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Validity of Different Methods for Assessing Overweight among Children Aged 6-10 Years in Kolkata, India

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ABSTRACT

Introduction: Various anthropometric measures including Body Mass Index (BMI) are used to assess overweight among children. The aim of the study was to assess the validity and compare the performance of different methods for assessing overweight children aged 6-10 years in Kolkata, India, taking BMI as standard. **Methods:** A total number of 5216 children (2738 girls and 2478 boys) were selected using multistage stratified sampling. Data collection was carried out from September 2013 to October 2014 by a team of trained researchers. **Results:** Prevalence of over nourished children was 32.4%. Sensitivity value was noticeably low for the fitness gram (FG) method, which was assessed by skinfold thickness at different body sites, but high for waist circumference (WC) and WC to height ratio (WHR). Low specificity was observed for weight-for-age (WAZ) and FG. Both positive and negative predictive values were high for WAZ and FG results, where positive/negative predictive values were the proportion of correct prediction among positive/negative prediction. High negative predictive values and low positive predictive values were observed for WC and WHR measures. **Conclusion:** This study suggests that if BMI measures are not available, other measures, namely waist circumference (WC) and WC-to-height ratio (WHR) can be used as proxy indicators for overweight among children.

Key words: Body mass index, children, India, over nutrition, waist circumference, waist circumference to height ratio

INTRODUCTION

Childhood obesity is currently a problem in urban India. It is believed that obesity is directly linked to affluence, but of late developing countries like India have experienced an increasing rate of obesity (Cherian, Cherian & Subbiah, 2012). In the study of public health, anthropometry is considered as one of the basic tools for assessing over or under nutrition. Generally, obesity is assessed through BMI. Wang & Hui (2015) found the diagnostic performance for weight and height-based references for obesity to be poorer than expected. They suggest that the cut-off values be revised to improve the diagnostic accuracy of childhood obesity. Nonetheless, body mass index(BMI) is taken as the standard though there are other anthropometric measures like weight for age, fitness gram, waist circumference (WC) and WC-to-height ratio (WHR) available for this purpose. If height measurement is not available, then

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only weight for age cut-off points may be used to predict obesity. Body fat can be measured through several anthropometric parameters such as fitness gram which is assessed through skin-fold thickness on a few regional body sites. Recently, to measure central adiposity among children of both genders, many new indicators such as waist circumference (WC) and waist-to -height ratio (WHR) have been used (Cai *et al*., 2013).

It is very important to validate different methods for assessing obesity among children particularly BMI given its widespread use all over the world as it does not require sophisticated tools or specialised personnel. Thus, the main objectives of the paper are (i) to measure the prevalence of overweight and obesity by different methods such as BMI for age, weight-for-age, fitness gram, WC and WHR and (ii) to validate and compare the performance of weight-for-age, fitness gram, WC and WHR by taking age and sex specific BMI through sensitivity and specificity tests.

METHODS

A cross-sectional study using multistage stratified random sampling procedure was conducted on children aged 6-10 years in the Kolkata Corporation and peripheral areas. However, due to obvious difficulty of identifying children who did not go to school, this study was restricted to only school-going children studying at classes I to IV. The total number of children in the sample was 5216, of whom 2738 were girls and 2478 boys.

Data collection was carried out between September 2013 and October 2014 by a team of trained researchers using multistage stratified sampling. Anthropometric measurements such as height, weight, WC and skin fold thickness on triceps and calf region were measured for all the students of the selected schools following standard techniques (Weiner & Lourie, 1981). BMI was calculated using the formula –Weight (Kg)/Height $(m)^2$. Hence BMI for age was used to classify each child into a nutritional status category such as underweight, normal, overweight and obese separately for boys and girls. Age and gender specific cut-off points were taken as per Center for Disease Control (CDC) norm. For each age and sex reference group, the 85^{th} percentile for overweight and the 95^{th} percentile for obesity were taken, while points below the 5^{th} percentile was designated as undernourished (WHO, 2006). Weight-for-age cut-off points were taken using the same procedure as that of BMI and the same standard was used (WHO, 2006).

The fitness gram body composition assessment helps to categorise children into "healthy fitness zone" or "needs improvement zone" categories based on skin fold thickness measurements irrespective of age, sex and ethnicity. Skin fold is sometimes regarded as a more accurate screening tool. The percent of body fat is calculated from the sum of triceps and calf skin folds as these are regarded as the measures of body composition on the fitness gram (Welk & Meridith, 2008). Here skin fold thickness cut-off points were used to identify whether the children were above the healthy weight range (>25 % for boys and >32 % for girls). For WC, the cut-off point was the 75^{th} percentiles for each age-sex combination (Kuriyan *et al.,* 2011) and for WHR, the cut-off point was 0.48 for both boys and girls (Panjikkaran, 2013).

