Original Article

Utility of anthropometry in defining overweight and obesity in urban South Indian children

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Abstract

Introduction: Waist-based indicators of obesity are being used to detect central obesity and are predictive for metabolic syndrome (MS). The aim of the study is to assess the basic anthropometric indices in children, to determine the prevalence of overweight and obesity, and to determine the association between various waist-based measurements and body mass index (BMI). **Methodology:** A cross-sectional study was conducted among children aged 10 to 15 years attending government corporation schools in Chennai. Basic anthropometric measurements were taken. BMI, waist circumference/height ratio (WHtR), and waist circumference/hip circumference ratio (WHR) were calculated. The percentiles (Indian reference cutoffs) were determined for waist circumference (WC) and BMI. The prevalence of overweight and obesity was determined and compared to waist-based parameters. **Results:** Of 820 children, males constituted 47.1%. Stunting was seen in 9.8% and 7.8% were underweight. 8.2% had BMI less than the 3rd percentile. The prevalence of overweight and obese children was 9% and 3.2%, respectively, with female predominance. The majority had WC less than the 5th percentile. The prevalence of children under risk for MS based on WC >70th percentile was 4.5% and based on WHtR >0.5 was 8.2%. A significant association was identified between all waist-based anthropometric measurements to detect children at risk for MS and overweight/obese children as per BMI category. WHtR >0.5 was an indicator of overweight/obese children in logistic regression analysis. **Conclusion:** Early identification of children at risk of MS would require a combination of BMI to detect general obesity and waist-based anthropometric measurements to identify central obesity.

Keywords: BMI, children, obesity, overweight, underweight, urban, waist circumference

Introduction

Childhood obesity is becoming a global health problem and can affect the physical and emotional well-being of children.[1,2] Childhood obesity and specifically abdominal obesity may lead to cardiometabolic health complications in adulthood such as type 2 diabetes mellitus (T2DM) and cardiovascular disease (CVD).[3,4] Indian children are prone to central obesity.[5,6]

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Though body mass index (BMI) is a good marker of general obesity,[7] it is an inadequate marker of central obesity because it cannot differentiate between fat and fat-free mass. Waist circumference (WC) is a better marker of central obesity[8] and a good marker of cardiometabolic risk. Age- and sex-specific percentile charts are available for Indian children.[9] WC percentile of greater than 70 may be at a higher risk for metabolic syndrome (MS).[9] Waist by height ratio (WHtR) greater than 0.5 was taken as a cutoff value for diagnosis of obesity at all ages in many studies.[10-12] In growing children, WHtR may be a better criterion for the classification of abdominal obesity than waist circumference alone. We wanted to assess the prevalence of overweight/obese children by using the BMI method and waist-based measurement indices in government school-going

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children in urban areas. A simple parameter that can be easily checked in office practice will enable primary care physicians to identify children at risk for MS and initiate early lifestyle changes.

Materials and Methods

Study setting and duration

This cross-sectional study was conducted in five government corporation schools located in Chennai between January 2012 and March 2012. Parental informed consent was obtained.

Sample size

The sample size calculated was 801, based on Indian studies with an average of 26% prevalence of overweight and obesity among adolescents with a 99% confidence limit and 4% of allowable error of the estimate.

Study population

Children in the age group of 10 to 15 years, who were willing to participate in the study, were included. Children, who were in the age group of 10 to 15 years suffering from a significant illness that can affect their nutritional status, were excluded from the study. Children, who had skeletal deformities like kyphosis, scoliosis, genu valgum, and genu varum, were also excluded.

Data collection

The anthropometric parameters measured were weight, height, waist circumference, and hip circumference. Anthropometric indices defining overweight and obesity are obtained by using the above-mentioned parameters. Height was measured by a portable stadiometer that was standardized and calibrated before measurement (to the nearest 0.1 cm). Height was measured twice and the mean of two was taken. Weight was measured in kilograms (to the nearest 0.01 kg) using a SECA digital portable weighing scale. Waist circumference (WC) was measured at the midpoint between the superior border of the iliac crest and the lowest rib in mid axillary line at the end of normal expiration using a nonelastic tape (to the nearest 0.1 cm). The widest portion of the buttocks was measured as hip circumference (HC). Measurements were taken in light school dress and without shoes.

