RESEARCH PAPER

Measuring Obesity among School-aged Youth in India: A Comparison of Three Growth References

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Objective: To compare three growth references that can be used to assess the weight status of school-aged youth living in India, with a particular focus on identifying overweight and obese youth.

Study Design: Cross-sectional study. Kappa scores were used to measure agreement between growth references. Regression models were used to test for differences in weight status by grade level, gender, and school type, using each growth reference.

Setting: Private (*n*=4) and Government schools (*n*=4) in Delhi, India.

Participants: Students (*n*=1818) in eighth and tenth grade attending the schools.

Main outcome measures: Weight status was derived using age- and gender-specific cut-points provided by: (*a*) a national growth reference specific to India; (*b*) an international reference recommended by the International Obesity Task Force (IOTF); and (*c*) a new international reference recommended by the World Health Organization (WHO).

Results: The IOTF reference consistently classified participants in a lower weight status category, compared with the national reference (κ=0.57) and the WHO reference (κ=0.69). The agreement between the WHO and the national references was higher (κ=0.84).

Conclusions: To date, all published studies of childhood obesity in India have used the IOTF reference, the national reference, or an old WHO reference to measure weight status among school-going youth. The new WHO reference may be a better choice. Compared to the IOTF reference, it does not appear to underestimate obesity and can still be used to compare trends, globally.

Key words: *Adolescents, Growth reference, India, Measurement, Obesity.*

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Obesity among school-aged youth is a growing public health problem in India [1]. This crisis appears to be rising rapidly, especially in cities and among affluent youth [2-4]. Compared to countries in the West, many negative sequelae of obesity, like diabetes, occur at earlier ages [4,5] and at lower BMI cut-points [6] in India, which makes obesity a particularly serious public health issue in this country.

It is critical to be able to accurately identify obesity among school-going youth, for clinical and epidemiologic purposes. Many growth references can be used [7-10]. Each uses age- and gender-specific body mass index (BMI) cut-points to classify young people according to their weight status (eg, overweight or obese). To date, all studies of obesity among school-going youth in India have employed either (*a*) a National reference [7]; (*b*) the older National Center for Health Statistics/ World Health Organization (NCHS/WHO) reference [8]; and/or (*c*) the International Obesity Task Force (IOTF) reference [9]. None have used the growth reference

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recently released by the WHO for school-aged children [5 to 19 years old) [10]. This growth reference was developed after the release of a new reference for preschool children (0 to 5 years old) in 2006 [11]. Data from a multi-national sample of preschool children, including children from India, were merged with the 1977 NCHS data (1-21 years old) to construct new growth curves for school-aged youth. This "new" WHO reference replaces the "old" WHO/NCHS reference.

The purpose of this paper is to compare this WHO reference [10] with the national [7] and IOTF [8] references to assess the extent to which they agree in regards to classifying weight status, with a special focus on identifying overweight or obese youth.

METHODS

This cross-sectional study was conducted in 2006, when eight schools in New Delhi, India were recruited to participate in the study. Four were Private schools (middle-upper SES) and four were Government schools (low SES). Ethical clearances for the study were obtained from the appropriate boards in India and the US. Passive parental consent and active student assent were required to participate. The study included (*a*) anthropometric measures; (*b*) a survey of nutrition and physical activity behaviors; and (c) a survey specific to 'westernization' or cultural adaptation within this setting.

All students enrolled in the 8th and 10th grades in these eight schools were eligible and asked to participate (*n*=2339). Response rates for the anthropometric measures, the survey of the behaviors, and the "westernization" survey were 87.2%, 88.6%, and 92.0%, respectively. Non-participants included parent refusals (<1%), student refusals (<1%), and absentees (7-11%). The analysis sample includes 1818 students who participated in all three data collection efforts. Of these, 60% were boys, 52% attended a Private school, and 55% were in 8th grade. The mean age of 8th and 10th graders was 13.9 and 15.8 years, respectively.

