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Metabolic syndrome positively correlates with the risks of atherosclerosis and diabetes in a Chinese population

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ABSTRACT

Background: Published studies seldom tested the weight of different waist circumference (WC) cut-off values for the diagnosis of metabolic syndrome (MetS) in predicting clinical outcomes, including cardiovascular disease and diabetes.

Methods: This is a Chinese population-based cross-sectional study screening subjects from a Health Examination Program since 1999 to 2015. The MetS identification and scores were determined either according to the Adult Treatment Panel III/American Heart Association/National Heart, Lung, and Blood Institute (ATP III/AHA/NHLBI)- or Asian-WC cut-off points. The developments of a higher brachial-ankle pulse wave velocity (baPWV), defined as ≥1400 cm/s, and diabetic-level hyperglycemia, defined as a high fasting glucose level ≥6.99 mmol/L or postprandial glucose level ≧11.10 mmol/L, were surveyed by comparing the areas under receiver operating characteristic curves (AUC-ROC) for both MetS scores.

Results: According to the ATP III/AHA/NHLBI- vs Asian-MetS criteria, 6633 vs 9133 (24.8% vs 34.2%, $p < 0.001$) subjects were diagnosed as the MetS among 26,735 study subjects with a mean age of 55 ± 12 years. The stepwise increases in baPWV and prevalence of diabetic-level hyperglycemia were associated with both MetS scores after adjusting for age and sex. Both MetS scores yielded similar results for correlation with a higher baPWV (AUC-ROC = 0.685 for ATP III/AHA/HLBI- vs 0.680 for Asian-MetS, $p = 0.271$) and diabetic-level hyperglycemia (AUC-ROC = 0.791 for ATP III/AHA/HLBI- vs 0.784 for Asian-MetS, $p = 0.546$).

Conclusions: In a stepwise manner, both ATP III/AHA/NHLBI- or Asian-MetS scores were strong risk factors for arterial stiffness and diabetes. Through a novel and holistic approach, the performance of the ATP III/AHA/NHLBI-MetS score for the risks of arterial stiffness and diabetes was comparable to the Asian-MetS score among a Chinese population.

1. Introduction

The prevalence of the metabolic syndrome (MetS) is increasing worldwide [1]. The MetS is defined as a cluster of components that reflect an expanding waist circumference (WC) resulting from a sedentary lifestyle, over-nutrition, and resultant excess abdominal adiposity [1,2]. In 1988, Reaven reported in the Banting Lecture that several risk factors (hyperglycemia, dyslipidemia, hypertension) are commonly clustered together [3]. This clustering, as its later termed, the MetS, includes insulin resistance, central obesity, atherogenic dyslipidemia, and raised blood pressure, and is associated with other comorbidities including a proinflammatory state, prothrombotic state, reproductive disorders, and nonalcoholic fatty liver disease [4–6]. The MetS has been associated with a nearly two-fold increased risk for atherosclerotic cardiovascular disease (ASCVD), and a five-fold increased risk for incident type 2 diabetes [5].

As the MetS is a cluster of different conditions with the core pathophysiology of insulin resistance and central obesity rather than a single disease, multiple concurrent definitions exist [5]. The prevalence and outcome estimates of the MetS are dependent on the definition used

Abbreviations: ABI, ankle-brachial-index; ASCVD, atherosclerotic cardiovascular disease; ATP III/AHA/NHLBI, Adult Treatment Panel III by the American Heart Association and the National Heart, Lung, and Blood Institute; AUC-ROC, areas under receiver operator characteristic curves; baPWV, brachial-ankle pulse wave velocity; HDL-C, high-density lipoprotein cholesterol; IDF, International Diabetes Federation; MetS, metabolic syndrome; SBP, systolic blood pressure; WC, waist circumferences

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to determine inclusion [7,8]. Until recently, the 2001 National Cholesterol Education Program-Adult Treatment Panel III (NCEP-ATP III), 2005 modified ATP III by the American Heart Association and the National Heart, Lung, and Blood Institute (ATP III/AHA/NHLBI) [9] and 2005 International Diabetes Federation (IDF) [10] definitions are the most commonly applied worldwide [11]. In 2009, the MetS definitions are harmonized to form the latest version stating that there is no an obligatory component for the MetS diagnosis and WC cut-off points should be population- and country-specific according to the epidemiology [12].

Pulse wave velocity (PWV) indicates arterial stiffness and has been thoroughly studied as a risk predictor of coronary artery disease [13] and all-cause mortality [14] among the general population. Even beyond systolic blood pressure (SBP), PWV is a powerful independent predictor of mortality in both diabetic and glucose intolerant patients [15]. Although some progress on the MetS has been made, previous studies seldom tested the weight of different WC cut-off values in correlation with the risks of clinical outcomes of MetS. Therefore, this study was designed to compare the performance of the MetS applying either ATP III/AHA/NHLBI- or Asian-WC cut-off points for the risks of arterial stiffness and diabetes among a Chinese population.

