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Sex-specific relationship between visceral fat index and dyslipidemia in Chinese rural adults: The Henan Rural Cohort Study

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ABSTRACT

The study aimed to explore the relationship between visceral fat index (VFI) and dyslipidemia and evaluate the efficiency of VFI as a marker for identifying dyslipidemia in Chinese rural adults. The cross-sectional study recruited 35,832 aged 18–79 years eligible participants from The Henan Rural Cohort Study. VFI was measured by bioelectrical impendence methods and classified into sex-specific quartiles. Fasting blood samples were collected. Logistic regression models with VFI as a categorical variable and restricted cubic spline regression models with VFI as a continuous variable were performed to obtain odds ratios (*ORs*) and 95% confidence intervals (*CIs*). Receiver-operating characteristic (ROC) curve was conducted to evaluate the identifying performance of VFI. The age-standardized prevalence of dyslipidemia was 29.80% and 26.01% in male and female, respectively. Increasing VFI quartiles were significantly positively related to the risk of dyslipidemia and its components ($P_{\text{for trend}} < 0.01$). The adjusted *ORs* (95% *CIs*) for per 1-SD increase in VFI were 2.11 (2.02–2.20) and 1.52 (1.47–1.56) in male and female, respectively, and dose-response relationships were observed in both genders ($P_{\text{for nonlinearity}} < 0.01$). In addition, area under the curves (AUCs) in male (0.697) was larger than in female (0.655) ($P < 0.05$). VFI was significantly positively related to the risk of dyslipidemia and its components, and the risk was shown to be more prominent in male. Meanwhile, dose-response relationships were observed in both genders. Furthermore, VFI might be a relatively effective marker for identifying dyslipidemia in male, but not in female.

1. Introduction

Dyslipidemia referring to the abnormal quantity and quality of lipids is a well-established risk factor for various cardiovascular diseases (CVDs) (Ford et al., 2003; Parhofer, 2015; Pisciotta et al., 2015). It affected over half of the middle-aged and elderly and became increasingly prevalent in China (Li et al., 2005; Wang et al., 2011; Luo et al., 2014). Result from a meta-analysis involving a total of 387,825 participants showed that the pooled prevalence of dyslipidemia was estimated to be 41.9% in Chinese adults (Huang et al., 2014), which was more than doubled in the past decade (Li et al., 2005). The reasons for the escalating rates of dyslipidemia in China have still not been properly characterized but likely attribute to demographic changes (such as population aging) and increasing levels of obesity caused by dramatic lifestyle changes (such as westernization of diet pattern and declining physical activity) coupled with rapid economic development and urbanization (Zhai et al., 2014; Adair et al., 2014). Dyslipidemia has posed a serious threat to the health of the general population.

Obesity, particularly visceral obesity, is strongly related to dyslipidemia and many other metabolic disturbances (Kaess et al., 2012; Tchernof and Despres, 2013; Jung and Choi, 2014; Hamdy et al., 2006; Hwang et al., 2016; Fujibayashi et al., 2016). One study conducted by Hwang et al. (2016) found that baseline and change in visceral fat tissue were linked to future atherogenic dyslipidemia, nevertheless,

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subcutaneous fat tissue, body mass index (BMI) and waist circumference (WC) were not. Another study reported that the accumulation of visceral fat might precede the occurrence of metabolic disorders (Freedland, 2004). Furthermore, the distribution and accumulation of abdominal visceral fat was the most deleterious in Chinese individuals than Europeans at a given BMI and WC level (Nazare et al., 2012). Therefore, early and accurate assessment of visceral obesity is urgently needed in terms of identifying individuals at high risk of dyslipidemia.

Magnetic resonance imaging (MRI) and computed tomography (CT), as the gold standards for determining visceral obesity, are inappropriate for large-scale epidemiological investigation due to their time-consuming, costly and invasive characteristics (Rossner et al., 1990; Wang et al., 2014). BMI and WC were well-known and frequently used anthropometric indices to define general obesity and abdominal obesity, respectively (Chen, 2008; Choo, 2002; Zeng et al., 2014). However, BMI failed to distinguish between lean mass and fat mass, and WC couldn't differentiate between subcutaneous and visceral fat. Visceral fat index (VFI), which was utilized to reflect body fat reserved around some important internal organs, was an accurate and reliable indicator for evaluating visceral obesity (Amato et al., 2014), and several studies have reported that VFI was highly relevant to visceral fat measured by the gold standard methods (Oh et al., 2013; Amato et al., 2010).

Currently, study regarding the relationship between VFI and dyslipidemia has not been documented yet. In previous studies, visceral fat tissue has often been evaluated by MRI or CT (Kaess et al., 2012; Hwang et al., 2016; Fujibayashi et al., 2016), which are unrealistic to apply in large populations. Thus, the purposes of the present study were to explore the relationship between VFI and dyslipidemia in Chinese rural adults, and to examine the performance of VFI as a marker for identifying dyslipidemia.