Measurements were made of the sensitivity and specificity of weight for age, percentage of body fat (measured through fitness gram formula), WC and WHR using BMI classification, which is taken as the gold standard. High sensitivity denotes low Type II error and high specificity denotes low Type I error. The formulae for positive and negative predictive values are as follows:

$$\text{Positive Predictive Value (PPV)} = \frac{\text{Positives Correctly Classified}}{\text{Total Positives Found by the Classifier}}$$

$$\text{Negative Predictive Value (NPV)} = \frac{\text{Negatives Correctly Classified}}{\text{Total Negatives Found by the Classifier}}$$

Ethical clearance from the appropriate committee of the Indian Statistical Institute was obtained for this study.

RESULTS

A total of 5216 school children (2478 boys and 2738 girls) of class I to IV of age 6-10 years were included in this study. Sex-wise distribution of the samples was more or less equal (47.50% were boys and 52.50% were girls). Based on BMI, it was seen that out of a total of 5216 children, 14.5% children were underweight, 53.1% were normal, 10.2% overweight and 22.2% were obese (Table 1). Based on weight-for-age, 18.2% were underweight, 56.1% normal, 9.9% overweight and 15.8% were obese. The percentage of obesity was higher based on BMI compared to weight-for-age. It was seen that boys were more overweight or obese than girls by both the methods.

Table 2 shows the results of assessment of overweight or obesity through different anthropometric methods including BMI, weight-for-age, fitness gram, WC and WHR, using age and sex-specific cut-off points, overall for children and by sex. Different percentages of overweight or obese children were found through different techniques. The percentage of obese children was the lowest based on weight-for-age and the highest using WHR for all children by age and sex.

The degrees of sensitivity and specificity of overweight or obese children were found by weight-for-age and fitness gram taking BMI as the standard (Table 3). Percentage of sensitivity was higher in the case of weight-for-age than in the case of fitness gram in all age groups of children; percentages of specificity were very high in both weight-for-age and fitness gram. Percentages of positive predictive values and negative predictive values were also very high in both weight-for-age and fitness gram.

Table 4 shows the same analysis as in Table 3 for WC and WHR. Sensitivity and negative predictive values were seen to be very high in the case of WC and WHR. But specificity and positive predictive values (PPV) were in the range of 55% - 80%.

DISCUSSION

Recent reviews show that childhood obesity is increasing in Kolkata as in India and in other countries. Our results also corroborate the finding that there are substantial proportions of obese children in India, regardless of whatever measures are used. Percentages of overweight or obese children were found to be 32.4% and 25.7% based on BMI for age and weight-for-age respectively. Percentages of obese children were seen to be the lowest through weight-for-age and the highest through WHR. This was also true for each sex.

The sensitivity value was found to be somewhat low when weight-for-age was used and markedly low when fitness gram was used. But it was very high in the case of WC and WHR. On the other hand, low specificity was observed in weight-for-age and fitness gram. It was also seen that both positive and negative predictive values were high for weight-for-age and fitness gram. But in the case of WC and WHR, high negative predictive values and low positive predictive values were observed.

There are different opinions about the appropriateness of different methods of measuring the adiposity among children, though body mass index (BMI) is widely recommended by WHO (1995) for

Table 1. Percentage distribution of nutritional status of 6-10-year-old children in Kolkata by BMI for age and weight-for-age level

Age (years)	*N*	*Underweight*	*Normal*	*Overweight*	*Obese*	*Overweight & obese*	*Underweight*	*Normal*	*Overweight*	*Obese*	*Overweight & Obese*
		BMI for age					*Weight for age*				
						All 6-10-year-old children					
6	1030	14.0	53.8	9.1	23.1	32.2	16.1	57.7	9.3	16.9	26.2
7	1514	15.1	53.3	9.4	22.2	31.6	17.7	56.3	10.4	15.6	26.0
8	1442	13.2	53.4	11.0	22.4	334	18.0	55.5	9.5	17.0	26.5
9	970	14.4	51.7	11.3	22.6	33.9	19.5	55.2	10.7	14.6	25.3
10	260	21.2	51.9	10.8	16.2	26.9	25.4	55.4	8.5	10.8	19.2
6-10	5216	14.5	53.1	10.2	22.2	32.4	18.2	56.1	9.9	15.8	25.7
						6-10-year-old boys					
6	576	10.8	52.4	10.9	25.9	36.8	12.5	57.3	9.9	20.3	30.2
7	716	12.4	50.6	8.4	28.6	37.0	14.2	53.8	10.3	21.6	32.0
8	655	11.1	52.7	9.5	26.7	36.2	16.0	54.7	9.3	20.0	29.3
9	414	12.1	49.8	8.5	29.7	38.2	14.5	53.6	11.4	20.5	31.9
10	117	17.1	50.4	12.0	20.5	32.5	21.4	54.7	11.1	12.8	23.9
6-10	2478	11.9	51.4	9.4	27.3	36.7	14.7	54.9	10.2	20.3	30.5
						6-10-year-old girls					
6	454	17.4	56.4	6.7	19.5	26.2	20.7	58.1	8.6	12.6	21.2
7	798	17.4	55.8	10.4	16.4	26.8	20.8	58.5	10.4	10.3	20.7
8	787	14.9	54.1	12.2	18.8	31.0	19.7	56.2	9.7	14.5	24.1
9	556	16.2	53.1	13.5	17.3	30.8	23.2	56.3	10.3	10.3	20.5
10	143	24.5	53.1	9.8	12.6	22.4	28.7	55.9	6.3	9.1	15.4
6-10	2738	16.9	54.6	10.9	17.6	28.5	21.4	57.2	9.6	11.8	21.4

