without abdominal obesity given the same BMI (Janssen et al., 2002; Wildman et al., 2005).

Several studies have reported that there are geographic differences in health and cardio-metabolic risk factors between populations living in the north and south of China (Gu et al., 2003, 2005a,b; He et al., 2004; Reynolds et al., 2007; Zhao et al., 2004). These include the prevalence of overweight and obesity (Reynolds et al., 2007), DM (Gu et al., 2003), hypertension (Zhao et al., 2004), the metabolic syndrome (Gu et al., 2005b) and CVD risk factor clustering (Gu et al., 2005a). However, it remains unknown whether geographic differences in obesity related risk factors are also evident across different levels of adiposity among Chinese people. The present study aimed to investigate the geographical (north–south) differences in the prevalence of obesity and obesity

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doi:10.1016/j.ypmed.2009.01.004

related metabolic abnormalities including the metabolic syndrome, dyslipidemia, hypertension and DM among people with different obesity phenotypes in China. Additionally, urban–rural differences in obesity related metabolic abnormalities were evaluated.

## Methods and procedures

### *Study design and study population*

The Nutrition and Health of Ageing Population in China Study is a population-based cross-sectional study among non-institutionalized Chinese people aged 50 to 70 years in Beijing and Shanghai, China (Ye et al., 2007). This study was designed to investigate environmental and genetic factors associated with age-related chronic diseases. We selected Beijing and Shanghai, including their urban and surrounding rural areas, to represent the north and the south of China, respectively. Beijing and Shanghai are the biggest municipalities located in the north and south of China, respectively. There are many comparable aspects between the two municipalities regarding population size and socioeconomic development. Whereas, dietary and disease patterns are different between the two municipalities. Importantly, each municipality has typical food resources and lifestyles that accurately represent the northern and southern populations of China (Wang, 2005). The study was conducted simultaneously in both geographic locations from March to June 2005. A multistage sampling method was utilized to recruit the study participants. In each city, two urban districts and one rural district were chosen to represent people with high to low socio-economic status. In the sampling process, 400 participants from each urban district and 800 persons from each rural district were planned to be selected randomly from the eligible candidates listed in the residential registration record. The eligibility of the candidates has been described in a previous study (Ye et al., 2007). The protocol was approved by the Institutional Review Board of the Institute for Nutritional Sciences. Informed consent was obtained from the study participant. As a whole, 3378 participants completed the questionnaires, 3331 participants undertook the physical examination and 3357 participants provided blood samples, respectively. In all, 3324 participants completed all these measurements. 35 participants were subsequently excluded from the analysis because of missing data on age ($n=2$) and biochemical assay ($n=1$), fasting duration <7 h ($n=19$), age <50 ($n=11$) and age >70 ($n=2$). A total of 3289 eligible participants (1458 men and 1831 women) were included in the present analyses.

### *Data collection*

A home interview was conducted by trained physicians or public health workers from the local Centers for Disease Control and Prevention and community hospitals. Information on demographic factors, health status, health behavior and physical activity was collected

