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Waist Circumference Percentiles in 2-18 Year Old Indian Children

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Objectives To develop reference percentile curves in Indian children for waist circumference (WC), and to provide a cutoff of WC percentile to identify children at risk for metabolic syndrome (MS).

Study design A multicenter, cross-sectional study was performed in 5 major Indian cities. Height, weight, and blood pressure (BP) were measured in 10 842 children (6065 boys). Elevated BP was defined as either systolic BP or diastolic BP >95th percentile. WC was measured with the child standing using a stretch-resistant tape. Sex-specific reference percentiles were computed using the LMS method which constructs reference percentiles adjusted for skewness. To determine optimal cutoffs for WC percentiles, a validation sample of 208 children was assessed for MS risk factors (ie, anthropometry, BP, blood lipids), and receiver operating characteristic (ROC) curve analysis was performed.

Results Age- and sex-specific WC percentiles (5th, 10th, 15th, 25th, 50th, 75th, 85th, 90th, and 95th) are presented. WC values increased with age in both the boys and the girls. The median WC at age >15 years was greater in boys compared with girls. ROC analysis suggested the 70th percentile as a cutoff for MS risk (sensitivity, 0.84 in boys and 0.82 in girls; specificity, 0.85 in both boys and girls; area under the ROC curve, 0.88 in boys and 0.92 in girls).

Conclusion Age- and sex-specific reference curves for WC for Indian children and cutoff values of 70th WC percentile for screening for MS risk are provided. *(J Pediatr 2014;164:1358-62)*.

The prevalence of childhood obesity is rising in developing countries, including China and India.[1] Abdominal obesity is also on the rise and is associated with increased risk for metabolic syndrome (MS) and in turn with increased risk for hypertension, type 2 diabetes mellitus, and atherosclerotic cardiovascular disease.[2,3] Indians are prone to central obesity, an observation widely reported not only in Indian adults, but also in Indian children.[4,5]

Prevalence rates of MS in the pediatric age group vary depending on the criteria used. The International Diabetes Federation's definition of the MS in children, divided into 3 age groups (6-10 years, 10-16 years, and 16+ years), includes waist circumference (WC) as a criterion for the diagnosis of MS in children.[6]

WC is considered a good predictor of visceral adipose tissue and has been found to be a strong predictor of hypertension in Indian adolescents.[7,8] WC is predictive of such adverse outcomes as abnormal lipid profile and insulin resistance and is a component of pediatric MS.[9-13] Measurement of WC may be useful not only for assessing children and adolescents with obesity, but also for identifying children with excessive abdominal adiposity and at risk for MS who are not overweight or obese. There is a need to describe WC percentiles for Indian children in relation to sex and age.

With reference WC percentiles, it is also helpful to identify the cutoff level above which the risk for MS increases. The National Health and Nutrition Examination Survey (NHANES) has proposed the 90th percentile as the cutoff for identifying central adiposity.[14,15] Although previous studies have suggested an empirical cutoff of the 75th percentile to screen for the MS in Indian children,[16] to date no study has proposed a biologically rational cutoff. The objectives of the present study were to develop WC percentile curves for Indian children, and to define a cutoff of WC percentile to identify children at risk for MS.

Methods

Five zones of India (as suggested by the Indian Academy of Paediatrics) were considered for data collection. Because children belonging to affluent families in urban areas are believed to have fewer constraints on nutrition and growth, 5 major cities

BAZ	Body mass index for age z-score	MS	Metabolic syndrome
BMI	Body mass index	NHANES	National Health and Nutrition Examination Survey
BP	Blood pressure		
DBP	Diastolic blood pressure	ROC	Receiver operating characteristic
HAZ	Height for age z-score	SBP	Systolic blood pressure
HDL	High-density lipoprotein	WAZ	Weight for age z-score
LDL	Low-density lipoprotein	WC	Waist circumference

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(based on per capita income) were selected for data collection: Chennai-South, Delhi-North, Kolkata-East, Pune-West, and Raipur-Center.[17] A list of schools catering to children of socio-economically well-off families was compiled for each city with the help of local coinvestigators. Six schools were then randomly selected from each city and were approached for permission to carry out measurements. The mean yearly fee for these schools was INR 26 000 (US $477; range, INR 15 000-54 000 [$275-$990]; per capita income, INR 60 603 [$1112]).[17] All 2- to 18-year-old children from particpating schools whose parents consented to measurements were included.

The study was approved by the Ethics Committee of the Hirabai Cowasji Jehangir Medical Research Institute. Institutional consent was obtained from the principal of each school, and written consent was obtained from a parent of each child before study commencement. Data were collected between July 2010 and January 2012.

