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Original Article

The discriminative ability of waist circumference, body mass index and waist-to-hip ratio in identifying metabolic syndrome: Variations by age, sex and race

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ABSTRACT

Objectives: Many studies have suggested that there is variation in the capabilities of BMI, WC and WHR in predicting cardiometabolic risk and that it might be confounded by gender, ethnicity and age group. The objective of this study is to examine the discriminative abilities of body mass index (BMI), waist circumference (WC) and waist–hip ratio (WHR) to predict two or more non-adipose components of the metabolic syndrome (high blood pressure, hypertriglyceridemia, low high density lipoprotein-cholesterol and high fasting plasma glucose) among the adult Malaysian population by gender, age group and ethnicity.

Methods: Data from 2572 respondents (1044 men and 1528 women) aged 25–64 years who participated in the Non Communicable Disease Surveillance 2005/2006, a population-based cross sectional study, were analysed. Participants' socio-demographic details, anthropometric indices (BMI, WC and WHR), blood pressure, fasting lipid profile and fasting glucose level were assessed. Receiver operating characteristics curves analysis was used to evaluate the ability of each anthropometric index to discriminate MetS cases from non-MetS cases based on the area under the curve.

Results: Overall, WC had better discriminative ability than WHR for women but did not perform significantly better than BMI in both sexes, whereas BMI was better than WHR in women only. Waist circumference was a better discriminator of MetS compared to WHR in Malay men and women. Waist circumference and BMI performed better than WHR in Chinese women, men aged 25–34 years and women aged 35–44 years.

Conclusions: The discriminative ability of BMI and WC is better than WHR for predicting two or more non-adipose components of MetS. Therefore, either BMI or WC measurements are recommended in screening for metabolic syndrome in routine clinical practice in the effort to combat cardiovascular disease and type II diabetes mellitus.

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1. Introduction

Previous studies have shown that general obesity is positively associated with increased cardiovascular diseases (CVD) and diabetes [1], while abdominal obesity increases the risk of all cause, cardiovascular and cancer mortality [2,3]. Anthropometric indices (body mass index, waist circumference, waist–hip ratio) are the most widely used methods to measure general and abdominal obesity in large epidemiological studies, body mass index (BMI) for general adiposity while waist circumference (WC) and waist–hip ratio (WHR) are proxy measures of abdominal adiposity. There is high correlation between both BMI and WC and total body adipose tissue mass. But, WC is reportedly better than BMI in estimating intra-abdominal fat tissue and provides a measure of body fat distribution [4].

Many studies have suggested that there is variation in the capabilities of BMI, WC and WHR in predicting cardiometabolic risk and that it might be differ by gender [5], ethnicity [6] and age

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group [7]. Therefore, our study objective is to evaluate the discriminative abilities of BMI, WC and WHR in predicting two or more non-adipose components of the metabolic syndrome (high blood pressure, hypertriglyceridemia, low high density lipoprotein-cholesterol and high fasting plasma glucose) in the adult Malaysian population by gender, age group and ethnicity.

2. Methods

2.1. Study design and sampling

This study was approved by the National Institutes of Health, Ministry of Health, Malaysia (NMRR-11-319-9194). We used data from the MyNCDS-1 study which was a cross-sectional, population-based baseline survey on non-communicable diseases and its risk factors conducted in 2005–2006 (Malaysia NCD Surveillance 2006). The MyNCDS-1 study was approved by the Medical Research Ethics Committee of the Ministry of Health, Malaysia. Participants were recruited from all thirteen states and one federal territory (Kuala Lumpur) in Malaysia through a complex multistage cluster sampling using the year 2000 National Household Sampling Frame with the assistance of the Department of Statistics, Malaysia. A sample size of 3040 subjects was calculated based on the lowest NCD risk factor prevalence, i.e. prevalence of obesity of 5% [8], precision of 1.2%, design effect of 2 and non-response rate of 20%. Stratifying variables were state/federal territory and setting (urban/rural), with enumeration blocks (EBs), living quarters (LQs) and households as the primary, secondary, and elementary sampling units respectively. The numbers of EBs and LQs selected per state were based on the desired sample size and proportionate to the 2005 Malaysian adult (age 25–64 years) population size for each state. In all, a total of 398 EBs and 1683 LQs were selected. All household members in all households in the selected LQs who met the eligibility criteria were included in the sample. The inclusion criteria were Malaysian citizen and aged between 25 and 64 years. The exclusion criteria were pregnant women, mentally ill, very ill, and institutionalised individuals [9].

