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A proposed cutoff point of waist-to-height ratio for metabolic risk in African township adolescents

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ABSTRACT

Objective: A waist:height ratio (WHtR) higher than 0.5 has been proposed as a cutoff point for abdominal obesity in both sexes and at all ages. It is unknown if this cutoff point is appropriate for previously undernourished adolescents. We assessed the cutoff value of the WHtR associated with an increased metabolic risk in 178 black South African 14- to 18-y-old adolescents (69 boys, 109 girls).
Methods: We measured weight, height, waist circumference, fasting plasma glucose and insulin levels, serum high-sensitivity C-reactive protein, and blood pressure and calculated the WHtR and homeostasis model assessment of insulin resistance (HOMA-IR). Using receiver operating characteristics curve analyses, we assessed the WHtR with the highest sensitivity and specificity to discriminate adolescents with increased fasting plasma glucose, HOMA-IR, serum high-sensitivity C-reactive protein, and blood pressure from those with “normal” values.
Results: The WHtR cutoff points derived from the receiver operating characteristics curves ranged from 0.40 to 0.41, with best diagnostic value at 0.41. A WHtR of 0.40 had 80% sensitivity and 38.5% specificity to classify adolescents with fasting blood glucose level higher than 5.6 mmol/L (area under the curve [AUC] 0.57). A WHtR of 0.41 had 64% sensitivity and 58.5% specificity for a HOMA-IR higher than 3.4 (AUC 0.66), 55% sensitivity and 55.6% specificity for a high-sensitivity C-reactive protein level higher than 1 mg/L (AUC 0.57), and 64% sensitivity and 50.2% specificity for a blood pressure higher than the age-, sex-, and height-specific 90th percentiles (AUC 0.56). Adolescents with a WHtR higher than 0.41 had an odds ratio of 2.46 (95% confidence interval 0.96–6.30) for having a HOMA-IR higher than 3.4.
Conclusion: The WHtR cutoff to indicate metabolic risk for black South African adolescents is 0.41, which is lower than the proposed international cutoff of 0.5. The WHtR can be used for screening adolescents with components of the metabolic syndrome in intervention programs.

Introduction

The increase in obesity in children and adolescents in developing countries has been attributed to the nutritional transition, with increasingly sedentary lifestyles and higher energy content of diets than previously [1,2]. A growing interest in abdominal obesity in children and adolescents has been documented [3]. Waist circumference (WC) is one criterion in the diagnostic guidelines for metabolic syndrome in children and adolescents [4] because of its association with visceral fat distribution.

A recent systematic review of the prevalence of abdominal obesity in adolescents included 29 studies, 15 of which were from developing countries. The prevalence of abdominal obesity in adolescents from developing countries varied widely, ranging from 3.8% to 51.7%, but no sub-Saharan countries were included in the review [3]. Subsequently, a study from a rural South African district reported that 10% of adolescents, 3% of boys and 15% of girls, had a waist:height ratio (WHtR) higher than the cutoff point of 0.5 [2], which has been proposed as a cutoff point

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for abdominal obesity in both sexes and all age groups [5]. There are very few published reports on the prevalence of abdominal obesity in sub-Saharan African adolescents and no appropriate cutoff points for WC or WHtR to indicate abdominal obesity in black adolescents from Africa.

The prevalence of long-term undernutrition and the consequent stunted growth is high in adolescents from the developing world, exposing them to a vulnerable metabolic profile not typically observed in developed countries. In sub-Saharan Africa, the coexistence of stunting and overweight in children and adolescents is an alarming public health concern [2,6]. It is also not clear if international cutoff points for abdominal obesity are appropriate to detect increased metabolic risk in these black children and adolescents.

Fernandez et al. [7] published WC percentiles in nationally representative samples of African-American, European-American, and Mexican-American children and adolescents living in the USA. Similar WC percentiles were developed for British, Canadian, Australian, and Mexican youth [8–11]. A cutoff point of WC above the 90th percentile is used most often to indicate metabolic syndrome [4], but this value is based on the WC distribution in the study population and not necessarily on the relation to the clustering of metabolic and cardiovascular risk factors [12].

The metabolic syndrome in children and adolescents is defined as a cluster of cardiovascular and diabetes risk factors including abdominal obesity, dyslipidemia, impaired fasting glucose, and hypertension, with cutoff points above the 90th, 95th, or 97th percentiles for sex and age [4]. Metabolic syndrome in adolescents also has been linked to increased serum C-reactive protein (CRP) [13]. Zimmet et al. [4] recommended that one of the priorities for future research should be to develop ethnic-specific normal ranges of WC based on healthy values of these cardiovascular risk factors. However, use of the WHtR has the advantage over the WC because one cutoff point potentially can be used for both sexes over a specific age range. Therefore, the aim of this study was to assess ethnic-specific cutoff points of WHtR associated with high blood pressure (BP), blood glucose, insulin resistance, and CRP of black adolescents in South Africa.

Materials and methods

Study population and design

The study was performed in black high-school pupils from a township in the North-West Province of South Africa. The two schools selected represented children from households in the low socioeconomic areas, typically the transitional population of the township. A convenience sample of all grade 9 adolescents was invited to participate, and 248 available children received parental consent to participate. Of these, some were excluded (because they were >18 y old) and 184 adolescents agreed to give blood samples, leading to a 74.2% response rate. The study design has been described in detail elsewhere [14,15]. Briefly, demographic data were collected, and anthropometric measurements and Tanner staging were performed. The protocol was approved by the ethics committee of North-West University and the parents or guardians of the children signed informed consent forms. The children also gave assent to participate.

