RESEARCH PAPER

Waist Circumference and Waist for Height Percentiles in Urban South Indian Children Aged 3-16 Years

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Objectives: To develop age and gender specific waist circumference references for urban Indian children aged 3 -16 years.

Design: Cross-sectional study.

Setting: Urban preschools and schools of Bangalore.

Participants: 9060 children (5172 boys and 3888 girls) in the age group of 3-16 years.

Methods: Weight, height, and waist circumference were measured using standard anthropometric methodology. Percentiles for waist circumference and Waist/height ratio (W/Ht) for each age and gender were constructed and smoothed using the LMS method.

Results: Mean waist circumference increased with age for both girls and boys. The upper end of curve in boys continued to increase, whereas in the girls it tended to plateau at 14 years. The waist circumference of the Indian children from the present study was higher than age and sex matched European children. The proportion of children with W/Ht ratio greater than 0.5 decreased as their age increased.

Conclusions: These curves represent the first waist and waist height ratio percentiles for Indian children and could be used as reference values for urban Indian children. We suggest that for a start, the 75th percentile of waist circumference from this study be used as an "action point" for Indian children to identify obesity (as a tautological argument), while retaining the cut-off of 0.5 for the W/Ht ratio; however this underlines the need to derive biologically rational cut-offs that would relate to different levels of risk for adult cardiovascular disease.

Key words: *Child, India, Normal values, Obesity, Waist circumference, Waist-height ratio.*

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There are at least 20 million children globally, under the age of 5 years, who are overweight [1]. Although the health consequences of obesity are mostly seen during adulthood, it is likely that a tendency to overweight or obesity could start earlier in childhood and track into adulthood. The body mass index (BMI) is recommended for identifying overweight and obese children and youth [2]. The BMI is a measure of excess weight relative to height rather than excess body fat and may be a less sensitive indicator of fatness among children [3]. Patterns of fat distribution have shown to influence cardiovascular disease (CVD) risk and abdominal obesity predicts CVD risk better than overall obesity [4,5]. There is also increasing interest in the use of waist circumference as an index of obesity and obesity-related health risk among children and adolescence, as the waist circumference has shown strong associations with risk for coronary heart disease [6]. Thus, obtaining normative information and cut-offs of the waist circumference in children can be a useful means of identifying overweight and obese conditions in childhood population studies, and for identifying those children who could benefit from early intervention.

Accompanying Editorial: Page 763-4.

Waist circumference percentile curves have been generated for Cuban [7], Italian/Spanish [8,9], British [10], and American children [11]. In India,

data on childhood waist circumference percentiles is very limited; one study that measured waist circumference derived a percentile chart for Indian school going children as a product of BMI and waist-to-height ratio, in a smaller number of children with a restricted age range [12]. Since urban pediatric obesity levels in India are increasing [13,14], the aim of the present study was to develop age and gender specific waist circumference reference data for urban Indian children 3-16 years of age.

METHODS

The PEACH (Pediatric Epidemiology and Child Health) study was conducted by St. John's Research Institute, Bangalore in children recruited from 8 urban middle income preschools and schools in Bangalore from August 2008 to January 2010. The annual fees of the schools that were chosen ranged from Rs. 24,000 to 30,000, therefore, the term "middle income group" was used for these schools. The inclusion criterion was normal healthy children in the age group of 3 to 16 years. The exclusion criterion was a significant clinical history. The schools were selected by using convenience sampling procedure for operational feasibility. The total sample was 9060 children (5172 boys and 3888 girls). The minimum sample size at each age and sex group was fixed at 100 children, as this is the minimum recommended sample size at each age group when using the LMS procedure [15] to define percentile curves. However, for lowest and highest year of age we could not achieve the recruitment of this number, therefore the percentile values at these specific years should be read with caution.

Information regarding the study along with the consent sheet was sent to all parents through the school, along with a questionnaire to collect data on age, date of birth, sex, and history of any medical illness of the child. The study was approved by the institutional ethical review committee and parental informed consent was obtained.

Anthropometric measurements of weight, height and waist circumference were measured by utilizing standard methodology [16]. The body weight was measured to the nearest 0.1 kg using a calibrated electronic scale (Essae Teraoka Limited, India). The height was measured to the nearest 0.1 cm. Waist circumference was measured with a non-stretchable tape by trained nutritionists (exerting the same standard pressure on the tape) at the midpoint of the lowest rib cage and the iliac crest, to the nearest 0.1 cm [17], in a standing position during end-tidal expiration. The within and between measurer coefficient of variation (CV) was 0.2% and 0.3%, respectively. Waist/Height (W/Ht) ratio was computed as the ratio of the waist circumference (cm) and the height (cm).