Table 2. Percentage distribution of 6-10-year-old obese children in Kolkata through different anthropometric measures

Age (years)	*N*	*BMI for age*	*Weight for age*	*Fitness gram*	*Waist circumference*	*Waist / height ratio*
			All obese 6-10-year-old children			
6	1030	32.2	26.2	20.6	49.8	55.4
7	1514	31.6	26.0	23.7	46.7	51.5
8	1442	33.4	26.5	30.3	49.2	52.5
9	970	33.9	25.3	35.5	46.5	50.1
10	260	26.9	19.2	31.9	40.4	44.6
6-10	5216	32.4	25.7	27.5	47.7	52.0
			Obese 6-10-year-old boys			
6	576	36.8	30.2	25.3	53.8	57.3
7	716	37.0	32.0	33.5	49.2	51.1
8	655	36.2	29.3	37.3	47.2	49.4
9	414	38.2	31.9	41.4	49.4	47.5
10	117	32.5	23.9	42.7	45.3	52.1
6-10	2478	36.7	30.5	34.4	49.6	51.5
			Obese 6-10-year-old girls			
6	454	26.4	21.2	14.5	44.7	53.1
7	798	26.8	20.7	14.8	44.5	51.9
8	787	31.0	24.1	24.6	51.0	55.1
9	556	30.8	20.5	31.1	44.3	52.1
10	143	22.4	15.4	23.1	36.4	38.5
6-10	2738	28.5	21.4	21.3	45.9	52.3

Table 3. Sensitivity, specificity, PPV and NPV of weight for age and fitness-gram of 6 to 10-year -old school children in Kolkata taking BMI as standard

Age group	*N*	*Weight for age* *Percentage of overweight or obese*				*Fitness gram* *Percentage of over fat*			
		Sensitivity	*Specificity*	*PPV*	*NPV*	*Sensitivity*	*Specificity*	*PPV*	*NPV*
6	1030	74.69	96.85	91.85	88.95	57.53	96.99	90.09	82.76
7	1514	76.61	97.39	93.14	90.00	67.22	96.51	89.94	86.39
8	1442	74.01	97.29	93.19	88.20	75.25	92.27	83.02	88.13
9	970	68.99	97.03	92.27	85.91	82.01	88.50	78.65	90.49
10	260	67.14	98.42	94.00	98.04	85.71	87.89	72.29	94.35

Overweight or obese though BMI: Above 85^{th} percentile.
Over-fat through Fitness-gram: Summation of triceps and calf skin-fold ≥ 25.
Sensitivity = True positive rate = (Positives correctly classified)/(Total positives found by the standard classifier)
Specificity = True negative rate = (Negatives correctly classified)/(Total negatives found by the standard classifier)
PPV = Positive predictive value = (Positives correctly classified)/(Total positives found by the classifier);
NPV = Negative predictive value = (Negatives correctly classified)/(Total Negatives found by the classifier)

Table 4. Sensitivity, specificity, PPV and NPV of waist circumference and waist circumference to height ratio of 6 to 10-year-old school children in Kolkata taking BMI as standard

Age group	*N*	*Waist circumference*				*Waist circumference to height ratio*			
		Percentage of overweight or obese				*Percentage of overweight or obese*			
		Sensitivity	*Specificity*	*PPV*	*NPV*	*Sensitivity*	*Specificity*	*PPV*	*NPV*
6	1030	95.78	72.06	61.98	97.29	95.78	63.75	55.69	96.94
7	1514	94.78	75.51	64.21	96.89	95.62	68.92	58.79	97.13
8	1442	94.57	73.38	63.98	96.43	96.46	69.52	61.32	97.51
9	970	94.51	78.30	69.19	96.51	93.29	72.17	63.35	95.43
10	260	91.43	78.42	60.95	96.13	92.86	73.16	56.03	96.52