Weight, height, and BMI percentiles were calculated according to revised Indian Academy of Pediatrics (IAP) growth charts.[13]

Overweight and obesity were defined using BMI percentile curves given by IAP.[13] For boys, BMI of 23 kg/m^2 (>71 percentile) and BMI of 27 kg/m^2 (>90 percentile) were considered as overweight and obese, respectively. For girls, BMI 23 kg/m^2 (>75 percentile) was considered as overweight and BMI 27 kg/m^2 (>95 percentile) was taken as obesity. WC percentiles were derived from percentiles for Indian children.[9] Children at risk for metabolic syndrome were determined by applying a cutoff of the 70th WC percentile as per Indian study criteria.[9] Waist circumference/height ratio (WHtR) was also determined across all age categories and children, who had WHtR >0.5, were considered obese.[11,14-16] Waist circumference/hip circumference ratio (WHR) was checked across all age categories. WHR >0.85 in girls and WHR >0.90 in boys were considered as substantially increased risk for metabolic complications.[7] We considered the children with BMI in the overweight and obese category to be at risk for metabolic syndrome (MS). Children with WHtR >0.5, WHR >0.85 in girls, WHR >0.90 in boys, and WC >70th centile were all considered at risk for MS.

Statistical analysis

Weight, height, BMI, and waist circumference were expressed in arithmetic mean and standard deviation across various categories. Pearson Chi-square test was used to compare between the categorical variables. Independent sample *t* test was used to compare the continuous variables by gender. One-way ANOVA test was used to compare the continuous variables by age group. The receiver operating characteristic (ROC) curve method was used to find the cutoff value of waist-based indices to detect overweight/obese children. Multiple binary logistic regression (forward conditional) method was used to estimate the odds ratio (OR) with 95% CI of risk factors for overweight/obese. Statistical analyses were conducted using SPSS version 20.0 for Windows (IBM Corporation ARMONK, NY, USA).

Ethical considerations

Institutional ethics committee approval was obtained (No. 14112011 dated 22/11/2011).

Results

Of the 834 children, 14 were excluded due to failure to give consent and due to the presence of systemic diseases (heart disease, renal disease). Females constituted 52.9% (n = 434). The distribution of children under each age category sex-wise was assessed [Table 1].

The mean BMI of the study population was 16.09 (±2.90). Mean ± standard deviation of WC, HC, WHR, and WHtR were 60.67 ± 7.85, 74.13 ± 8.27, 0.82 ± 0.5, 0.43 ± 0.05, respectively. Girls had statistically significantly higher mean BMI, mean WC, mean HC, and mean WHtR compared to boys [Table 2]. Mean values of BMI, WC, and HC increased with age and were statistically significant [Table 3]. Mean BMI was higher in girls across all age groups (P < 0.01). Mean waist circumference

Table 1: Age characteristics of the study population

Age	Male	Female	Frequency, *n* (%)
10	60	105	165 (20.1)
11	74	126	200 (24.4)
12	89	86	175 (21.3)
13	106	74	180 (22)
14	39	35	74 (9)
15	18	8	26 (3.2)
Total	386	434	820

was higher in girls across all age categories and was statistically significant in 12 years (P = 0.007), 13 years (P < 0.001), and 14 years (P = 0.002) age category.

Age-specific weight and height percentiles revealed 64 children (7.8%) with less than the 3rd weight percentile and 80 children (9.8%) less than the 3rd height percentile [Table 4]. Four children (0.5%) and three children (0.4%) had more than 97th weight and height percentiles, respectively. Males were more underweight (less than 3rd percentile) 9.1% (n = 35) than females 6.7% (n = 29). All the four children (0.9%) with more than 97th weight percentile were females. Short stature (height <3rd percentile) was observed in 7.4% of females (n = 32) and 12.4% of males (n = 48). Height more than 97th percentile was found in two females (0.5%) and one male (0.3%). BMI was less than the 3rd percentile in 8.2% [Table 5].