Data are presented as Mean (SD). All analyses were performed using Microsoft Excel 97. The data consisted of 9060 children (5172 boys and 3888 girls) aged 3.0-16.9 years and was divided into distinct age and sex groups. For the presentation of the data in tables, each age was rounded down to the last completed year.

Smoothed percentiles for waist circumference for each gender were obtained using LMS method [15]. The LMS method enables normalized growth centile standards to be developed, and deals generally with skewness which might be present in the distribution of the waist circumference measurements. The power L, Mean M and coefficient of variation S were calculated for each age group. The maximum power required to obtain normality was calculated for each age group series and the trend was summarised by a smooth (L) curve. The trends observed for the mean (M), and coefficient of variation (S), were smoothed using weighted third order polynomial equations using the Solver routine in Microsoft Excel.

RESULTS

The descriptive statistics for weight, height, BMI, waist circumference and W/Ht ratio for boys and girls by age are given in ***Web Table* I.** ***Table* I** shows the selected waist circumference percentile values at each age for boys and girls separately.

***Figure* 1** shows the smoothed computed waist circumference percentile curves for the 5th, 10th 25th, 50th, 75th, 85th 90th and 95th percentile for boys and girls separately. The upper end of curve in boys continued to increase, whereas in the girls it tended to plateau at about 14 years. ***Table* II** depicts the W/Ht percentile values for the boys and girls.

TABLE I SMOOTHED AND WEIGHTED AGE AND SEX-SPECIFIC WAIST CIRCUMFERENCE PERCENTILE VALUES (CM) FOR INDIAN CHILDREN 3-16 YEARS OF AGE

Sex	Age (y)	Percentiles							
		5th	10th	25th	50th	75th	85th	90th	95th
Boys	3	42.9	44.0	46.0	48.4	51.1	52.7	53.9	55.7
	4	44.1	45.3	47.4	49.9	52.8	54.5	55.7	57.6
	5	45.2	46.5	48.7	51.5	54.6	56.4	57.8	59.8
	6	46.3	47.6	50.1	53.1	56.5	58.6	60.0	62.4
	7	47.4	48.8	51.5	54.8	58.6	60.9	62.5	65.2
	8	48.5	50.0	52.9	56.6	60.8	63.4	65.2	68.2
	9	49.6	51.3	54.4	58.4	63.1	66.0	68.1	71.5
	10	50.8	52.6	56.0	60.4	65.6	68.8	71.1	74.9
	11	52.2	54.1	57.8	62.5	68.1	71.7	74.2	78.5
	12	53.7	55.7	59.6	64.7	70.7	74.6	77.4	82.0
	13	55.4	57.6	61.7	67.0	73.4	77.5	80.4	85.4
	14	57.4	59.6	63.9	69.4	76.1	80.3	83.4	88.5
	15	59.7	62.0	66.3	72.0	78.7	83.0	86.1	91.3
	16	62.4	64.7	69.0	74.7	81.3	85.5	88.6	93.6
Girls	3	44.3	45.3	47.1	49.3	51.8	53.3	54.4	56.1
	4	44.6	45.7	47.7	50.2	52.9	54.6	55.8	57.7
	5	45.3	46.5	48.7	51.4	54.5	56.4	57.8	59.9
	6	46.3	47.6	49.9	52.9	56.4	58.6	60.1	62.6
	7	47.5	48.9	51.5	54.8	58.7	61.1	62.8	65.6
	8	48.9	50.4	53.2	56.8	61.1	63.8	65.8	69.0
	9	50.5	52.1	55.1	59.0	63.7	66.7	68.9	72.4
	10	52.2	53.9	57.1	61.3	66.4	69.6	72.0	75.9
	11	54.0	55.8	59.2	63.7	69.1	72.5	75.0	79.3
	12	55.8	57.7	61.3	66.0	71.6	75.2	77.9	82.3
	13	57.7	59.7	63.4	68.2	74.0	77.7	80.4	84.9
	14	59.7	61.7	65.4	70.2	76.1	79.7	82.5	87.0
	15	61.7	63.7	67.3	72.1	77.7	81.3	83.9	88.2
	16	63.7	65.6	69.1	73.6	79.0	82.3	84.7	88.6