The same team led the data collection at all sites, and the same set of equipment (calibrated daily) was used for all measurements. Training of core team members was carried out at Hirabai Cowasji Jehangir Medical Research Institute, to minimize intraobserver and interobserver variability in measurements; local study staff was trained as well. WC was measured by trained nutritionists (V.E., S.K., N.K., and L.P.) at all study sites. Team members were tested for interobserver and intraobserver variations in the measurements of height, blood pressure (BP) (recorded by A.K. and S.K.), and WC. Mean interobserver and intraobserver coefficients of variation were <0.01 (1%) for height, WC, and BP, and there were no significant differences among observers ($P > .05$).

Standing height was measured with a portable stadiometer (Leicester Height Meter; Child Growth Foundation, London, United Kingdom; range, 60-207 cm) with the child barefoot. Weight was measured with a portable electronic scale (Salter India, Faridabad, India) accurate to 100 g (calibration performed using standard weights). Body mass index (BMI) was calculated, and height for age z-score (HAZ), weight for age z-score (WAZ), and BMI for age z-score (BAZ) were computed.[17]

WC measurements were performed in accordance with methodology used in the NHANES.[18] WC was measured with the child standing using a stretch-resistant tape with a constant 100 g of tension maintained through the use of a special indicator buckle. The tape was applied horizontally just above the upper lateral border of the right ileum. Each measurement was made at the end of a normal expiration and was recorded to the nearest 0.1 cm.[18]

Clinical assessments to rule out major illnesses were performed by doctors from the core team. Children with a serious illness were measured, but their data were not included in our analysis.

BP was measured with the child sitting and the cubital fossa supported at heart level. Measurements were made after at least a 5-minute rest using a mercury sphygmomanometer, with an appropriate-sized cuff. Systolic blood pressure (SBP) was defined by the onset of the first Korotkoff sound; diastolic blood pressure (DBP), by the disappearance of fifth Korotkoff sound.[19] The average of 3 consecutive readings was used for analysis. In children with elevated readings, BP was remeasured after 10 minutes, and the reading was confirmed by another doctor from the team. BP was classified as normal (SBP/DBP <90th percentile), prehypertension (SBP/DBP 90th-95th percentile), or hypertension (SBP/DBP >95th percentile) using reference data specific for sex, age, and height.[20]

To determine cutoffs for WC percentile, we studied an independent set of children (other than those measured for WC measurements). A total of 250 children coming for regular checkups to Jehangir Hospital were invited to participate in the study, 208 of whom accepted (104 boys; age range, 6-17 years, mean age, 11.4 ± 2.9 years), and their parents provided informed consent. The children in this cohort ranged from those with with normal BMI, BP, and metabolic measures to those with BMI in the obese range with abnormal BP and metabolic measures. Obese children underwent a detailed workup to rule out an endocrine cause of obesity. All children were assessed with respect to anthropometry data (weight, height, BMI, and WC for abdominal obesity), BP measurements, and levels of fasting triglycerides, high-density lipoprotein (HDL) cholesterol, and plasma glucose were recorded for all patients. Anthropometric measurements, BP measurement, and clinical assessment were performed as described for the main study.

A venous blood sample (8 mL) was collected from each child at 9:00 a.m. after an overnight fast using a Vacutainer (BD Bioscience, Franklin Lakes, New Jersey). Samples were immediately transported to the laboratory in ice bags, where serum was separated by centrifugation at 2500 rpm for 15 minutes. Fasting serum total cholesterol, triglycerides, HDL cholesterol, low-density lipoprotein (LDL) cholesterol, very-low-density lipoprotein cholesterol and plasma glucose measurements were recorded for all children. LDL cholesterol was calculated using the Friedewald equation.[21]

Children were classified with normal or elevated BP according to age, sex, and height.[20] Children with $\geq$2 of the following risk factors as defined by Ford et al[10] were considered at risk for MS: HDL cholesterol $\leq$40 mg/dL, triglycerides $\geq$110 mg/dL, fasting plasma glucose >110 mg/dL, and BP $\geq$95th percentile according to age and sex.

Data are presented as mean $\pm$ SD. The statistical significance of differences in anthropometric variables between 2 groups was evaluated using the independent-samples Student t test. A P value <.05 was considered significant.

Sex-specific reference percentiles were computed using the LMS method.[22] Each variable of interest was summarized by 3 smooth curves plotted against age representing the median (M), coefficient of variation (S), and skewness (L) of the measurement distribution.[23] Models were checked for goodness of fit using detrended Q-Q plots, Q tests, and worm plots.[24]

To determine the cutoff for WC percentiles, the independent set of children studied were classified as having no metabolic risk factors versus $\geq$2 metabolic risk factors.[25] WC was not included as a risk factor, and children with only 1 risk factor were excluded from this analysis. Receiver operating characteristic (ROC) analysis was performed for WC with $\geq$2 risk