Anthropometric data (i.e., height, weight) were collected from these students using standardized protocols adapted from Lohman and colleagues [13] to meet needs specific to this context. Weight was measured using a digital scale that was transported to each school. The scale was calibrated daily, and each student's weight was recorded to the nearest 0.1 kg. Height was measured using a calibrated vertical bar and was recorded to the nearest 0.5 cm. Data were collected by two-person teams of trained research staff.

Body mass index (BMI) was used to classify the participants according to their weight status (i.e., underweight, normal weight, overweight, or obese) using age- and gender-specific cut-points recommended by three growth references: (*a*) the International Obesity Task Force (IOTF) [9]; (*b*) the WHO recommendations [10]; and (*c*) a National (i.e., Indian) study [7]. The classification of participants across these growth references was compared. Kappa statistics were calculated to measure agreement between each pair of growth references [14,15]. Kappa at 1.00 implies perfect agreement. Mixed-effects regression models were used to test for differences in the percentage of participants who could be classified as overweight or obese by grade level, gender, and school type. School was specified as a nested random effect in the regression models [16].

RESULTS

The mean and median BMI in this sample of school-going youth were 19.16 and 18.14 kg/m^2,

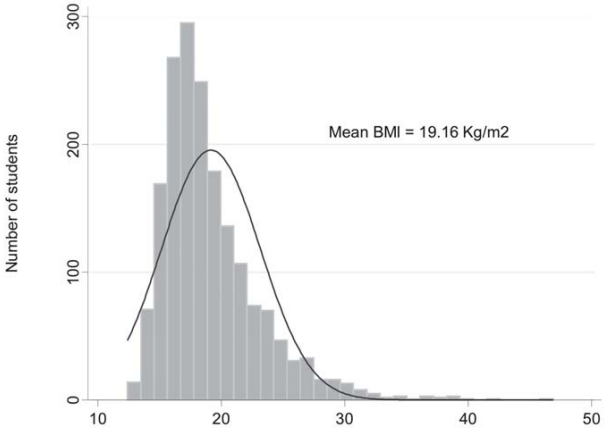

FIG. 1 *Distribution of BMI among study subjects (n=1818).*

respectively. The distribution of BMI was skewed to the right, with a long tail at higher BMI values (***Fig.* 1**). Tenth graders had a higher BMI than eighth graders (19.64 *vs* 18.54, $P<0.001$), girls had a higher BMI than boys (19.42 *vs* 18.77, $P<0.001$), and Private school students had a higher BMI than students in Government schools (20.44 *vs* 17.63, $P<0.001$).

The distribution of participants by weight status and growth reference is presented in ***Table* I**. The agreement between the IOTF and WHO references (κ=0.69) and the IOTF and Indian references (κ=0.57) was similar and lower than the agreement between the WHO and Indian references (κ=0.84). The IOTF reference classified participants in lower weight status categories,

TABLE I DISTRIBUTION OF PARTICIPANTS BY WEIGHT STATUS AND GROWTH REFERENCE (*N*=1818)

	IOTF reference*					
	Obese *n* (%)	Overweight *n* (%)	Normal weight *n* (%)	Underweight *n* (%)	Total	Kappa (95% CI)
WHO reference[#]						
Obese	59 (65.6%)	31 (34.4%)	0	0	90	
Overweight	0	158 (75.2%)	52 (24.8%)	0	210	
Normal weight	0	0	910 (73.6%)	327 (26.4%)	1237	
Underweight	0	0	0	281 (100%)	281	
Total	59	189	962	608	1818	
						0.69 (0.66, 0.72)**
						0.89 (0.86, 0.92)[##]
Indian reference‡						
Obese	59[#] (64.8%)	32* (35.2%)	0*	0*	91	
Overweight	0	157 (67.1%)	77 (32.9%)	0	234	
Normal weight	0	0	885 (66.9%)	437 (33.1%)	1322	
Underweight	0	0	0	171 (100%)	171	
Total	59	189	962	608	1818	
						0.57 (0.55,0.61)**
			WHO reference[#]			0.84 (0.81,0.88)[##]
Indian reference‡						
Obese	85 (93.4%)	6 (6.6%)	0	0	91	
Overweight	5 (2.1%)	197 (84.2%)	32 (13.7%)	0	234	
Normal weight	0	7 (0.5%)	1203 (91.0%)	112 (8.5%)	1322	
Underweight	0	0	2 (1.2%)	169 (98.8%)	171	
Total	90	210	1237	281	1818	
					0.85 (0.83,0.87)**	
					0.92 (0.90,0.95)**	

