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ARTICLE

Body mass index percentiles for rural Bengalee pre-school children aged 2-6 years, in comparison with the WHO reference and other studies

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ABSTRACT Objective: Compare the body mass index (BMI) percentiles of the rural Bengalee children with those in two recently developed international references: the WHO and the US Centers for Disease Control and Prevention (US CDC) growth references and two other studies. Design: A cross-sectional ethnic based survey. Setting: Thirty randomly selected villages, from rural areas of Purulia, Paschim Medinipur and Darjeeling. Subjects: 1,872 preschool children aged 2–6 years. Results: BMI percentiles were established using the LMS method, and were compared with the percentiles of the WHO reference, the US CDC reference and two other studies. BMI distributions and growth patterns in Bengalee preschool children were dramatically different from those in the two international reference populations. Compared with the international reference populations, rural Bengalee boys and girls (2-6 years) had substantially lower BMI percentiles than their counterparts in the reference populations. Conclusions: The present study described the different patterns of BMI values at the regional/ethnic level, and these values are useful as a reference for comparing different regions and for monitoring changes over time in Bengalee and children of Indian subcontinent. Higher proportions of children with extreme values in uni-directions indicate that Bengalee children currently facing an increasing level of undernutrition.
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KEY WORDS
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Growth is the increase in number, size and functional advancement of the cells in the body. Growth references are used widely in the developed and developing worlds, both as a clinical tool to monitor growth in individual children and as a public health indicator to compare nutritional status over time or among different populations (WHO 1978; WHO 1979).

Recently, the WHO released the newly constructed growth references for school-age children, the WHO references (2006), while the US Centers for Disease Control and Prevention (US CDC 2002) released updated growth charts – the US CDC growth table (US CDC 2002). Both include body mass index (BMI) percentiles for school-age children. These percentiles reflect BMI distributions in the reference populations. Understanding the differences in BMI distributions between rural Bengalee preschool children of West Bengal, India with the WHO (2006) references population, US CDC (2002) growth table, Jiang et al. (2006) and Bose et al. (2011) is important for interpreting the prevalence of underweight and obesity among rural preschool children of West Bengal, India calculated using different references. The extreme values of BMI in either direction (obese or underweight) are of major public interest in both developed and developing countries. Therefore, comparing BMI distributions between rural Bengalee preschool children and their counterparts in the reference populations provides evidence on relative discrepancy among the reference data with the present study. The data are useful for prioritizing major public health issues and for developing preschool nutrition programmes in rural areas of West Bengal, India. The aims of the present study were to establish BMI percentile curves for rural Bengalee preschool children aged 2–6 years, and to compare BMI percentiles of the same preschool children with those in two reference populations: the WHO references (2006) and CDC growth tables (2002) and also with two other studies: Jiang et al. (2006) and Bose et al. (2011) to validate the percentile values of the reference population.

Materials and Methods

The present community based cross-sectional study was conducted between September-2010 and November 2010 among the rural preschool children of Purulia, Paschim Medinipur and Darjeeling district of West Bengal, India. The present study included 1,872 participants who were preschool children aged 2–6 years randomly selected from thirty villages. The participants were free from overt physical or mental illness. The present study collected data on sex, age, weight

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Table 1(a). BMI-for-age charts and selected smoothed BMI percentiles (boys aged 2-6 years).

Age (years)	n	5p	10p	25p	50p	75p	85p	90p	95p
2	134	11.43	12.34	13.69	15.01	16.19	16.77	17.16	17.70
3	141	11.37	12.18	13.40	14.63	15.75	16.32	16.69	17.22
4	211	11.23	11.98	13.14	14.32	15.41	15.97	16.34	16.86
5	223	11.18	11.87	12.97	14.11	15.18	15.73	16.09	16.62
6	198	11.45	12.04	13.01	14.03	15.02	15.53	15.87	16.37

Table 1(b). BMI-for-age charts and selected smoothed BMI percentiles (girls aged 2-6 years).