**Table 1**
Characteristics of study participants *in Beijing and Shanghai in 2005*

| | Beijing (North) | | Shanghai (South) | | *p* values[a] |
|---|---|---|---|---|---|
| | Urban ($n=829$) | Rural ($n=812$) | Urban ($n=811$) | Rural ($n=837$) | |
| Age (yr) | 58.9 (6.2) | 57.8 (5.6) | 58.8 (6.2) | 58.9 (5.9) | a, b, c |
| Sex (female, no., %) | 453 (54.6) | 447 (55.1) | 472 (58.2) | 459 (54.8) | ns |
| Education (yr, no., %) | | | | | a, b, c |
| 0–6 | 165 (19.9) | 402 (49.5) | 88 (10.9) | 705 (84.2) | |
| 7–9 | 331 (39.9) | 372 (45.8) | 344 (42.4) | 125 (14.9) | |
| ≥10 | 333 (40.2) | 38 (4.7) | 379 (46.7) | 7 (0.8) | |
| Marital status (no., %) | | | | | a, c |
| Married or living together | 749 (90.4) | 670 (82.5) | 697 (85.9) | 766 (91.5) | |
| Single or divorced or widowed | 80 (9.7) | 142 (17.5) | 114 (14.1) | 71 (8.5) | |
| Smoking (no., %) | | | | | a, b, c |
| Non-smoking | 507 (61.2) | 413 (50.9) | 578 (71.3) | 542 (64.8) | |
| Ex-smoking | 100 (12.1) | 108 (13.3) | 49 (6.0) | 73 (8.7) | |
| Current smoking | 222 (26.8) | 291 (35.8) | 184 (22.7) | 222 (26.5) | |
| Alcohol drinking (yes, no., %) | 313 (37.8) | 295 (18.0) | 184 (22.7) | 148 (17.7) | a, b, c |
| Physical activity (no., %) | | | | | a, b, c |
| Low | 58 (7.0) | 72 (8.9) | 26 (3.2) | 89 (10.6) | |
| Moderate | 392 (47.3) | 197 (24.3) | 589 (72.6) | 203 (24.3) | |
| High | 379 (45.7) | 543 (66.9) | 196 (24.2) | 545 (65.1) | |
| Body mass index (kg/m$^2$) | 25.6 (3.5) | 25.0 (3.8) | 24.2 (3.4) | 23.2 (3.3) | a, b |
| Waist circumference (cm) | 85.8 (10.1) | 85.9 (10.6) | 84.0 (10.3) | 79.4 (9.9) | a, b, c |
| Systolic blood pressure (mm Hg) | 141.8 (22.3) | 147.2 (22.3) | 133.8 (21.8) | 137.7 (21.3) | a, b, c |
| Diastolic blood pressure (mm Hg) | 78.9 (10.8) | 83.7 (10.5) | 79.9 (11.2) | 78.3 (9.9) | a, b, c |
| Total cholesterol (mmol/L) | 5.00 (0.98) | 4.85 (0.98) | 4.69 (0.99) | 4.25 (0.78) | a, b, c |
| HDL cholesterol (mmol/L) | 1.25 (0.31) | 1.34 (0.35) | 1.23 (0.34) | 1.29 (0.31) | a, b |
| LDL cholesterol (mmol/L) | 3.61 (0.99) | 3.38 (0.97) | 3.29 (0.96) | 2.78 (0.31) | a, b, c |
| Triglycerides (mmol/L) | 1.55 (1.13) | 1.36 (1.11) | 1.52 (1.15) | 1.13 (0.80) | a, b, c |
| Fasting glucose (mmol/L) | 6.1 (1.8) | 6.3 (2.1) | 5.6 (1.5) | 5.4 (1.3) | a, c |
| Metabolic syndrome[b] (no., %) | 419 (50.5) | 399 (49.1) | 352 (43.4) | 224 (26.8) | a, b, c |
| Dyslipidemia[c] (no., %) | 437 (52.7) | 346 (42.6) | 406 (50.1) | 192 (22.9) | a, b, c |
| Hypertension[d] (no., %) | 464 (56.0) | 537 (66.1) | 402 (49.6) | 393 (47.0) | a, b, c |
| Diabetes mellitus[e] (no., %) | 161 (19.4) | 132 (16.3) | 102 (12.6) | 52 (6.2) | a, b, c |
| Coronary heart disease (no., %) | 96 (12.3) | 69 (8.7) | 47 (5.8) | 15 (1.8) | a, b, c |
| Stroke (no., %) | 52 (6.3) | 38 (4.7) | 30 (3.7) | 13 (1.6) | a, b |
| Family history of diabetes (no., %) | 178 (21.9) | 81 (10.0) | 151 (18.8) | 44 (5.3) | a, b, c |
| Family history of CVD (no., %) | 261 (31.5) | 185 (22.8) | 21 (27.3) | 74 (8.8) | a, b, c |

HDL cholesterol = high-density lipoprotein cholesterol; LDL cholesterol = low-density lipoprotein cholesterol.

[a] Denotes $p<0.05$ for region (north vs. south); b denotes $p<0.05$ for residence (urban vs. rural); c denotes $p<0.05$ for interaction (region*residence); ns denotes non-significance.

[b] Metabolic syndrome, updated NCEP/ATP III criteria for Asian Americans.

[c] Dyslipidemia, total cholesterol ≥ 6.2 mmol/L and/or LDL cholesterol ≥ 4.1 mmol/L and/or HDL cholesterol < 1.0 mmol/L and/or triglycerides ≥ 2.3 mmol/L and/or current use of lipid-lowering medications.

[d] Hypertension, systolic blood pressure ≥ 140 mm Hg and/or diastolic blood pressure ≥ 90 mm Hg and/or current use of anti-hypertensive medications.

[e] Diabetes mellitus, fasting glucose ≥ 7.0 mmol/L and/or current use of anti-diabetic medications and/or diagnosed diabetes by a physician.