Science Journal Publication
Science Journal of Sociology and Anthropology

Research Article

New reference values of body mass index for rural pre-school children of Bengalee ethnicity.

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Short Running Title: Body adiposity index and nutritional status

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Abstract

Objective: There exists no ethnic-specific reference percentile values of body mass index (BMI) for pre-school children of Bengalee ethnicity. The research attempted to develop age and gender –specific reference values of BMI for pre-school children of Bengalee ethnicity.
Setting: This cross-sectional study was undertaken on 2016 Bengalee children (930 boys and 1086 girls) from Chapra Block of Nadia District, West Bengal, India.
Methods: Weight and height were measured and BMI was computed. The BMI values were smoothed and gender specific reference percentile curves were developed using the LMS method.
Results: For boys and girls, the median BMI at age three years were 14.94 kg/m^2 and 14.59 kg/m^2, respectively. These values decreased with advancement of age in both sexes. The L, M, S values, and age and sex specific percentile values were developed. Results showed that median BMI at all ages were lower than WHO reference medians.
Conclusion: The proposed values may be useful in evaluating growth and nutritional status of rural Bengalee preschool children. They may also be used for comparisons with other ethnic groups.

Keywords: Reference curve values; BMI; Preschool; Bengalee; India.

Introduction:

Age-specific reference curves are widely used in pediatric clinics and infant and child health units for growth screening of children. These charts are often used to determine the course of growth as a marker of nutritional status at individual and population levels to assist clinicians and public health policy makers. Differences between populations with respect to growth patterns because of racial, environmental and genetic factors affecting growth beside nutrition, necessitates the use of curves obtained from local data. Using the National Center for Health Statistics (NCHS) and international norms for assessing growth in Bengalee children from India may be confusing. Therefore, we attempted to develop local growth charts from our standardized and representative local data [1-4]. Several methods for developing age-

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related curves have been developed, some of them are based on distributional assumptions while others are not. One of the methods, the LMS method, is based on distributional assumptions. This method had been used by Cole and Green in [4, 5]. The LMS method is widely used to fit a centile curve [6]. The LMS method utilizes three statistics: skewness (L curve), median (M curve) and coefficient of variation (S curve).

The international BMI cut offs for child overweight and obesity [7] and thinness [8] cover the age range 2-18 years and are based on the BMI cut offs of 25kg/m^2 and 30 kg/m^2 at the age of 18 years. They have been widely used but there exists no ethnic-specific percentile values of body mass index (BMI) for pre-school children of Bengalee ethnicity. The aim of the present paper was to develop age and gender specific smoothed BMI reference values using the LMS method.

Material and Methods:

Location and subjects:

This cross sectional study was undertaken at Chapra Block, Nadia District, West Bengal, India, during December 2003 to November 2004. The study area is situated at the India–Bangladesh international border, 140 km from Kolkata, the provincial capital of West Bengal**.** The area is remote and mostly inhabited by Bengalee Muslims (71.14 %) and Bengalee Hindus (26.04 %). All preschool children (3.0–5.5 years old) living in Chapra Block are enrolled at these centres.

Sixty six (66) Integrated Child Development Scheme (ICDS) centres were randomly selected out of a total of 186 centers of Chapra Block. The response rate was approximately 95%. A total of 2028 children (935 boys and 1093 girls) aged 3.0–5.5 years were measured, out of whom 12 individuals (5 boys and 7 girls) were excluded because of missing data. The final sample size was 2016 (930 boys and 1086 girls). Age and ethnicity of the subjects were collected from official records and subsequently confirmed by the parents of the subjects. Formal ethical approval was obtained from Vidyasagar University and ICDS authorities prior to the commencement of the study.

Height and weight measurements were taken by first author (SB) on each subject following the standard techniques [9]. Weight was measured using spring balance weighing machine (Libra; Made in India) to the nearest 0.2 kg. Height was measured using Martin anthropometric rod (Galaxy International; New Delhi, Made in India) to the nearest 0.1 cm.

The BMI was computed following internationally accepted standard equation as weight in kg divided by square in height in meter, i.e. BMI = Weight(kg)/ Height (m^2).