Age (years)	n	5p	10p	25p	50p	75p	85p	90p	95p
2	137	11.37	12.06	13.18	14.38	15.53	16.13	16.53	17.12
3	182	11.55	12.12	13.09	14.18	15.29	15.90	16.31	16.93
4	200	11.63	12.12	12.98	13.98	15.06	15.66	16.08	16.72
5	218	11.67	12.08	12.82	13.74	14.77	15.38	15.82	16.51
6	227	11.65	12.00	12.66	13.50	14.49	15.10	15.54	16.27

Table 2 (a). Smoothed 5th & 95th BMI (kg/m²) percentiles among boys.

Age (Years)	WHO 2006		CDC 2010		Jiang et al. 2006		Bose et al 2011		Present study	
	5th	95th	5th	95th	5th	95th	5th	95th	5th	95th
2	13.9	18.0	14.7	18.3	14.7	18.8	-	-	11.4	17.7
3	13.7	17.8	14.3	18.2	14.2	18.3	13.3	16.5	11.4	17.2
4	13.4	17.6	14.0	17.8	13.9	18.5	12.7	15.9	11.2	16.9
5	13.3	17.7	13.8	17.9	13.6	19.0	12.6	15.6	11.2	16.6
6	-	-	13.7	18.4	13.6	19.9	-	-	11.6	16.4

Table 2 (b). Smoothed 5th & 95th BMI (kg/m²) percentiles among girls.

Age (Years)	WHO 2006		CDC 2010		Jiang et al. 2006		Bose et al 2011		Present study	
	5th	95th	5th	95th	5th	95th	5th	95th	5th	95th
2	13.5	17.8	14.4	19.0	14.4	18.4	-	-	11.4	17.1
3	13.5	17.8	14.0	18.3	14.1	18.0	12.8	16.6	11.6	16.9
4	13.2	17.9	13.7	18.0	13.7	18.0	12.6	16.2	11.6	16.7
5	13.1	18.1	13.5	18.2	13.4	18.3	12.3	15.7	11.7	16.5
6	-	-	13.4	18.8	13.1	18.8	-	-	11.7	16.3

and height. Weight was measured either in underclothes or adjusted for clothing weight, while height was measured with the head held in the Frankfort plane. Standard procedures were followed to measure body height and weight, with participants wearing light clothes Height and weight measurements were taken for each subject by the first author (S.D.) following standard techniques (Lohman et al. 1988). Technical errors of measurements (TEMs) were found to be within reference values (Ulijaszek and Kerr 1988) and thus not incorporated in statistical analyses. BMI was calculated as body weight (kg) divided by height (m) squared (kg/m²). Table 1 shows the number of children by age and sex with their BMI percentile values constructed by the LMS method (Cole 1990).

The BMI percentile for a specific age and sex group was calculated as $M(1+LSZ)^{1/L}$ (Freeman et al. 1990), where Z is the Z-score that corresponds to the percentile. We presented the following BMI percentile tables for rural Bengalee preschool children: 5th, 10th, 25th, 50th, 75th, 85th, 90th, and 95th. For the purpose of comparison, we plotted the 5th and

Table 3 (a). Difference in the 5^{th} & 95^{th} Percentile values of BMI (kg/m^2) of all studies with present study among Boys.

Age (Years)	(WHO 2006 -Present study)		(CDC 2010 - Present study)		(Jiang et al. 2006 - Present study)		(Bose et al 2011 - Present study)	
	5^{th}	95^{th}	5^{th}	95^{th}	5^{th}	95^{th}	5^{th}	95^{th}
2	2.5	0.3	3.3	0.6	3.3	1.1	-	-
3	2.3	0.6	2.9	1.0	2.8	1.1	1.9	-0.7
4	2.2	0.7	2.8	0.9	2.7	1.6	1.5	-1.0
5	2.1	1.1	2.6	1.3	2.4	2.4	1.4	-1.0
6	-		2.1	2.0	2.0	3.5	-	-

Table 3 (b). Difference in the 5^{th} & 95^{th} Percentile values of BMI (kg/m^2) of all studies with present study among girls.