Overweight or obese though BMI: Above 85th percentile, overweight or obese though waist circumference: Above 75*th* percentile
Overweight or obese though waist circumference to height ratio: Value > 0.48

measuring the excess weight relative to height rather than excess body fat. Thus BMI is a less sensitive indicator of fatness among children. Patterns of fat distribution also help to warn about cardio-vascular disease (CVD) risk rather than overall obesity. Waist circumference, which is used as an index of obesity, has a strong association with cardiovascular diseases (Ashwell, Gunn & Gibson, 2012).

Fujita *et al.* (2011) concluded that WHR is not effective to classify childhood obesity. Marradon *et al.* (2013) stated that WHR is an effective method to measure adiposity among children. Brambilla *et al.* (2013) also stated that WHR is the most effective predictor of adiposity compared to WC and BMI. Now the question arises, besides BMI, to what extent are other methods useful for assessing children's obesity? BMI is not unanimously accepted as a gold standard because during childhood, body composition varies greatly at similar BMI levels. BMI thus cannot be taken as a very accurate measure of adiposity (Chacar & Salameh, 2011). Regarding fitness gram, there exists some limitations because it accounts for only sub-cutaneous fat as not only is skin fold thickness difficult to measure in obese children but no cut-off point is widely recognised. So, in conclusion, we can say that if BMI values are not available, other measures of over-nutritional status, namely waist circumference (WC) and WC-to-height ratio (WHR) can be used as proxy.

Limitations of the study

As our study was restricted to the primary school children of Kolkata, it was not exhaustive. Further investigations need to be done before we extrapolate our findings to the general population on the basis of this study.

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Conflict of interest

The authors declare that there is no conflict of interest with respect to the research, authorship, and/or publication of this article.

REFERENCES

Ashwell M, Gunn P & Gibson S (2012). Waist-to-height ratio is a better screening tool than waist circumference and BMI for adult cardiometabolic risk factors: systematic review and meta-analysis. *Obesity Rev* 13: 275–286.

Brambilla P, Bedogni G, Heo M & Pietrobelli A (2013). Waist circumference-to- height ratio predicts adiposity better than body mass index in children and adolescents. *Int J Obes (Lond)* 37: 943-6.

Cai L, Lie A, Zhang Y & Wang P (2013). Waist-to-height ratio and cardiovascular risk factors among Chinese adults in Beijing. *Plos One* 8:1-6. e69298-69303.

Chacar HR & Salameh P (2011). Public school adolescents' obesity and growth curves in Lebanon. *Lebanese Med J* 59:80-88.

Cherian AT, Cherian SS & Subbiah S (2012). Prevalence of obesity and overweight in urban school children in Kerala, India. *Indian Pediatr* 49: 475-477.

Fujita Y, Kouda K, Nakamura H & Iki M (2011). Cut-off values of body mass index, waist circumference, and waist-to-height ratio to identify excess abdominal fat: population-based screening of Japanese school children. *J Epidemiol* 21: 191-6.

Kuriyan R, Thomas T, Lokesh DP, Sheth NR, Mahendra A, Joy R, Sumithra S, Bhat S & Kurpad AV (2011). Waist circumference and waist for height percentiles in urban South Indian children aged 3-16 years. *Indian Pediatr* 48: 765-771.

Marrodán MD, Martínez-Álvarez JR, González-Montero De Espinosa M, López-Ejeda N, Cabañas MD & Prado C (2013). Diagnostic accuracy of waist to height ratio in screening of overweight and infant obesity. *Med Clin (Barc)* 140: 296-301.

Panjikkaran ST (2013). Waist-to-height ratio for recording the risks of overweight in South Indian schoolchildren in Kerala. *Indian Pediatr* 50: 493-495.

Wang L & Hui S Sai-Chuen (2015). Diagnostic accuracy of different body weight- and height-based definitions of childhood obesity in identifying overfat among Chinese children and adolescents: a cross-sectional study. *BMC Public Health* (2015) 15:802-808.

Weiner JS & Lourie JA (1981). Practical Human Biology. Academic Press, New York.

Welk GI & Meridith MD (2008). Fitnessgram/ Activitygram Reference Guide (3rd). The Cooper Institute, Dallas, TX.

World Health Organization (WHO) Multicentre Growth Reference Study Group. (2006) Child growth standards: length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index for age methods and development. Geneva.

World Health Organization(WHO) (1995). Physical status: the use and interpretation of anthropometry. WHO Technical Report Series, 854, Geneva.