The BMI smooth percentile values were developed using the LMS method as described by Cole and Green [5]. Firstly, it summarizes the distribution of BMI by age and sex in terms of three curves as skewness (L curve), the median (M curve) and coefficient of variation (S curve). The M curve represents median BMI by age, the S curve is the coefficient of variation of BMI, while the L curve represents skewness of the BMI distribution in terms of the Box-Cox power transform for normality of the data. This method uses a penalized maximum likelihood to fit cubic smoothing splines to the L, M and S values. In general, a BMI centile chart is prepared based on user define(d) set of centiles (for example, 3rd, 5th, 10th, 25th, 50th, 75th, 90th, 95th, 97th).

Statistical method:

Technical errors of measurements (TEM) were found to be within reference values [10] and thus not incorporated in statistical analyses. Age and gender specific smooth BMI percentile reference values were developed using the LMS method. Student's t-tests were used to determine the significance of differences in means between the sexes at each age group as well as between sexes on an overall basis. One-way ANOVA (Scheffe) tests were

undertaken to evaluate the significance of age differences in means for each sex. Statistical significance was set at $p < 0.05$.

Results:

Among boys (age combined), the mean (sd) values of height, weight and BMI were 96.81 (6.68) cm, 13.59 (1.85) kg and 14.48 (1.14) kg/m^2, respectively. The corresponding values among girls were 96.10 (6.75) cm, 13.12 (1.87) kg and 14.18 (1.14) kg/m^2. Significant sex differences were observed in mean height ($t = 2.35$, $p< 0.05$), weight ($t = 5.59$, $p < 0.001$) and BMI ($t = 5.84$, $p< 0.001$). The sex-specific mean (sd) values of height were 89.19 (4.45) cm, 92.51 (4.41) cm, 95.45 (4.53) cm, 98.79 (4.63) cm, 101.09 (4.80) cm and 103.93 (4.81) cm among 3.0, 3.5, 4.0, 4.5, 5.0 and 5.5 years boys, respectively. Significant age variation ($F = 225.51$, $p < 0.001$) was observed. The corresponding age specific mean (sd) values among girls were 89.07 (4.54) cm, 91.70 (4.34) cm, 92.51 (4.41) cm, 94.90 (4.28) cm, 98.65 (4.93) cm, 100.86 (4.94) cm and 103.68 (5.03) cm, respectively. Significant age variation ($F = 244.54$, $p < 0.001$) was observed. Age specific significant sex differences in mean height were observed at the age of 3.0 ($t = 3.49$, $p < 0.001$) and 3.5 ($t = 2.92$, $p < 0.001$) years. The sex-specific mean (sd) values of weight were 11.80 (1.36) kg, 12.44 (1.44) kg, 13.10 (1.45) kg, 13.77 (1.53) kg, 14.41 (1.77) kg and 15.02 (1.66) kg among 3.0, 3.5, 4.0, 4.5, 5.0 and 5.5 years of boys, respectively. A significant age variation ($F = 103.96$, $p < 0.001$) was observed. The corresponding age specific mean (sd) values among girls were 11.61 (1.37) kg, 12.19 (1.43) kg, 12.86 (1.40) kg, 13.60 (1.53) kg, 14.19 (1.84) kg and 14.75 (1.70) kg. A significant age variation in weight was observed ($F = 100.96$, $p < 0.001$).

Significant age variation was observed in mean BMI among boys ($F = 15.19$, $p < 0.001$) as well as girls ($F = 17.30$, $p < 0.001$). Age specific mean (sd) BMI values among boys were 14.82 kg / m^2 (1.17), 14.51 kg / m^2 (1.08), 14.36 kg / m^2 (1.11), 14.10 kg / m^2 (1.07), 14.07 kg / m^2 (1.15) and 13.89 kg / m^2 (0.98) at the age of 3.0, 3.5, 4.0, 4.5, 5.0 and 5.5 years, respectively. Corresponding mean values of BMI among girls were 14.62 kg / m^2 (1.17), 14.47 kg / m^2 (1.10), 14.27 kg / m^2 (1.09), 13.97 kg / m^2 (1.09), 13.92 kg / m^2 (1.13) and 13.70 kg / m^2 (0.94). Boys had greater mean BMI values than girls at all ages ($p < 0. 05$) except 3.5 years.