Age (Years)	(WHO 2006 - Present study)		(CDC 2010 - Present study)		(Jiang et al. 2006 - Present study)		(Bose et al 2011 - Present study)	
	5^{th}	95^{th}	5^{th}	95^{th}	5^{th}	95^{th}	5^{th}	95^{th}
2	2.1	0.7	3.0	1.9	3.0	1.3	-	-
3	1.9	0.9	2.4	1.4	2.5	1.1	1.2	-0.3
4	1.0	0.2	2.1	1.3	2.1	1.3	1.0	0.5
5	1.4	1.6	1.8	1.7	1.7	1.8	0.6	0.8
6	-	-	1.7	2.5	1.4	2.5	-	-

95^{th} percentiles of rural Bengalee preschool children against the corresponding values in the WHO references (2006), the US CDC (2002), Jiang et al. (2006) and Bose et al. (2011). All analyses were conducted by using Statistical packages for social sciences (SPSS-17) and Microsoft excels Office- 2003.

Results

Among 1,872 participants, 48.7% (911) were boys and 51.5 % (965) were girls. Table 1 (a) and (b) shows the smoothed BMI percentiles for rural Bengalee boys and girls aged 2–6 years. The 5th, 10th, 25th, 50th, 75th, 85th, 90th and 95th percentiles were included. The values of the two tables are different. Bengalee boys have higher values in all percentiles, except for 5^{th} percentiles of ages 3, 4, 5 & 6 years and for 10^{th} percentiles of 4 & 5 years age. The 5^{th} percentile (except 2 year) and 95^{th} percentile for girls remained below those from boys of the same ages.

Table 2 (a) & (b) shows BMI percentiles of Bengalee preschool boys and girls with those of the WHO references (2006), the US CDC (2002), Jiang et al. (2006) and Bose et al., (2011). Percentiles in all five studies are dramatically different. All BMI percentiles for Bengalee preschool children boys are substantially and consistently lower than the corresponding values in all reference population and studied population throughout the age range, particularly the lower percentiles for all years of age except at 4 years the 95^{th} percentile value among boys and at 3, 4 & 5 years age among girls are less than from Bose et al. (2011).

The largest disparities between all studied populations for boys were 3.3, and 3.5 kg/m^2 for the 5^{th} and 95^{th} percentiles, respectively (Table 3 (a), Fig. 1 (a & b)). For boys, the difference in 5^{th} percentile decreased with increasing age from all other studied population. And for the high (95^{th}) percentile values for rural Bengalee boys the difference increased with increasing age from all other studied population. In other words, the younger Bengalee boys had more extreme BMI values in 5^{th} percentile and below in 95^{th} percentile than their counterpart studied reference and other population.

Similar to the comparison with the reference and studied population, for girls, the difference in 5^{th} percentile decreased with increasing age from all other studied populations. For the high (95^{th}) percentile values for rural Bengalee girls the differences were uneven for all ages from all other studied populations. In other words, the younger Bengalee girls had more extreme BMI values (Table 3 (b), Fig. 2 (a & b)). The largest disparities between all studied populations for girls were 3.0, and 2.5 kg/m^2 for the 5^{th} and 95^{th} percentiles, respectively.

Discussion & Conclusion

The current paper presents BMI percentile values for Bengalee preschool children aged 2-6 years. These tables represent the current overall BMI distribution in rural Purulia, Paschim Medinipur and Darjeeling districts of West Bengal, India, and are useful as a reference for regional comparisons and for monitoring BMI changes over time. Importantly, we found that the current BMI distributions in rural West Bengal are substantially different from those of the WHO reference (2006), US CDC reference (2002) and Jiang et al. (2006). All BMI percentiles in rural Bengalee girls are lower