Age: completed age, e.g. 3 y = 3.00-3.99 y

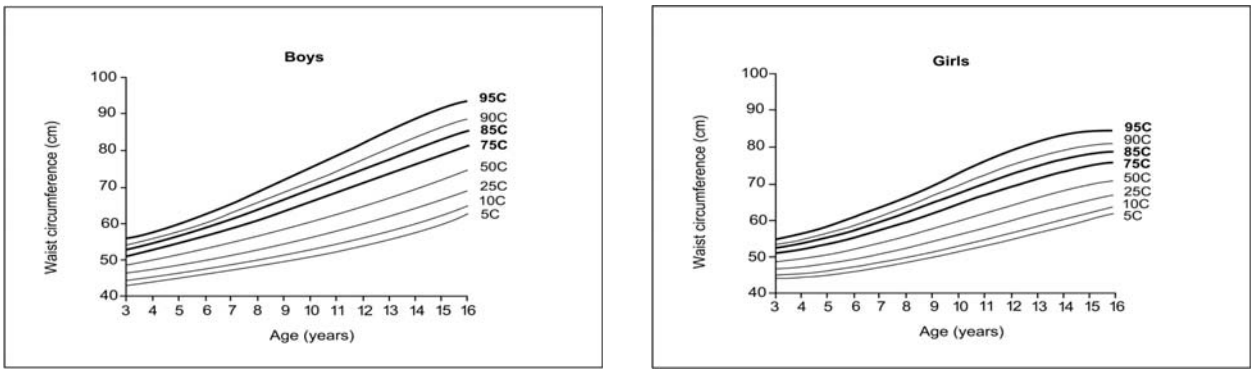

FIG. 1 *Smoothed percentile curves of waist circumference for Indian children aged 3-16 years.*

The smoothed W/Ht ratio percentile curves are depicted in ***Fig.* 2.** The 90th percentile of W/Ht ratio for boys was ≥ the recommended 0.5 ratio, whereas in girls, the 85th percentile value was ≤0.5.

***Web Table* II** depicts the percentage of the children above the BMI cut off from Cole, *et al*. [2] for overweight and obesity, the percentage of children above the 75th and 90th percentile of waist circumference in British children [10] as well as those above the 0.5 cut-off of W/Ht. On an average 7.8% and 2.5% of the children (both sexes) were above the Cole, *et al.* [2] cut off for overweight and obesity, respectively. However, based on the 75th and 90th waist percentiles of British children [10], far more of the present Indian children were over these cut-offs; 48% of the current Indian children had waist circumferences that were above the 75th percentile and 30% were above the 90th percentile. In addition, about 21% of the children had a W/Ht ratio greater than 0.5.

Similar figures existed for BMI based obesity by sex-wise analyses, but girls had more discordant results with the British waist circumference cut-off. Using the BMI cut off values of Cole *et al*. [2], it was observed that the highest percentage of obese boys (4.2%) and girls (4.5%) were at age 5. In girls, aged 16 years, the percentage was 6%. In boys aged 14 years, it was observed that 43% had waist circumferences that were above the 75th percentile of British children, while 30% were above the 90th percentile. In girls aged 14 years, 75% had waist circumferences that were above the 75th percentile of the British children, while 54% were above the 90th percentile. The highest percentage of children with W/Ht ratio greater than 0.5 was seen at 4 years in boys (43%) and at 3 years (71%) in girls.

DISCUSSION

Waist circumference percentile curves have been developed for children from different countries [7-11], and form a useful alternative to the measurement of BMI in terms of defining adiposity. In the present study, we have developed smoothed waist percentile curves for middle class South Indian children of both sexes, aged 3-16 years. These curves, which were developed on the largest data set available on waist circumference in Indian children, represent the first attempt to further our knowledge to develop smoothed waist circumference percentile curves and to suggest cut offs for defining abdominal obesity in this population. The waist circumference of the Indian children from the present study is higher when compared to age and gender matched British children [10], using similar techniques of measurement. For example, the 75th percentile values of waist circumference for 16 years was about 5.6% higher in boys and 12% higher in girls of the present study (compared to the British children), and this trend existed at all age groups, albeit with smaller differences. This suggests that urban middle class children in India already demonstrate leanings towards the adult South Asian phenotype that has features that are collectively termed "metabolically obese". These features have been demonstrated in Asian Indians, where a high percentage of body fat