Table 2: Mean anthropometric measurements among boys and girls

Variable	Boys Mean±SD	Girls Mean±SD	P
Age (yrs)	12.11±1.38	11.61±1.33	<0.001
Weight (kg)	31.36±8.16	33.16±8.99	0.003
Height (cm)	141.24±10.09	140.46±9.47	0.253
BMI (kg/m^2)	15.5±2.6	16.6±3.1	<0.001
WC (cm)	59.56±6.79	61.66±8.56	<0.001
Hip circumference (cm)	72.24±6.99	75.82±8.93	<0.001
Waist/Hip circumference ratio	0.82±0.05	0.81±0.05	<0.001
Waist circumference/Height ratio	0.42±0.04	0.44±0.05	<0.001

12.2% (n = 100) of children had a BMI above 23. Among females, 11.3% (n = 49) and 3.7% (n = 16) were overweight and obese, respectively. In the male group, 6.5% (n = 25) and 2.6% (n = 10) were categorized as overweight and obese, respectively. Obesity and overweight status were more in females (P = 0.01). The majority (56.7%) had WC less than the 5th centile as per Indian reference population studies. 66.8% of males (n = 258) and 47.7% of females (n = 207) had WC less than 5th centile. A waist percentile above 70 was seen in 4.5% (n = 37) of the study population. Central obesity as per WHR > 0.85 for girls and >0.90 for boys was 14.4% (n = 118). Gender-wise prevalence as per WHR criteria was 21.2% girls (n = 92) and 6.7% boys (n = 26) (P < 0.001).

The prevalence of central obesity by WHtR among various ages was 10 years (1.2%, n = 2), 11 years (7.5%, n = 15), 12 years (11.4%, n = 20%), 13 years (7.8%, n = 14), 14 years (16.2%, n = 12), and 15 years (15.4%, n = 4). The increase in trend for abnormal WHtR > 0.5 as the age increases was statistically significant (P < 0.001). As per WHtR criteria, the prevalence of central obesity was 8.2%. A combination of WC percentile >70 and WHtR > 0.5 yielded a prevalence of central obesity of 4.3%.

There was a significant association between all waist-based anthropometric measurements to detect children at risk for metabolic syndrome and BMI-based detection of overweight and obese category (P < 0.001) [Table 6]. WHtR >0.5 was a predictor (OR: 63.5, 95%CI: 25.9–155.6, P < 0.001) for overweight/obesity on multiple binary logistic regression analysis of all significant factors.

Table 3: Age-specific mean anthropometric data given as mean and standard deviation

Parameter	10 yr (n=165) Mean±SD	11 yr (n=200) Mean±SD	12 yr (n=175) Mean±SD	13 yr (n=180) Mean±SD	14 yr (n=74) Mean±SD	15 yr (n=26) Mean±SD	P
BMI (kg/m^2)	15.0±2.0	15.5 (2.6)	16.2 (3.0)	16.6 (2.7)	18.0±3.5	17.9±4.3	<0.001
WC (cm)	56.30±5.05	58.97±6.65	61.99±8.35	62.39±7.05	65.95±9.29	65.48±10.78	<0.001
HC (cm)	68.62±6.18	71.91±6.85	75.24±7.92	76.87±7.41	80.91±8.58	80.52±9.60	<0.001
WHR	0.82±0.05	0.82±0.05	0.823±0.05	0.81±0.05	0.81±0.04	0.81±0.06	0.21
WHtR	0.43±0.03	0.43±0.04	0.44±0.05	0.43±0.05	0.44±0.06	0.43±0.07	0.21