2. Methods

2.1. Study population

A sample of 39,259 participants were recruited from The Henan Rural Cohort Study (Registration number: ChiCTR-OOC-15006699), which was launched in five rural areas (Tongxu county of Kaifeng city, Yima county of Sanmenxia city, Suiping county of Zhumadian city, Xinxiang county of Xinxiang city and Yuzhou county of Xuchang city) in Henan province, China, during July 2015 and September 2017. In brief, a multistage stratified random cluster sampling conducted in eligible candidates listed in the residential registration record was adopted to obtain the target population. Stage 1, five rural areas located in the east, west, south, north and central of Henan province were selected by simple cluster sampling. Stage 2, 1–3 townships in each county were selected by the local Centre for Disease Control and Prevention, taking into account the adherence of the population and local medical conditions. Stage 3, all permanent residents who were 18–79 years and signed informed consent in each rural village of the selected townships were selected as the study subjects. We excluded individuals with self-report cancer (n = 332), heart failure (n = 82), kidney failure (n = 18) or stroke (n = 2613), and those with missing information concerning VFI (n = 256) or diagnosis of dyslipidemia (n = 48). Additionally, the subjects who were pregnant (n = 51) or on a diet (n = 27) were also excluded. The final analytic samples were 35,832 (14,006 males and 21,826 females).

2.2. Data collection

The survey was conducted in the participants' residential sites by well-trained investigators, following the standard operating procedures (Chen and Lu, 2004) with stringent levels of quality control. Data on socio-demographic characteristics, lifestyle behaviors such as smoking, alcohol drinking and diet, personal and family medical history, and family history of diseases were collected by face-to-face structured questionnaire interviews. The present study was approved by Zhengzhou University Life Science Ethics Committee. All of our work adhered to the Declaration of Helsinki. Written informed consents were signed by all respondents prior to data collection.

2.3. Assessment of visceral fat index

Physical measurements such as height, weight, waist circumferences, and visceral fat index (VFI) were performed by special trained research staff using calibrated equipment. VFI was assessed by bioelectrical impendence methods using Omron body fat and weight measurement device (V-body HBF-371; Omron, Kyoto, Japan). In order to obtain the data of VFI from the resistance between the two hands and feet, an individual's height, weight, age and gender need to be input into the instrument, with the subjects standing on the footplate barefoot and holding the handle electrodes in both hands horizontally forward. VFI was divided into four groups on the basis of sex-specific quartiles: Q1:1-, Q2: 8-, Q3:11-, Q4: 14- for male; and Q1:1-, Q2: 5-, Q3: 8-, Q4: 10- for female.

2.4. Assessment of potential covariates

Current smokers were defined as smoking at least one cigarette per day in the past 6 months, and current drinkers were defined as alcohol drinking (liqueur, beer, wine, and other alcohol beverages) at least 12 times per year. According to Chinese dietary guidelines (Wang et al., 2016), an average daily intake of > 500 g of vegetables and fruits per person was considered as more vegetables and fruits intake, and an average daily intake of > 75 g of meat from livestock and poultry per person was considered as high fat diet. Participants whose parents or siblings had a history of disease were recorded as having family history of diseases.

Venous blood sample was drawn from each participant after an overnight fast for at least 8 h. Serum was immediately centrifuged at 3000 rpm for 10 min, 4 °C, and was further assayed for triglycerides (TG), total cholesterol (TC), high density lipoprotein cholesterol (HDL-C), low density lipoprotein cholesterol (LDL-C) with an automatic chemistry analyzer (Cobas C501, Roche Diagnostics GmbH).

2.5. Ascertainment of dyslipidemia

According to Guidelines on Prevention and Treatment of Dyslipidemia for Chinese Adults (2007), TC was defined as high when it was ≥6.22 mmol/L, TG was defined as high when it was ≥2.26 mmol/L, HDL-C was defined as low when it was < 1.04 mmol/L, LDL-C was defined as high when it was ≥4.14 mmol/L. Dyslipidemia was defined as the presence of one or more abnormal serum lipid concentrations or using of anti-dyslipidemia medications in the last two weeks.

2.6. Statistical analysis

Descriptive analyses were conducted according to sex-specific VFI quartiles using one-way analysis of variance or chi-square test as appropriate to compare the differences between groups.

The age standardized prevalence of dyslipidemia was estimated based on the 2010 census data of the Chinese adult population.

Binary logistic regression models were performed to obtain odds ratios (*ORs*) and 95% confidence intervals (*CIs*) for dyslipidemia in relation to VFI quartiles and per 1-SD increase of VFI. For nonlinear relationship between continuous VFI levels and risk for dyslipidemia, we applied restricted cubic spline regression to model the dose-response relationship using 5 knots placed at the 5th, 25th, 50th, 75th and 95th percentiles of VFI levels, respectively, with 8 in male and 5 in female (approximate the lowest sex-specific VFI quartile) as the reference.