The median BMI at age of 3 years were 14.94 kg/m^2 and 14.59 kg/m^2 for boys and girls, respectively. These values decreased with advancement of age in both sexes. Similarly, the median values of BMI at age of 5.5 years were 14.05 kg/m^2 and 13.62 kg/m^2, respectively. The results of L, M, S, values as well as age and sex specific percentile reference values for boys and girls are presented in **tables 1 and 2**. Among boys, the median values of BMI were 14.61 kg/m^2, 14.41 kg/m^2, 14.26 kg/m^2 and 14.16 kg/m^2 at age 3.5 years, 4.0 years, 4.5 years and 5.0 years, respectively. Among girls these were 14.41 kg/m^2, 14.18 kg/m^2, 13.94 kg/m^2 and 13.62 kg/m^2 at the age of 3.5 years, 4.0 years, 4.5 years and 5.0 years, respectively. **Figures 1 (boys) and 2 (girls)** graphically present the smoothed percentile curves of BMI. The figures showed that, median BMI decreased from 14.94 kg/m^2 and 14.59 kg/m^2 among boys and girls, respectively, at age 3 years to 14.05 kg/m^2 and 13.62 kg/m^2 among boys and girls, respectively, at age 5.5 years

Table 1. Smoothed percentile values of BMI obtained from LMS method among rural Bengalee preschool boys.

Age year	L	M	S	BMI percentile									
				3p	5p	10p	25p	50p	75p	85p	90p	95p	97p

3.0	-0.347	14.942	0.074	13.03	13.25	13.60	14.22	14.94	15.72	16.16	16.46	16.93	17.25
3.5	0.189	14.611	0.075	12.66	12.89	13.26	13.88	14.61	15.37	15.79	16.08	16.51	16.80
4.0	0.202	14.411	0.076	12.46	12.69	13.06	13.69	14.41	15.17	15.58	15.87	16.31	16.60
4.5	0.026	14.257	0.076	12.35	12.58	12.93	13.54	14.26	15.01	15.43	15.72	16.16	16.45
5.0	-0.354	14.162	0.075	12.33	12.55	12.88	13.47	14.16	14.91	15.33	15.62	16.07	16.38
5.5	-0.842	14.054	0.072	12.35	12.55	12.85	13.40	14.05	14.77	15.19	15.48	15.93	16.24

Table 2. Smooth percentile values of BMI obtained from LMS method among rural Bengalee preschool girls.

Age Year	L	M	S	BMI percentile									
				3p	5p	10p	25p	50p	75p	85p	90p	95p	97p
3.0	0.130	14.590	0.079	12.56	12.80	13.18	13.83	14.59	15.39	15.83	16.13	16.60	16.90
3.5	-0.278	14.407	0.077	12.50	12.72	13.07	13.68	14.41	15.18	15.62	15.92	16.39	16.70
4.0	-0.686	14.180	0.076	12.37	12.58	12.91	13.48	14.18	14.94	15.37	15.68	16.16	16.48
4.5	-1.095	13.941	0.075	12.23	12.42	12.72	13.27	13.94	14.69	15.12	15.43	15.92	16.25
5.0	-1.503	13.782	0.073	12.16	12.34	12.62	13.14	13.78	14.51	14.94	15.25	15.74	16.08
5.5	-1.911	13.620	0.070	12.11	12.27	12.53	13.02	13.62	14.31	14.73	15.03	15.52	15.86

Figure 1: Smoothed BMI percentile curve (Boys).