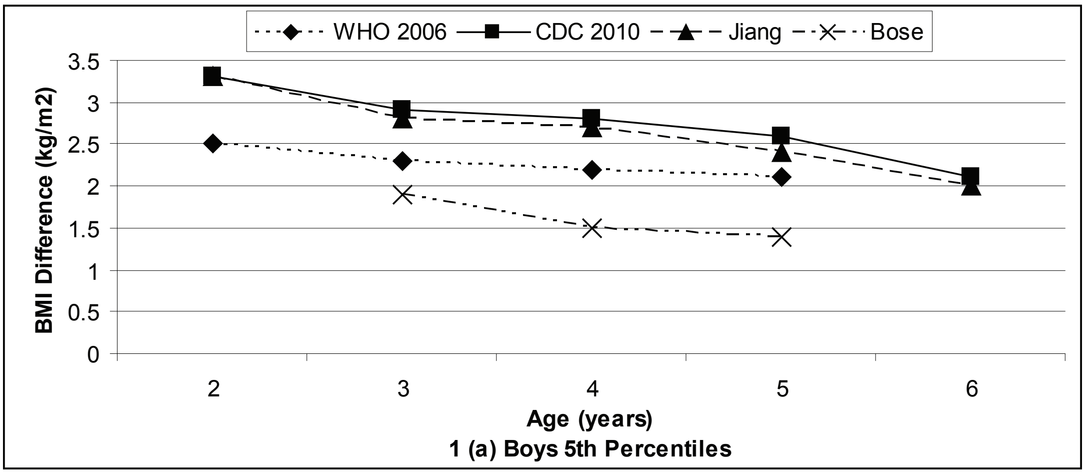

Figure 1 (a). Difference in the 5th Percentile values of BMI (kg/m²) of all studies with present study among Boys.

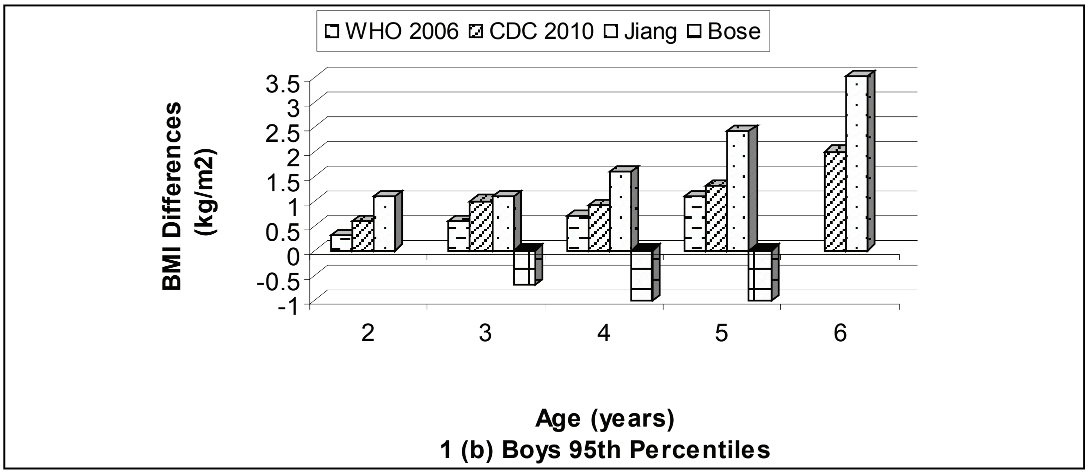

Figure 1 (b). Difference in the 95th Percentile values of BMI (kg/m²) of all studies with present study among Boys.

than those in the WHO reference (2006), US CDC reference (2002), Jiang et al. (2006) and Bose et al. (2011) except for 3, 4 & 5 years age in 95th percentile (from Bose et al. 2011). Rural Bengalee boys had higher proportions of extreme BMI values in both directions than the four international reference populations & studied population. This implies that Bengalee children are currently facing the existence of high prevalences of underweight. Therefore, public health strategies need to tackle undernutrition issue in West Bengal. There is evidence of such a rapid nutritional transition amplifying the burden of chronic diseases and obesity in India (Shetty 2002). BMI levels are generally higher in reference population than in present study and are therefore likely to be higher than the regional, State and national levels. As the BMI distribution of the reference population among the preschool children is significantly different from the current study population. This has raised a question about the appropriateness of using the 5th and 95th percentiles of BMI to define underweight and obesity in preschool children of West Bengal, India. We do not propose to raise BMI cut-off values for defining underweight and obesity in preschool children according to the currently deviated BMI levels from reference population. Ideally, BMI cut-offs for underweight and obesity should be determined according to the association between BMI and health outcomes. Therefore, we consider the ethnic specific percentile values in this paper as a reference for the rural Bengalee preschool children and not standards. The BMI percentiles presented in the current study provide useful baseline data for observing future changes in nutritional status among Bengalee pre-school children. Our data show that the BMI