BMI=Body mass index, WC=Waist circumference, HC=Hip circumference, WHR=Waist circumference/hip circumference ratio, WHtR=Waist circumference/height ratio

Table 4: Age-specific distribution of weight and height percentiles of the study population

Age	Parameter	<3 n (%)	3–10 n (%)	10–25 n (%)	25–50 n (%)	50–75 n (%)	75–90 n (%)	90–97 n (%)	>97 n (%)
10	Weight	5 (3.0)	40 (24.2)	54 (32.7)	37 (22.4)	17 (10.3)	12 (7.3)	–	–
	Height	12 (7.3)	39 (23.6)	37 (22.4)	39 (23.6)	19 (9.5)	13 (7.9)	5 (3.0)	1 (0.6)
11	Weight	17 (8.5)	38 (19)	60 (30.0)	48 (24)	20 (10.0)	11 (5.5)	5 (2.5)	1 (0.5)
	Height	15 (7.5)	40 (20.0)	54 (27.0)	53 (26.5)	19 (9.5)	15 (7.5)	4 (2.0)	–
12	Weight	16 (9.1)	38 (21.7)	49 (28.0)	40 (22.9)	18 (10.3)	10 (5.7)	2 (1.1)	2 (1.1)
	Height	19 (10.9)	34 (19.4)	46 (26.3)	40 (22.9)	17 (9.7)	12 (6.9)	6 (3.4)	1 (0.6)
13	Weight	15 (8.3)	43 (23.9)	53 (29.4)	36 (20.0)	24 (13.3)	9 (5.0)	–	–
	Height	21 (11.7)	37 (20.6)	51 (28.3)	34 (18.9)	23 (12.8)	9 (5.0)	4 (2.2)	1 (0.6)
14	Weight	6 (8.1)	13 (17.6)	14 (18.9)	24 (32.4)	10 (13.5)	6 (8.1)	–	1 (1.4)
	Height	8 (10.8)	21 (28.4)	14 (18.9)	11 (14.9)	12 (16.2)	8 (10.8)		–
15	Weight	5 (19.2)	4 (15.4)	7 (26.9)	5 (19.2)	2 (7.7)	2 (7.7)	1 (3.8)	–
	Height	5 (19.2)	7 (26.9)	5 (19.2)	2 (7.7)	6 (23.1)	1 (3.8)	–	–
Total	Weight	64 (7.8)	176 (21.5)	237 (28.9)	190 (23.2)	91 (11.1)	50 (6.1)	8 (1.0)	4 (0.5)
	Height	80 (9.8)	178 (21.7)	207 (25.2)	179 (21.8)	96 (11.7)	58 (7.1)	19 (2.3)	3 (0.4)

Table 5: Age-specific distribution of BMI and WC percentiles among the study population