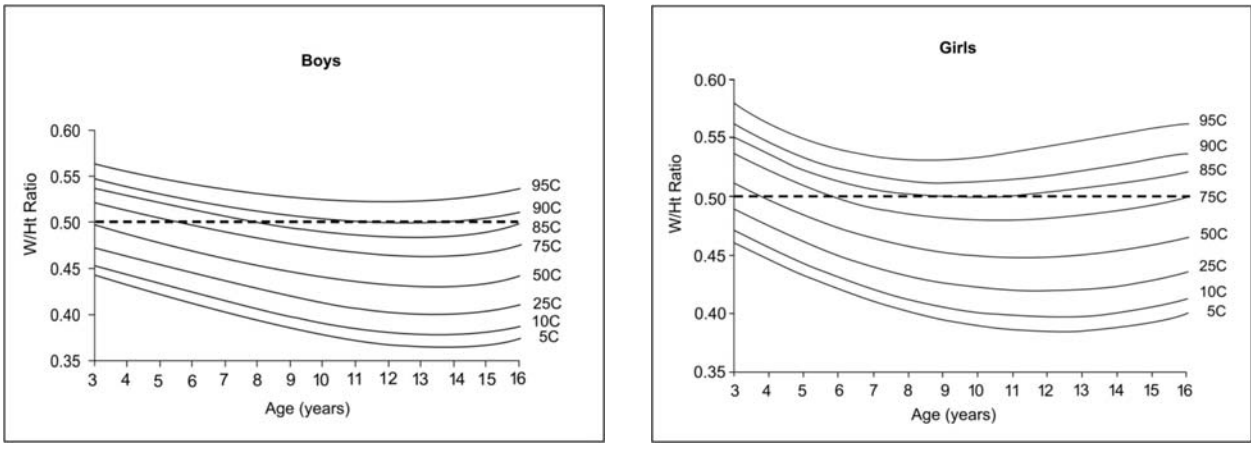

FIG. 2 *Smoothed percentile curves of waist to height ratio (W/Ht) for Indian children aged 3-16 years.*

TABLE II SMOOTHED AND WEIGHTED AGE AND SEX-SPECIFIC WAIST- HEIGHT (W/HT) RATIO PERCENTILE VALUES FOR INDIAN CHILDREN 3-16 YEARS OF AGE

Sex	Age (y)	Percentiles							
		5th	10th	25th	50th	75th	85th	90th	95th
Boys	3	0.44	0.45	0.47	0.50	0.52	0.54	0.55	0.56
	4	0.43	0.44	0.46	0.49	0.51	0.53	0.54	0.56
	5	0.42	0.43	0.45	0.48	0.51	0.52	0.53	0.55
	6	0.41	0.42	0.45	0.47	0.50	0.51	0.52	0.54
	7	0.40	0.41	0.44	0.46	0.49	0.51	0.52	0.54
	8	0.39	0.41	0.43	0.45	0.48	0.50	0.51	0.53
	9	0.38	0.40	0.42	0.45	0.48	0.49	0.51	0.53
	10	0.38	0.39	0.41	0.44	0.47	0.49	0.50	0.52
	11	0.37	0.38	0.41	0.43	0.47	0.49	0.50	0.52
	12	0.37	0.38	0.40	0.43	0.46	0.48	0.50	0.52
	13	0.36	0.38	0.40	0.43	0.46	0.48	0.50	0.52
	14	0.36	0.38	0.40	0.43	0.46	0.49	0.50	0.52
	15	0.37	0.38	0.40	0.43	0.47	0.49	0.50	0.53
	16	0.37	0.39	0.41	0.44	0.48	0.50	0.51	0.53
Girls	3	0.46	0.47	0.49	0.51	0.54	0.55	0.56	0.58
	4	0.45	0.46	0.47	0.50	0.52	0.54	0.55	0.56
	5	0.43	0.44	0.46	0.48	0.51	0.52	0.53	0.55
	6	0.42	0.43	0.45	0.47	0.50	0.51	0.52	0.54
	7	0.41	0.42	0.44	0.46	0.49	0.51	0.52	0.54
	8	0.40	0.41	0.43	0.46	0.48	0.50	0.51	0.53
	9	0.39	0.41	0.43	0.45	0.48	0.50	0.51	0.53
	10	0.39	0.40	0.42	0.45	0.48	0.50	0.51	0.54
	11	0.39	0.40	0.42	0.45	0.48	0.50	0.52	0.54
	12	0.39	0.40	0.42	0.45	0.48	0.50	0.52	0.54
	13	0.39	0.40	0.42	0.45	0.49	0.51	0.52	0.55
	14	0.39	0.40	0.42	0.45	0.49	0.51	0.53	0.55
	15	0.39	0.41	0.43	0.46	0.49	0.52	0.53	0.56
	16	0.40	0.41	0.44	0.47	0.50	0.52	0.54	0.56