2.2. Anthropometric and blood pressure measurements

Height was measured without footwear to the nearest 0.1 cm using a stadiometer. Weight was measured to the nearest 0.1 kg using a balance beam scale or SECA beam scale with minimal clothing and no shoes. Body mass index was calculated as weight in kilograms divided by the square of height in metres. Waist circumference (WC) was measured directly over skin or light clothing to the nearest 0.1 cm at the smallest circumference below the rib cage and above the umbilicus while standing with abdominal muscles relaxed. Hip was measured directly over the skin to the nearest 0.1 cm at largest circumference of the buttocks-hip area while the person is standing. Waist–hip ratio was calculated as waist circumference in centimetres divided by hip circumference in centimetres. Resting blood pressure (BP) was measured by the auscultatory method. BP was measured two times, or three times if the first two readings differed by more than 10 mmHg, at no less than 30 s between measurements, and averaged.

2.3. Biochemical measurements

Five ml of venous blood samples after overnight fasting were collected for the measurement of total cholesterol, HDL-cholesterol, triglycerides and glucose. All blood samples were kept in dry ice prior to laboratory analysis. Concentrations of HDL cholesterol, triglyceride and fasting blood glucose were measured using enzymatic assay kits (Automated HDL Cholesterol Flex®, Triglyceride Flex® and Glucose Flex®). Total cholesterol was determined using an enzymatic colorimetric method.

2.4. Sociodemographic factors

Sociodemographic factors captured were residential area (urban/rural), gender, ethnicity, age, marital status, highest education attained, occupational status and monthly household income. The detailed definitions used in the classification of these variables are published elsewhere [9].

2.5. Definition of metabolic syndrome

Metabolic syndrome (MetS) is defined by using the 'harmonised' criteria proposed by the IDF Task Force on Epidemiology and Prevention, National Heart, Lung and Blood Institute, American Heart Association, World Heart Federation and the International Association for the Study of Obesity [10]. MetS is said to be present with the presence of any three of the following in an individual: (1) Abdominal obesity (WC $\geq$90 cm in men, $\geq$80 cm in women); (2) systolic blood pressure $\geq$130 mmHg, or diastolic blood pressure $\geq$85 mmHg or known hypertension; (3) fasting plasma glucose $\geq$5.6 mmol/L or previously diagnosed type 2 diabetes; (4) triglycerides $\geq$1.7 mmol/L; (5) HDL-cholesterol $<$1.0 mmol/L in men and $<$1.3 mmol/L in women. Abdominal obesity was omitted from the ROC analyses to avoid self-correlation [5].

2.6. Statistical analysis

All statistical analyses were performed using SPSS software version 18 (IBM SPSS, Chicago). Analysis of the complex sample was performed with post-stratification weights for locality, gender and age group applied. Socio-demographic characteristics were described in percentages with 95% confidence intervals (95% CI) by gender. The anthropometric measurements, blood pressure and biochemistry test were expressed in means and 95% CI. Receiver operating characteristics (ROC) curves analysis was used to evaluate the ability of each anthropometric index to discriminate MetS cases from non-MetS cases based on the area under the curve (AUC). The higher the value of AUC indicates higher discriminative ability in predicting MetS. A significant difference in the discriminative powers of two anthropometric indices is suggested when there is no overlap between the 95% confidence intervals of the AUC of the two indices or if the AUC value of one anthropometric index does not fall within the 95% confidence interval of the other. Ethnicity, age group and gender-specific ROC analyses were applied to evaluate the discriminative ability of the three indices in different ethnic, age and gender subpopulations. For all analyses, p values of less than 0.05 were considered statistically significant.

3. Results

The overall response rate achieved was 84.6% (2572/3040). The sample consisted of 1044 (40.6%) men and 1528 (59.4%) women. The median age was 44 years (interquartile range = 17). The demographic characteristics, anthropometric and biochemistry results are presented in Table 1. Overall, waist circumference had better discriminative ability than WHR but its AUC value was not significantly higher than BMI for both sexes, whereas BMI was better than WHR in women only. Waist circumference was a better discriminator compared to WHR in Malay men and women. Waist circumference and BMI had better discriminative ability than WHR in Chinese women only. WHR was unable to discriminate MetS in Indian men and women (Table 2). Analysis of AUC for these three

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