Variable	Percentile	10 yrs *n* (%)	11 yrs *n* (%)	12 yrs *n* (%)	13 yrs *n* (%)	14 yrs *n* (%)	15 yrs *n* (%)	Total *n* (%)
BMI	<3	17 (10.3)	17 (8.5)	16 (9.1)	12 (6.7)	2 (2.7)	3 (11.5)	67 (8.2)
	3–5	7 (4.2)	15 (7.5)	10 (5.7)	11 (6.1)	4 (5.4)	2 (7.7)	49 (6.0)
	5–10	16 (9.7)	29 (14.5)	22 (12.6)	19 (10.6)	7 (9.5)	3 (11.5)	96 (11.7)
	10–25	47 (28.5)	55 (27.5)	48 (27.4)	46 (25.6)	17 (23.0)	8 (30.8)	221 (27.0)
	25–50	43 (26.1)	46 (23.0)	35 (20.0)	47 (26.1)	23 (31.1)	3 (11.5)	197 (24.0)
	50–70	19 (11.5)	17 (8.5)	19 (10.9)	24 (13.3)	7 (9.5)	2 (7.7)	90 (11.0)
	23 (Eq 71/75)	15 (9.1)	13 (6.5)	18 (10.3)	18 (10.0)	7 (9.5)	3 (11.5)	74 (9.0)
	27 (Eq 90/95)	1 (0.6)	8 (4.0)	7 (4.0)	3 (1.7)	5 (6.9)	2 (7.6)	26 (3.1)
WC	<5	95 (57.6)	117 (58.5)	94 (53.7)	106 (58.9)	36 (48.6)	18 (69.2)	466 (56.7)
	5–10	21 (12.7)	23 (11.5)	16 (9.1)	20 (11.1)	10 (13.5)	1 (3.8)	91 (11.1)
	10–15	9 (5.5)	19 (9.0)	10 (5.7)	10 (5.6)	3 (4.1)	–	50 (6.1)
	15–25	16 (9.7)	12 (6.0)	13 (7.4)	14 (7.8)	8 (10.8)	1 (3.8)	64 (7.8)
	25–50	18 (10.9)	12 (6.0)	26 (14.9)	21 (11.7)	8 (10.8)	2 (7.7)	87 (10.6)
	50–75	5 (3.0)	11 (5.5)	6 (3.4)	4 (2.2)	5 (6.8)	2 (7.7)	33 (4.0)
	75–85	1 (0.6)	3 (1.5)	5 (2.9)	5 (2.8)	2 (2.7)	2 (7.7)	18 (2.2)
	85–90	–	3 (1.5)	2 (1.1)	–	–	–	5 (0.6)
	90–95	–	1 (0.5)	2 (1.1)	–	1 (1.4)	–	4 (0.5)
	>95	–	–	1 (0.6)	–	1 (1.4)	–	2 (0.2)

BMI=Body mass index, WC=waist circumference

Table 6: Association between various waist-based measurements to detect children at risk of metabolic syndrome and BMI status

Variable	Category	BMI status		*P*
		Normal weight *n* (%)	Overweight or obese *n* (%)	
WC Percentile	<70	718 (91.7)	65 (8.3)	<0.001
	>70	2 (5.4)	35 (94.6)	
WHtR	≤0.5	711 (94.4)	42 (5.6)	<0.001
	>0.5	9 (13.4)	58 (86.6)	
WHR >0.85 in females and >0.90 in males	Yes	79 (66.9)	39 (33.1)	<0.001
	No	641 (91.3)	61 (8.7)	
WC >70 percentile + WHtR >0.5	Yes	718 (91.5)	67 (8.5)	<0.001
	No	2 (5.7)	33 (94.3)	

ROC curves were plotted to detect the performance of waist-based measurements to detect overweight/obese children. ROC performance for WHtR (cutoff > 0.45) was excellent with a sensitivity of 91%, specificity of 81.9%, and AUC of 0.94 ($P < 0.001$). WHR performed modestly in the ROC curve (AUC: 0.74) with a sensitivity of 73% and specificity of 64.7% for a cutoff value of 0.83.

Discussion

This study was performed among children in government schools in an urban area who are mostly from the underprivileged section of society. We mostly used growth charts and reference percentile curves derived from Indian children. Studies have shown that Asian Indians had a higher magnitude of abdominal obesity, adiposity, and a lower muscle mass compared to white Caucasians. There was a higher prevalence of central obesity in Indian children compared to other ethnic groups.[17] There was a higher prevalence of insulin resistance in postpubertal children and excess truncal fat mass was a major determinant of insulin sensitivity.[18,19] BMI is an indicator of excessive weight relative to height rather than excess body fat and may not be the best indicator of fatness among children because there is no distinction between fat mass and lean mass.[20]

