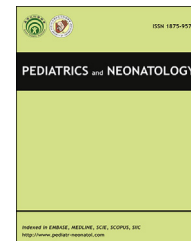


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ORIGINAL ARTICLE

How to Simplify the Diagnostic Criteria of Metabolic Syndrome in Adolescents

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Key Words

adolescents;
blood pressure-to-
height ratio;
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waist-to-height ratio

Background: This study evaluated the feasibility and accuracy of the height-corrected definition for identifying metabolic syndrome (MS).

Methods: In 2006, anthropometric and biochemical measurements were assessed in a cross-sectional population-based study of 3136 Han adolescents, aged 13–17 years. MS was defined according to the definitions of Cook et al, International Diabetes Federation, and the Society of Pediatrics, Chinese Medical Association. Waist-to-height and blood pressure-to-height ratios were alternatives to waist circumference and blood pressure in the height-corrected definition. **Results:** According to the MS definition and the height-corrected MS definition, this agreement would be classified as “very good” (National Cholesterol Education Program kappa coefficients: 0.850 in boys and 0.816 in girls; International Diabetes Federation kappa coefficients: 0.953 in boys and 0.807 in girls; Society of Pediatrics, Chinese Medical Association kappa coefficients: 0.932 in boys; $p < 0.001$) and “good” (Society of Pediatrics, Chinese Medical Association kappa coefficients: 0.737 in girls; $p < 0.001$).

Conclusion: The present study demonstrates that the height-corrected definition of MS is a simple, inexpensive, and accurate tool for identifying MS in Han adolescents.

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1. Introduction

Metabolic syndrome (MS) is defined as a cluster of glucose intolerance, hypertension, dyslipidemia, and central obesity, and insulin resistance is the pathogenesis. MS represents a significant risk for the development of cardiovascular disease, type 2 diabetes mellitus, and all-cause mortality.^{1–3}

Owing to changes in childhood lifestyle, which are characterized by the lack of physical activity and an energy-dense diet, MS is highly prevalent among adolescents in China.⁴ The Bogalusa Heart Study indicated that the progression of atherosclerotic disease starts in children and young adults, and the severity of atherosclerosis is related to multiple cardiovascular risk factors, such as obesity, hypertension, and dyslipidemia.⁵ Patient motivation leading to improved lifestyle adherence is a key factor in achieving a reduction in MS components.⁶ Appropriate early-stage diagnosis and intervention in overweight and obese children are important for reducing the risk of obesity-related disorders. Identifying MS in adolescents is more complicated than that in adults because it is based on a set of age- and sex-specific references of waist circumference (WC), and age-, sex-, and height-specific references of blood pressure. More recently, an increasing number of studies documented that WC-to-height ratio [waist-to-height ratio (WHtR)] and blood pressure-to-height ratio (BPHR) were easy anthropometric indexes for the detection of obesity and hypertension in children and adolescents.^{7–9} However, it is not known whether WHtR and BPHR can be used as alternatives to WC and blood pressure in the definition of MS for adolescents.

The present study, for the first time, evaluated the feasibility and accuracy of the height-corrected definition for identifying MS in Han adolescents aged 13–17 years.

2. Methods and procedures

2.1. Participants

After obtaining informed consent from adolescents and their parents, a cross-sectional, population-based study was conducted. The study population was determined according to two-stage cluster sampling. In the first stage, samples of middle schools in Qinhuangdao, China, were randomly obtained; in the second stage, adolescents (aged 13–17 years) in these schools were invited to participate in 2006. A total of 3136 Han adolescents (1601 boys and 1535 girls) were included in the study population. All participants were required to be healthy. For this purpose, both a detailed medical history and a complete physical examination were performed prior to the study. This study was approved by the Ethics Committee of the First Hospital of Qinhuangdao.

2.2. Measurements

Anthropometric measurements, including those of height, weight, and WC, were obtained while the participants were in light clothing and were barefoot. Height and weight were measured to the nearest 0.1 cm and 0.1 kg, respectively. WC was measured at a level midway between the lowest rib and the top of the iliac crest. All measurements were taken twice,

and the two measurements were averaged for analysis. The body mass index was calculated by dividing weight (kg) by height squared (m^2). WHtR was calculated by dividing the WC by height. Blood pressure was measured three times with a mercury sphygmomanometer while the participants were seated after 10 minutes of rest, and the three measurements were averaged for analysis. Blood pressure cuff width was 40–50% of the arm circumference. Systolic blood pressure (SBP) was determined by the onset of the “tapping” Korotkoff sounds (K1). The fifth Korotkoff sound (K5) was defined as the diastolic blood pressure (DBP). Only when a very low K5 persisted, K4 (muffling of the sounds) was recorded as the DBP. The following equations for BPHR were used: SBP-to-height ratio = SBP (mmHg)/height (cm) and DBP-to-height ratio = DBP (mmHg)/height (cm). All research staff received technical training for anthropometric measurements.

After a 10-hour overnight fast, blood samples were collected from an antecubital vein into heparinized tubes. Fasting plasma glucose concentration was measured using the glucose oxidase method. Blood lipid analyses were conducted using enzymatic procedures with an auto-analyzer (model 7170A; Hitachi, Tokyo, Japan). Nonhigh-density lipoprotein cholesterol (non-HDL-C) was calculated by subtracting HDL-C from total cholesterol; non-HDL-C = total cholesterol – HDL-C.

2.3. Definition of MS

We applied three commonly used definitions of pediatric MS. Each definition included the following five major components: (1) central obesity; (2) blood pressure; (3) blood glucose; (4) triglycerides; and (5) HDL-C. The definition by Cook et al¹⁰ corresponds to the National Cholesterol Education Program (MS-NCEP) definition adapted for adolescents. According to this definition, an adolescent is diagnosed with MS if a predefined critical value is exceeded for three or more of these components. In the MS definition by the International Diabetes Federation (MS-IDF), the diagnosis of MS requires the presence of central obesity plus any two of the other four factors.¹¹ The definition of MS in children and adolescents developed by the Society of Pediatrics, Chinese Medical Association in 2012 (MS-CHN) was also used. In MS-CHN, the fifth component was defined as HDL-C <1.03 mmol/L or non-HDL-C ≥ 3.76 mmol/L.¹² All definitions are summarized in Table 1.

WC cut-off values were age and sex specific according to the WC cutoff references for Chinese children and adolescents. The 90th percentile of WC appeared to be the optimal cut-off point for predicting a substantially increased risk of cardiovascular factors in Chinese children and adolescents.¹³ Abnormal blood pressure was defined according to the 2004 National High Blood Pressure Education Program Working Group definition.¹⁴

2.4. Height-corrected definition of MS

In the height-corrected definition of MS, central obesity was defined as WHtR ≥ 0.48 for boys and ≥ 0.46 for girls.¹² The data involved 21,858 children and adolescents aged 7–16 years who were randomly surveyed from six representative geographical areas, including Beijing, Tianjin, Hangzhou, Shanghai, Chongqing, and Nanning. SBP/DBP $\geq 90^{\text{th}}$ percentile

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