Body composition and physical maturation

Weight was measured to the nearest 0.01 kg on the electronic scale of the BODPOD body composition system (Life Measurement, Concord, CA, USA). Air displacement plethysmography was performed by the BODPOD system with the adolescents wearing tight-fitting underwear and a swim cap. Thoracic lung volume and body volume were measured, and the percentage of body fat (%BF) and fat-free mass were calculated using the equation of Siri [16]. WC was measured at the midpoint between the lowest rib and the top of the iliac crest using a steel tape (Lufkin, Apex, NC, USA). A stadiometer was used to measure height to the nearest 0.1 cm with the children barefoot and standing erect and the head in the Frankfort plane. All measurements were performed by intensively trained postgraduate students according to the standards of the International Society for the Advancement of Kinanthropometry [17]. Height-for-age *z*-scores (HAZs) were calculated based on the World Health Organization (WHO) 2007 reference values using WHO AnthroPlus 1.0 software. Stunting was defined as an age- and sex-specific HAZ lower than −2. The body mass index (BMI), calculated as weight (kilograms) divided by height (meters) squared, was used to identify adolescents who were overweight or obese according to international BMI cutoff values [18]. The assessment of the Tanner stage was performed by trained fieldworkers, where the children indicated to an adult interviewer of the same sex their own physical maturation on the five-stage Tanner scales for breast development in female adolescents and genital development in male adolescents.

Metabolic variables

The BP was measured in duplicate on the right arm with the adolescents sitting for at least 5 min by using an Omron HEM-757 (Omron Healthcare, Kyoto, Japan). Fasting blood samples were drawn and serum was prepared and frozen at −84°C for subsequent analysis. Plasma glucose was measured using a Vitros DT60 II Chemistry Analyzer (Ortho-Clinical Diagnostics, Rochester, NY, USA). The interassay coefficient of variation (CV) was 2.1% and the intra-assay CV was 1.2%. Plasma insulin was measured by a microparticle enzyme immunoassay (AxSYM method, Abbott, Wiesbaden, Germany). The interassay CV was 5.7% and the intra-assay CV was 3.8%. The homeostasis model assessment of insulin resistance (HOMA-IR) was used to calculate insulin resistance according to the equation: HOMA-IR = (fasting insulin [mU/ml] × fasting glucose [mmol/L])/22.5 [19]. High-sensitivity CRP (hs-CRP) was measured by turbidimetry using an hs-CRP kit (CRPH, IMMAGE, Immunochemistry Systems, Fullerton, CA, USA). The intra-assay CV for hs-CRP was 8.6%.

Statistical analyses

Statistical analyses were done using Statistica 10 for Windows (StatSoft, Tulsa, OK USA) and PASW 18 (SPSS, Inc., Chicago, IL, USA). Descriptive statistics are presented as median and interquartile range because many variables were not normally distributed (%BF, WC, serum CRP, plasma insulin, and HOMA-IR). Differences between groups were assessed using the Mann–Whitney *U* test. % BF, WC, serum CRP, plasma insulin, and HOMA-IR were logarithmically transformed for subsequent correlation analyses. To assess whether the WHtR was independent of sex- and age-related growths in height, the difference between the WHtRs of the boys and girls and the correlation between the WHtR and height were calculated separately for the boys and girls. To evaluate the appropriateness of the WHtR for the assessment of metabolic risk, sensitivity (proportion of true positives, i.e., cases correctly identified as having an increased risk factor) and specificity (proportion of true negatives, i.e., cases correctly identified as not having an increased risk factor) were determined by the creation of area under the receiver operating characteristic (ROC) curves. The ROC curve is a plot of sensitivity (true positive fraction) against 1 − specificity (false-positive fraction) for each metabolic risk variable. The area under the curve (AUC) provides a measurement of the ability to discriminate the independence of a particular threshold. The WHtR with the maximum sensitivity and specificity for each metabolic risk variable were identified: fasting plasma glucose level higher than 5.6 mmol/L [4]; systolic BP (SBP) higher than the 90th percentile and/or diastolic BP (DBP) higher than the 90th percentile for age, sex, and height [20]; serum hs-CRP higher than 1 mg/L [21]; and a HOMA-IR higher than 3.4 [22]. Univariate and multivariate odds ratios and positive and negative predictive values were also calculated for the new cutoff point to identify children with BP, fasting plasma glucose, HOMA-IR, and serum hs-CRP above the published cutoff values. Multivariate odds ratios were calculated with logistic regression, with binary codes for the WHtR as the dependent variable and blood glucose, HOMA-IR, serum hs-CRP, or BP in combination with age, Tanner stage, sex, and height as independent variables. Results with a *P* value less than 0.05 were considered statistically significant.

Results

Demographic and anthropometric data

Most subjects lived in brick houses and had a television (86%), but few had computers at home (3%). Parents or caregivers generally worked in low-income occupations and had at most a high-school education. The differences between participants who gave blood samples and those who did not are presented elsewhere [15].

The BMI, %BF, fasting insulin, and HOMA-IR values of the girls were significantly higher than those of the boys. Only 4.1% of the