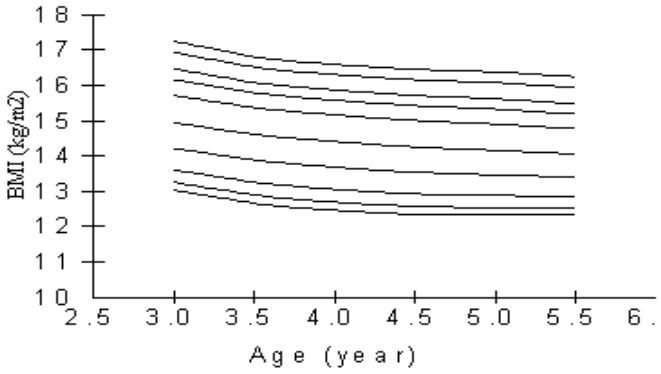
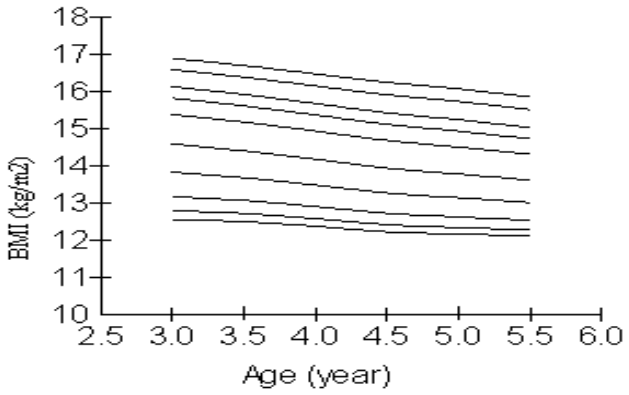


Figure 2: Smoothed BMI percentile curve (Girls)



Discussion:

The present cross-sectional study was conducted in West Bengal, the eastern province of India and all children were beneficiaries of ICDS programme, initiated by Government of India. The main aim of this study was to develop smoothed percentile reference values of BMI for children aged 3.0 to 5.5 years. Children were apparently healthy and attended nearest ICDS centre for preschool education and nutritional supplementation. These curves are applicable to Bengalee pre-school children. The present study showed that the median BMI of children aged 3.0 to 5.5 years living Chapra Block, West Bengal, eastern India were lower than WHO [4] median but higher than affluent Indian children [11] for both sexes **(Figures 3 and 4).** They also showed that affluent Indian children have similar median BMI at the age of 5.0 years among girls. One of the probable reasons for the lower BMI among affluent Indian children is due to the fact that they had much greater mean height compared to our rural pre-school children. This was indicative of the fact that the pre-school children of our study were facing chronic nutritional stress resulting in them having lower mean height.

Figure 3: Comparisons of BMI 50th percentile for rural Bengalee boys with WHO (2006) reference data and affluent Asian Indian boys (Virani 2010).

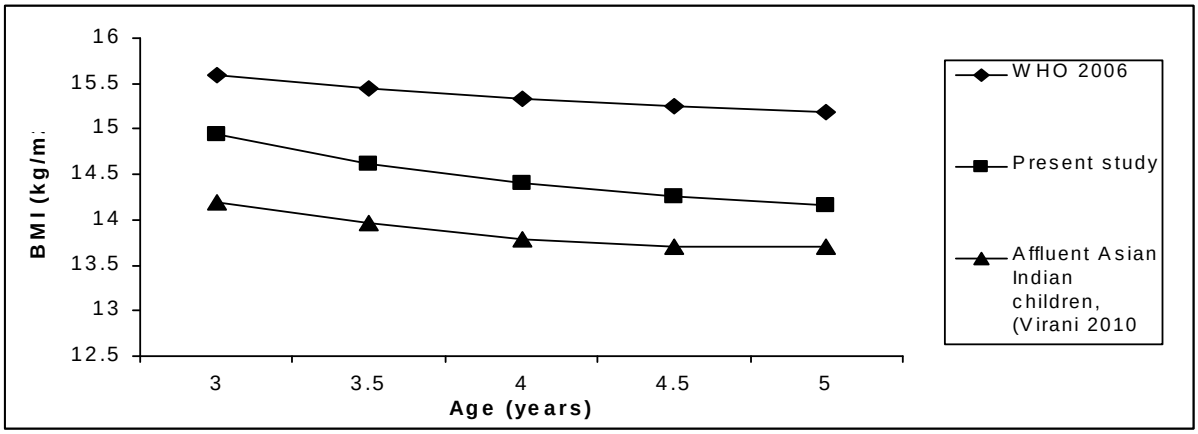
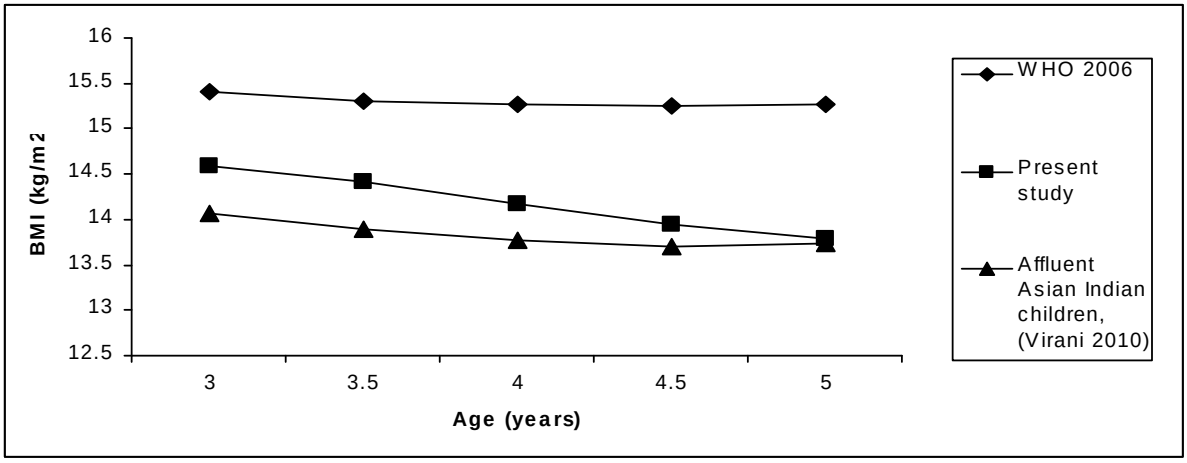