Age: completed age, e.g. 3 y = 3.00-3.99 y

has been found compared to BMI matched white Caucasians and blacks [18,19].

There are some considerations that are relevant when addressing the obviously higher waist circumference percentile values in our Indian children; first, it is possible that since the children of the present study were from urban middle class schools, they were not economically disadvantaged nor did they have household food insecurity, and had free access to food even within the school. Therefore, this study may have measured waist circumference in children who may already have been tending towards overweight. However, by the BMI standard, the average prevalence of overweight was about 7.8%, which is not very high when compared to prevalence rates reported earlier in North Indian schools [13]. Second, the mean height of the children from the present study was also lower than the height of the British children. The rate of stunting is high in Indian children at about 48% in poor children [20], nevertheless, it must be considered that even in these urban middle class schools, the children were possibly not reaching their full capacity for height, even if the children were genetically different. It is known that stunted children with access to food develop larger waist circumferences and weight, along with signs of early cardiovascular morbidity [21,22].

WHAT IS ALREADY KNOWN?

- Waist circumference in children is an important measure of adiposity, but no large scale percentile data is available in India

WHAT THIS STUDY ADDS?

- Provides waist circumference and waist-height ratio percentile for Indian children aged 3-16 years.
- The study suggests that the 75th percentile of waist circumference from this study be used as an "action point" for Indian children to identify obesity.

Another question is the choice of percentile for the cut-off value to determine an overweight or obese waist circumference. From ***Web Table* II,** it is clear that while the BMI based Cole, *et al*. [2] standards gave prevalence of overweight that were less than 10% in general, the UK based waist circumference standard (based on their 75th and 90th percentile) gave values for overweight and obese that were in excess of 50%. Clearly, there is a need for population based waist circumference percentiles and specific population based cut-offs. As a tautology, it may be considered that the 85th percentile may be more appropriate as a starting cut-off value, but given the foregoing discussion about the selection of the present sample of children, it might be prudent to choose the 75th percentile in the present study data set as well, to represent overweight.

The waist-height ratio, in principle, is a good measure to represent the waist circumference in relation to another easily measurable body proportion so that distortions based on the body frame size in different populations are removed. It is being used increasingly to assess the risk of diseases related to central adiposity in adults [23,24] and W/Ht ratio greater than 0.5 has been suggested as a value for indicating whether the upper body fat accumulation is excessive and poses a risk to health in adults [25]. Studies in children using W/Ht ratios [8] have also shown that the ratio is superior in its ability to predict cardiovascular disease compared with BMI or percentage body fat. In the present study, it was observed that the percentage of children with W/Ht ratio greater than 0.5, decreased with increasing age in boys and girls. The value of the W/Ht ratio was skewed in the younger children (3-6 years), where the prevalence of children with a W/Ht ratio of greater than 0.50 was higher than 50% in these age groups. This could reflect the difference in the velocities of growth in height and waist circumference with age, but also suggests that the most rational employment of the W/Ht ratio may be in older, school going children.

In conclusion, this study provides reference values and percentile curves for waist circumference and W/Ht ratio of urban Indian children. However, within a framework that links anthropometry to adiposity which links to risk and morbidity, it is very important to identify precise cut off points for waist circumference and W/Ht ratio that could equate to different levels of risk for cardiovascular disease. Until large-scale data are available, we suggest that the 75th percentile of waist circumference from this study be used as an "action point" for Indian children to identify abdominal obesity.

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Contributors: RK conceived and designed the study, interpreted the data and wrote the manuscript. TT and SS conducted the statistical analysis. DPK, NRS, AM and RJ collected the data and helped in drafting the manuscript. SB was involved in reviewing the results and critically reviewing the manuscript. AVK was involved in the design of the study, interpretation of the data and revised the manuscript for important intellectual content. He will act as the guarantor of the study. The final manuscript was approved by all the authors.

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