** Using age- and gender-specific cut-points from the International Obesity Task Force (9); [#] Using age- and gender-specific cut-points from the World Health Organization(10); [‡] Using age- and gender-specific cut-points from an Indian growth reference study (7); [d] Considers four weight status categories, separately (i.e., obese vs. overweight vs. normal weight vs. underweight); [**] Kappa statistic, considering four weight status categories, separately; [##] Kappa statistic, considering two groups of weight status categories, combined.*

across all categories, compared to both the WHO and Indian growth references. Similar trends were observed when comparing the IOTF and Indian growth references. The Indian and WHO growth references were, in contrast, reasonably similar. The agreement between all references improved when weight status categories were collapsed to reflect obese/overweight students *vs* normal weight/ underweight students (IOTF *vs* WHO, $\kappa = 0.89$; IOTF *vs* India, $\kappa = 0.94$; WHO *vs* India, $\kappa = 0.92$).

Using the IOTF, the WHO, and the Indian growth references, the prevalence of obesity was estimated at 3.25%, 4.95%, and 5.01%, respectively, while the prevalence of overweight was estimated to be 10.40%, 11.55%, and 12.87%, respectively. These estimates were combined to examine whether the prevalence of obesity/overweight varied by grade, gender, or school type (***Table* II**). There were no differences by grade level. The prevalence of overweight/obesity was slightly higher among boys compared to girls, but this difference was only statistically significant when using the Indian reference (13.86% *vs* 9.80%, $P=0.007$). The prevalence of overweight/obesity, by comparison, was much higher among students enrolled in private schools compared to those in Government schools. The difference was statistically significant in each of the three growth references (WHO: 26.62% *vs* 3.98%, $P<0.001$; IOTF: 21.99% *vs* 3.13%, $P<0.001$; Indian: 28.61% *vs* 4.48%, $P<0.001$). The percentage of students who were either overweight or obese was 6 to 7 times higher among students in private schools compared to students in Government schools.

DISCUSSION

In studies of child and adolescent obesity, the International Obesity Task Force reference is typically recommended for use, especially for comparisons, worldwide [9]. In this study of school-going youth from India, the IOTF reference consistently classified participants in a lower weight status group, across all categories, compared to the new WHO references and Indian references. That is, compared to these references, the IOTF reference underestimated obesity. The WHO and Indian references, in contrast, were very similar.

The "new" WHO reference was recently adopted at a national workshop in India as the growth reference of choice for infants and pre-school aged youth [17]. It may also be a good choice for school-going youth in this setting, as well. Like the IOTF reference, the "new" WHO reference uses an international sampling frame to construct its cut-points, which allows for cross-national comparisons. Its sampling frame, however, includes

TABLE II DIFFERENCES IN THE PREVALENCE OF OBESITY/OVERWEIGHT BY GRADE LEVEL, GENDER, AND SCHOOL TYPE (N=1818)