Figure 4: Comparisons of BMI 50th percentile for rural Bengalee girls with WHO (2006) reference data and affluent Asian Indian girls (Virani 2010).



Construction of local reference values to measure growth pattern in children to determine the population at risk of malnutrition may be much more helpful than using international norms or charts obtained from other populations. Comparing our reference median with recent WHO [4] standards showed significant differences between growth patterns of Bengalee children and recent WHO [4] reference data. Similar differences have been highlighted in other studies from various countries [6] and different ethnic groups [12, 13].

Moreover, although the WHO or NCHS references can give a good measure of children's growth status and may be used for risk assessment, they cannot always be reliably applied to all ethnic populations. Moreover, because of inconsistency of growth pattern of Indian children, they may even be misleading. Therefore, constructing local reference is of utmost importance. However, because of the cross-sectional nature of our data, the obtained references may need to be confirmed by longitudinal data with more representative samples across the province of West Bengal.

It is important to consider some limitations of the present study when using the obtained reference curves. Primarily, data on general health and dietary practices were not available. However, the obtained reference curves can be regarded as reliable considering the large sample size and healthy condition of the recruited children. Moreover the data used in this study were cross-sectional and obviously less informative compared to longitudinal data. Despite all these limitations, the reference curve values prepared by using a well-known method and based on a data set of a representative sample of Bengalee children may be preferred over those prepared by using data of other populations. Therefore, we recommend using our local reference curve values instead of international ones until longitudinal data are available or our reference curves updated.

Conclusion:

We present new reference BMI percentile data on rural pre-school children of Bengalee ethnicity. These percentile values may be used not only to determine nutritional status of rural pre-school Bengalee children but also serve in the comparisons with other ethnic groups, both in India as well as abroad. Further studies using longitudinal data would be required to validate our results. Till such time as such data becomes available, we recommend that the percentile values given by us be used in

determining the nutritional status of Bengalee pre-school children. These percentile values may also be used for national and international comparisons with other ethnic groups.

Acknowledgements:

All subjects who participated in the study are gratefully acknowledged. Special thanks are due to the ICDS authorities of these centres. S. Biswas is a recipient of UGC (Government of India) financial assistance in the form of a Ph.D. fellowship. Dr. A. Mukhopadhyay and Dr. M. Bhadra are gratefully acknowledged for their assistance.

Contributors: SB planned and undertook the study, performed data entry, statistical analyses as well as preparation of manuscript. KB planned the study, undertook statistical analyses and prepared the manuscript. SB undertook statistical analyses and prepared the manuscript.

Conflict of Interest: None

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