2. Materials and methods

2.1. Study design and population

In this Chinese population-based cross-sectional study, we collected data from September 1999 to March 2015 from a self-paid Health Examination Program at the Health Care Center of Chang Gung Memorial Hospital, Taoyuan Branch. All subjects were required to be afebrile and to have undergone a standardized protocol, including structured questionnaires covering their personal and family histories of chronic diseases and lifestyle, as well as measurements of WC, body weight, BP, height, and brachial-ankle-PWV/ankle-brachial-index (baPWV/ABI), used to survey the risk of arterial stiffness. The inclusion criterion was available data of fasting plasma glucose. A total of 171,839 subjects were screened. The exclusion criteria were an age younger than 20 years, unavailable data of the other four MetS components, postprandial glucose or baPWV, or an abnormal ABI value (< 0.9) (Fig. 1). The enrolled subjects were categorized as having MetS or not either according to ATP III/AHA/NHLBI- or Asian-WC cut-off points. A baPWV ≥1400 cm/s was defined as an abnormal level, and considered more severe arterial stiffness [16]. A high fasting glucose level ≥6.99 mmol/L or postprandial glucose level ≥11.10 mmol/L was defined as diabetic-level hyperglycemia, and considered a high risk for diabetes [17]. In Taiwan, type 2 diabetes is reported to account for 97% of all adult diabetic patients [18].

All subjects provided written informed consent. This study was approved by the Ethics Committee of the Institutional Review Board of Chang Gung Memorial Hospital (approval number: 102-4175B) and performed according to the ethical principles of the Declaration of Helsinki.

2.2. MetS identification and scores

The MetS identification and scores were determined either according to ATP III/AHA/NHLBI- or Asian-WC cut-off points [12]. They include: 1) increased WC (≥102 cm in men or ≥88 cm in women according to the ATP III/AHA/NHLBI; or ≥90 cm in men or ≥80 cm in women for Asians); 2) increased BP (≥130/85 mmHg); 3) increased fasting plasma glucose (≥5.55 mmol/L); 4) increased triglyceride (≥1.7 mmol/L); and 5) reduced high-density lipoprotein cholesterol (HDL-C) (< 1.0mmol/L in men or < 1.3 mmol/L in women). Any three of these five components constitute the diagnosis of MetS. Each individual component was given a score, and the scores were summed to obtain ATP III/AHA/NHLBI- and Asian-MetS scores for each subject.

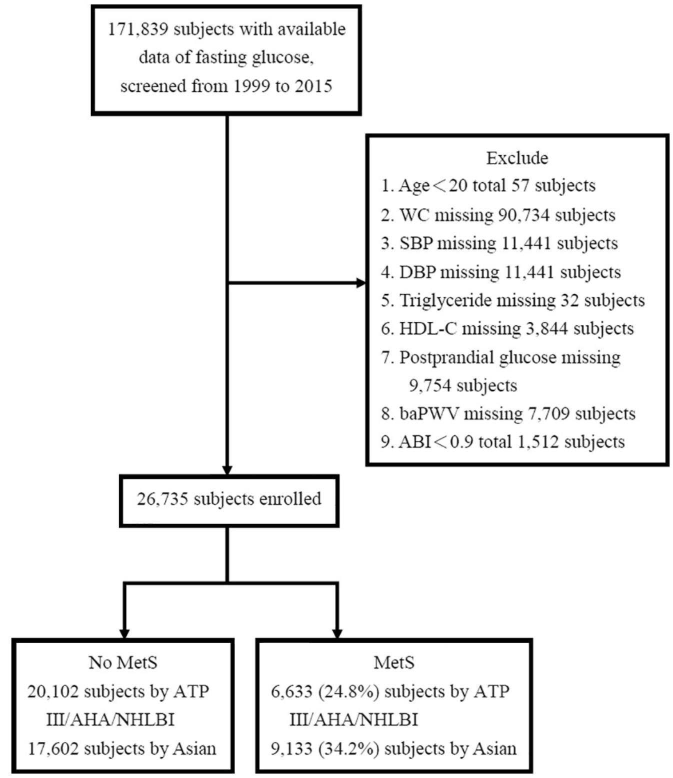

Fig. 1. Flow diagram of study population. ABI, ankle/brachial index; baPWV, brachial-ankle pulse wave velocity; DBP, diastolic blood pressure; HDL-C, high-density lipoprotein cholesterol; MetS, metabolic syndrome; SBP, systolic blood pressure; WC, waist circumference.

2.3. Measurements

Subjects completed anthropometric measurements, and venous blood samples were collected in the morning after overnight fasting for 12 h. The biochemical tests included assessments of fasting plasma glucose, triglyceride, and HDL-C at the central laboratory of Taoyuan Chang Gung Memorial Hospital. Then we provided equally the standard food for all subjects, and tested postprandial plasma glucose after two hours.

2.4. Arterial stiffness, represented by baPWV

baPWV measurements were made using an automated system (Colin VP-1000, Omron, Kyoto, Japan). The technicians from our center were all similarly trained and accredited. We requested that the subjects avoid tobacco or any stimulants such as alcohol or coffee the night before the examination. The examination room was maintained at a standardized temperature. Right and left baPWVs were calculated automatically as the length/transit time between the right arm and both ankles, and the mean of the right and left PWVs was calculated as the representative baPWV [19,20].

2.5. Statistical analysis

Data were analyzed using SPSS 22.0 software for Windows 7 (SPSS Inc., Chicago, IL, USA), and expressed as the mean ± SD or frequency, as appropriate. All variables were tested for normal distribution using the Kolmogorov-Smirnov test. One-way analysis of variance was applied to compare differences in continuous variables while 2-sample proportions test was applied to compare the prevalence of the MetS using the two WC cut-off points. Receiver operator characteristic (ROC) curves for the ATP III/AHA/NHLBI- and Asian-MetS scores to correlate