	IOTF reference*			WHO reference#			Indian reference‡		
	Prevalance (95% CI)		*P* value	Prevalence (95%CI)		*P* value	Prevalence (95% CI)		*P* value
By grade									
8th grade	8.37%	(3.92-16.97)		11.69%	(3.04-35.84)		11.84%	(5.72-22.94)	
10th grade	9.37%	(4.41-18.83)	0.395	11.59%	(3.35-33.17)	0.889	12.50%	(6.03-24.12)	0.642
By gender									
Boys	9.37%	(4.40 – 18.70)		11.63%	(5.50-22.90)		13.86%	(6.78-26.24)	
Girls	8.05%	(3.73 – 16.48)	0.288	9.76%	(4.52-19.80)	0.181	9.80%	(4.63-19.59)	0.007
By school									
Private	21.99%	(16.77-28.30)		26.62%	(20.49-33.80)		28.61%	(22.19-36.02)	
Government	3.13%	(1.95-4.98)	<0.001	3.89%	(2.48-6.04)	<0.001	4.48%	(2.91-6.82)	<0.001

*Using mixed-effects regression models, school specified as a nested random effect; *Using age- and gender-specific cut-points from the International Obesity Task Force(9); #Using age- and gender-specific cut-points from the World Health Organization(10); ‡Using age- and gender-specific cut-points from an Indian growth reference study(7).*

WHAT IS ALREADY KNOWN?

- Many growth references can be used to define childhood obesity in epidemiologic studies of school-going youth (ages 5-18 years) in India, but the best choice is unclear.

WHAT THIS STUDY ADDS?

- The new WHO growth reference, which was released in 2007, may be the best choice for measuring childhood obesity among school-going youth in India, as it does not appear to underestimate weight status and allows for comparisons with global trends.

data from India, while the IOTF reference does not [11,7]. At age 18 (IOTF) and 19 (WHO), both references align with the recommended cut-offs for overweight (≥ 25 kg/m^2) and obesity (≥ 30 kg/m^2) for adults in the West. In Asia, however, lower cut-points for overweight (≥ 23 kg/m^2) and obesity (≥ 25 kg/m^2) are recommended for adults, since related co-morbid conditions occur at lower BMI values [6]. Thus, the "new" WHO reference may still underestimate the true extent of obesity in school-going youth in India, but it performed better than the other international reference used here.

Regardless of the growth reference used, it is clear that obesity is problematic among adolescents in large cities of India, like Delhi. In this study, the distribution of BMI was skewed, with a longer tail at higher BMI values, which is characteristic of this epidemic in other regions of the world [18]. Consistent with similar studies from other cities in India, the prevalence of obesity was somewhat higher among boys, as compared to girls [2-4]. In contrast to what is typically observed in the West, obesity is most problematic among more affluent youth in India, *versus* the less affluent. About 1 in every 4 (>25%) students enrolled in Private schools in this study, which are more affluent than Government schools, was overweight or obese. This estimate is greater than that reported in comparable studies of affluent, school-aged youth in other parts of India, like Hyderabad (<7%) [2] and Ludhiana, (<15%) [3], but consistent with study from Delhi (>25%) [19]. Epidemiologic studies of adults seem to suggest obesity is most problematic in north India, in cities like Delhi [20]. This may also be true for adolescents.

Schools were not randomly chosen to participate in the study, but were selected to be representative of the mix of types of schools in Delhi. The study, therefore, provides a sample of school-aged youth of different affluence, as well as both boys and girls from different grade levels [13].

Future research should be cognizant of the different growth references that can be used to define obesity among school-aged youth in India, including their strengths and weaknesses. An accurate understanding of which school-aged youth are affected by this emerging epidemic is critical to subsequent studies designed to understand the reasons for the same. These studies, in turn, must then be used to drive the development of effective intervention, which is urgently required in India.

Contributors: MHS is the Principal Investigator. She was involved in study design, implementation, development of data collection protocols and the conceptualization of the data analysis. MA was involved as Project Director of the study in India, and worked on all aspects of the design and implementation of the study, including development of data collection protocols. PD and VT assisted with all data analyses. RS oversaw data collection. KSR and CLP are Co-Investigators on the study and assisted with its design and the development of data collection protocols. MHS wrote the manuscript, with significant input from all other co-authors listed. The final manuscript was approved by all the authors.

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