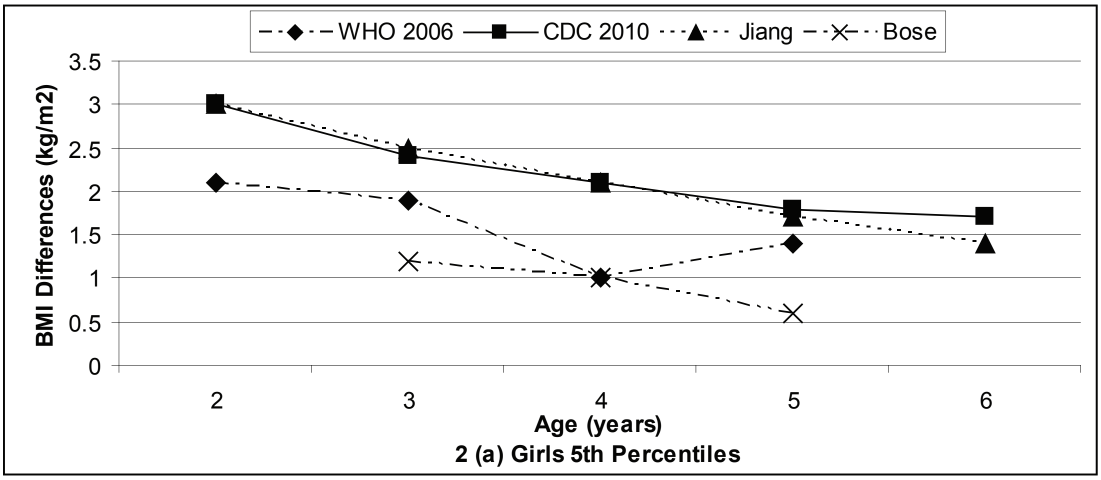

Figure 2 (a). Difference in the 5th Percentile values of BMI (kg/m^2) of all studies with present study among girls.

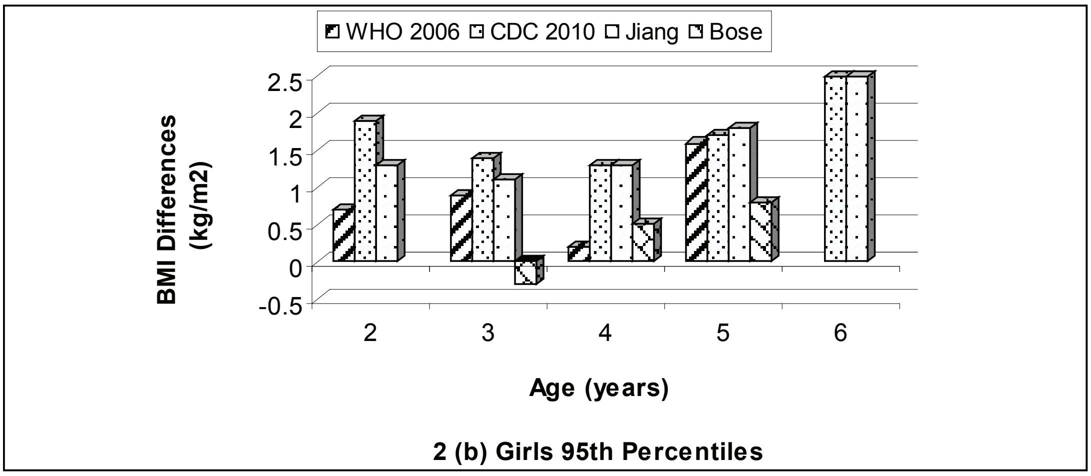

Figure 2 (b). Difference in the 95th Percentile values of BMI (kg/m^2) of all studies with present study among girls.

growth patterns in Bengalee preschool children are dramatically different from those of the WHO reference (2006), US CDC (2002) and Jiang et al. (2006). Although the prevalence of obesity is increasing rapidly in urban areas, undernutrition remains a major public health issue in rural areas. Although further research as the percentile curves were established using cross-sectional data, the pattern may not truly reflect how BMI change with age. This is a major limitation of the present study. In conclusion, our analysis provides BMI percentile curves for Bengalee preschool children aged 2–6 years. These values are dramatically different from those in the WHO reference (2006), US CDC reference (2002) and Jiang et al. (2006). The tables, figures and curves presented in this paper will allow anthropologists, pediatricians etc, to assess the nutrition status of a child and determine the relative rank of BMI for epidemiological studies.

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