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Prevalence and cardiometabolic risks of normal weight obesity in Chinese population: A nationwide study

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Abstract *Background and aims:* Several studies have reported increased cardiovascular risks in normal weight obesity (NWO) populations. We aimed to investigate the prevalence of NWO and its relationships with cardiometabolic risks in Chinese patients.
Methods and results: The data were from the 2007–2008 China National Diabetes and Metabolic Disorders Study. The body fat (BF) was measured using the biological impedance method. NWO was defined as a normal BMI (18.5–23.9 kg/m^2) but with excess BF% (BF% $\geq$ 24% for men and $\geq$33% for women). 23,748 people (9633 males and 14,115 females) were enrolled and the prevalence of NWO was 9.5% for men, 6.06% for women. The prevalence risks of diabetes (odds ratio [OR]1.519, 95% confidence interval [CI] 1.262–1.828), Framingham risk score (FRS) $\geq$10% (OR 1.973, 95% CI 1.596–2.439), hypertension (OR 1.525, 95% CI 1.333–1.745), and metabolic syndrome Mets (OR 2.175, 95% CI 1.920–2.463) significantly increased in the NWO group compared with the normal group. Subgroup analyses showed that, after ruling out participants with abnormal waist circumference, the male group had similar findings to the overall population; but in the female group, the prevalence risks of FRS $\geq$10%, hypertension, and Mets increased, although the risk of diabetes did not.
Conclusion: NWO is in a relatively high prevalence in Chinese population, and the prevalence of NWO is higher in Chinese men compared to Chinese women. Cardiometabolic risks significantly increase in an NWO population, and such risks persist after excluding the effect of abdominal obesity.

Introduction

Obesity has become a highly prevalent disease worldwide, and overweight and obesity are the fifth leading risk factors for death. Although body mass index (BMI) is currently the standard diagnostic assessment method for overweight and obesity, it cannot accurately estimate body fat percentage (BF%) [1]. Research has shown that metabolism may be normal in some patients with a BMI of

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≥30 kg/m^2 but can also be abnormal in other patients with a BMI of 18.5–30.0 kg/m^2. Thus, the role of BMI in the assessment of obesity has been constantly challenged along with advances in relevant studies.

The status of normal BMI but with increased BF% is defined as normal weight obesity (NWO) [2]. Populations with NWO are often neglected because they have no obvious changes in body shape. However, a number of studies have reported increased cardiovascular risks in NWO populations [3–6], and NWO may even increase the risk of death from cardiovascular disease in the elderly [7]. Moreover, NWO populations tend to develop some characteristic metabolic statuses such as low-grade proinflammatory state, increased oxidative stress, insulin resistance, and lipid abnormalities, which can lead to increased risks of metabolic syndrome and cardiovascular disease-associated deaths [2–4,8–11]. Notably, nutrigenomic studies have shown that NWO may interfere with the relationships between genetic polymorphisms and individual health [8,12–14].

However, the prevalence of NWO differs among different populations and may be as high as 30% or more in people with a normal BMI [3,15]. In most Caucasian populations, the prevalence of NWO in females is much higher than that in males [11,16]. It has even been reported that there are almost no NWO case in males [11]. While few studies have investigated the prevalence of NWO in Asian populations, two studies from South Korea and one from Malaysia found that the prevalence of NWO fluctuated from 19% to 21% among women and was about 4.5% in men [17–19].

Compared with other populous countries with the same BMI conditions, the BF% tends to be high in China [20,21]. In our previous studies, we have calculated the cut-off value of BF% in the Chinese population based on the prevalence of cardiometabolic risks [22]. We found that the cut-off value of BF% was lower in the Chinese than in Caucasian populations. In addition, the cut-off value of BMI for diagnosing diabetes in the Chinese also differed from that of Caucasian populations.

Therefore, because there is a lack of relevant research, we aimed to investigate the prevalence of NWO and its relationships with cardiometabolic risks in a cohort of Chinese patients.

Methods

Study population

Our research was part of the China National Diabetes and Metabolic Disorders Study. All the research participants were permanent Chinese residents aged 20 years or older between June 2007 and May 2008. By using a multi-stage cluster and stratified sampling method, we surveyed populations aged 20 years or older. First, six geographical areas (the North-East, North, East, South, West, and Southwest) were used; second, Beijing, Shanghai, and 12 provinces/autonomous regions were selected based on the degree of urbanization (including metropoles [Beijing, Shanghai, and capital cities of the included provinces], mid-sized city, county seats, and rural townships) and economic development levels (based on the gross domestic product [GDP] of each province). The random sampling method was applied: first, one mid-sized city, one developed county, one underdeveloped county, and a capital city were selected in each province/autonomous region; second, in each city and county the city districts, counties, and rural townships were randomly selected. A total of 152 street districts and 112 rural village were ultimately selected, and 46,239 participants completed the survey [23]. However, because BF% was not the primary endpoint of the survey, the BF% measurement was not performed in some centers. Therefore, the BF% data were not available for 22,313 participants and were thus excluded. In addition, we excluded 106 participants aged >75 years, and 21 without BMI data. We also excluded 46 participants with a BF% above 60% and 5 participants with a BF% below 5% due to the possible measurement error [24]. The remaining 23,748 participants entered the final (Fig. 1).

Written informed consent was obtained from each participant prior to data collection. The 17 institutional review boards' approvals covered every participant in the study.

Data collection

All participating physicians and nurses were uniformly trained. Data including demographics, personal history, family history, and unhealthy habits were collected using a standardized questionnaire. Body height, weight, and blood pressure were measured by using a standard method. A trained investigator used a measuring tape around the abdomen at the midpoint of the line between the anterior superior iliac spine and the lower edge of the twelfth rib at the horizontal level to obtain the waist circumstance (WC) (accurate to 0.1 cm). To measure blood pressure (BP), the participants were asked to relax for more than 5 min before the BP was measured twice on the right upper arm with a mercury sphygmomanometer. The BF was determined using a foot-to-foot Tanita body composition analyzer (TBF-300WA, Tanita Corporation, Tokyo, Japan).

Participants were required to fast overnight for at least 8 h before obtaining the measurements. Those without a history of diabetes received a 75-g oral glucose tolerance test (OGTT), whereas those with a history of diabetes were given a steamed bread meal test that contained approximately 80 g of complex carbohydrates for safety reason [23]. Fasting blood specimens were collected for measuring triglyceride, high-density lipoprotein, low-density lipoprotein, total cholesterol, and insulin. Homeostasis model assessment of insulin resistance (HOMA-IR) was applied for the evaluation of insulin resistance (HOMA-IR = fasting insulin × fasting glucose/22.5) [25]. All laboratory measurements conformed to standards and certification plans.

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