The prevalence of overweight and obesity as per BMI was higher in girls which is similar to previous studies in Indian children.[21-23] Girls had a higher mean weight and height in our study group. Average weight and height were higher in boys in studies that included adolescents up to 19 years of age which may have been due to significant postpubertal growth pattern in males.[23,24] As per the National Family Health Survey (NFHS)-5, approximately 30% of children were underweight or stunted under the age of 5 years.[25] The prevalence of underweight and stunting was highest in the age group 11–13 years in a study from urban slums in India and more boys were stunted than girls.[26] Even though we applied Indian reference growth charts, stunting and underweight were still prevalent in urban areas and were higher in boys. Hence, we do need to target the younger age group for nutritional surveillance and nutritional intervention programs as growth and development is a dynamic and continuous process during early school age. Urban slum dwellers whose children predominantly go to government corporation schools who constituted our study population are living in a different environmental condition with unique challenges compared to affluent people living in urban areas. This group of children may be going to primary care physicians who are closer to their home, and hence, this dual challenge of managing undernutrition and overnutrition must be known to them.

Overlap between children with general obesity and central obesity is inevitable. However, the presence of central obesity being a potential time bomb with respect to cardiometabolic risk is of major concern. Waist-based measurements have a pivotal role in the detection of central obesity which is a risk for future metabolic syndrome. The majority of children had waist percentiles less than the 5th percentile though we used Indian reference percentiles.[9] This was probably because reference percentiles suggested by Khadlikar[9] were drawn from urban school-going children from middle to higher socioeconomic strata who go to private schools. WC above the 70th percentile was seen in 4.5% compared to a study from North India which reported 8% of children above the 90th percentile.[27] A significant correlation exists between insulin resistance and higher WC percentiles.[28] Krishnan *et al.*[29] found a significant correlation between BMI and WC more than the 70th percentile, followed by WHR and WHtR. Multiple regression analysis of all significant factors revealed that among waist-based anthropometric measurements, WHtR had the best correlation with overweight/obesity which is similar to our study result.[29,30] WHtR negates the distortions based on body frame size in different populations. In our study, a higher prevalence of overweight/obesity was obtained with BMI cutoffs of IAP recommendation rather than waist-based measurement cutoffs. Revised IAP growth charts adopted the same method of International Obesity Task Force using 23 and 27 adult equivalent cutoff lines for overweight and obesity for use in Asian children as they were known to have more adiposity and increased cardiometabolic risk at a lower BMI. A study from Brazil reported a significant correlation between BMI and fat mass, suggesting that BMI may be a better screening tool to detect excess body fat compared to WC.[31] Centralization of body fat occurs after puberty and because of that waist-based indices may not reflect fat centralization in the peripubertal period. Moreover, the finding of more than half of our study population had less than 5th percentile WC suggests that centralization of fat mass was less in our children. Of all the waist-based measurement indices, WHtR is a robust marker of children at risk for metabolic syndrome.

A recent consensus statement recommended the use of WC in addition to BMI to assess obesity as that would enable us to detect a maximum number of obese children (general obesity and central obesity).[32] Children among lower socioeconomic groups are associated with elevated risk for obesity.[33] Obesity is linked to relative social inequalities and there is a slow change in prevalence among those living with lower socioeconomic status.[34] Easily measurable parameters, like weight, height, and WC, will enable the primary care physicians to promptly screen for children for obesity and give timely advice on the steps that need to be taken to prevent MS. Enabling our primary care physicians to effectively identify and initiate management will assuredly bring ground level changes in our society. Obesity prevention needs multisectorial coordinated approach involving primary care physicians and strategies to negate factors influencing the risk for obesity.

Limitations

Genetic factors, socioeconomic factors, dietary pattern, and lifestyle were not assessed and they could have a definite impact on this study. The pubertal staging was not done in our study and that may influence the outcome of our study.

Conclusions

A holistic approach is needed to tackle the dual problem of undernutrition and overnutrition which may be prevalent in a rapidly expanding urban area with mixed socioeconomic resources. Integrated programs will be beneficial in promoting healthy eating habits among mothers and children. Early detection of overweight/obese children and timely intervention with exercise and a balanced diet will prevent the development of cardiometabolic risk factors. A combination of BMI and waist-based measurements may enable us to detect more children at risk for metabolic syndrome at an early stage.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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