Body Mass Index in Bengali Adolescents

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We describe a mixed longitudinal analysis of body mass index (BMI) in a group of Bengali adolescents (age 11-17 years) from a middle income family background and compare this against existing national and international data. Healthy school children, comprising of 416 boys and 343 girls were consented for annual repeat measurements of weight, height and pubertal staging between the years 1998 and 2001. The LMS method was used to construct smoothed BMI mean and standard deviation (SD) curves. Bengali adolescents have lower BMI than affluent Indian children and are –1 to –2 SD below US children. BMI increases in adolescence (boys: r = 0.49, p <0.001, girls: r = 0.54, P <0.001) with age but SMR does not have an independent effect on BMI.

Key words: Adolescents, Body mass index, Mixed longitudinal study.
Seca beam balance to the nearest 0.1 kg. These values were converted to body mass index by the formula: BMI = weight in kg/(height in metres)^2. NCHS BMI charts (year 2000) were used to calculate BMI standard deviation scores (SDS). Pubertal staging (Sex Maturity Rating, SMR) was performed using the Tanner method(7). Breast staging in girls and genital staging in boys were chosen to represent SMR.

The distribution of BMI in a population depends on age and tends to be positively skewed. To construct mean curves, we used the LMS method(8) which summarizes the centiles by 3 smooth curves representing skewness (L curve), the median (M curve) and coefficient of variation (S curve). This program uses a penalised maximum likelihood to fit cubic smoothing splines to the L, M and S values. The choice of the smoothing parameters for the L, M and S curves was made on the basis of detrended QQ plots.

Data was analyzed by SPSS 11.5 (Chicago, Illinois) and non-parametric tests used to compare data in two or more groups. Univariate analysis of variance was used to compare non-parametric regression slopes of SMR subgroups in BMI versus age plots. Growth Analyser 2.0 (version 2.0, build 61) software was used for LMS curve fitting.

Results

We recruited 416 boys and 343 girls aged 11-16 years in 1998. These children were followed up ~27.2% boys and 31.7% girls were re-measured every year for the next 4 years. The number of children (boys, girls) in each age group were as follows: 11 (123, 169), 12 (117, 167), 13 (161, 197), 14 (161, 183), 15 (110, 140), 16 (58, 74), 17 (30, 42). The combined database provided a mixed longitudinal database of BMI measurements in the age range 11 to 17 years.

BMI was converted to SD scores using the NCHS data. The mean (SD) of BMISDS in Bengali children is lowest at -1.8 (1.8) at 11 years and rises to -1.1 (1.2) by age 17 years. All BMI values in Bengalis are -1 to -2 SD outside the mean for US children. Further comparison was made with cross-sectional data of nationally representative affluent children in the same age range. Mean plots (Figs. 1a and 1b) demonstrate higher BMI in Indian affluent adolescents in all ages. Of the Bengali adolescents, girls have higher BMI compared to boys in all age groups except at age 11 years (p = 0.4). There is stepwise rise of BMI with age [boys (r = 0.49, P <0.001) and girls (r = 0.54, P<0.001)]. To evaluate if SMR plays an independent role in BMI increment, we plotted BMI for age in SMR subgroups. Though the number of children and R^2 values were small, significant regression lines were present in SMR 2, 3, 4 in boys and SMR 2, 4, 5 in girls. Comparison of regression slopes in these subgroups demonstrated no independent effect of advancing puberty on increasing BMI.

We constructed mean curves (± 1, 2 SD) for BMI in boys and girls (Figs. 2a and 2b). For boys, the effective degrees of freedom (edf) were equal to 5 (M), 3 (S) and 2 (L) and for girls 6, 3 ad 2 respectively. Table I summarises the fitted LMS curves for BMI by age and sex. L values of 1 indicate normality and smaller values represent progressively greater skewness. The M curve is the 0 SD line for BMI. The S curve defines coefficient of variation (CV) and is rather high at 12-13%.

Discussion

There are few studies of anthropometric data in the adolescent age group. It is well known that BMI rises through the teenage years(1) but no longitudinal studies in Indian children demonstrate this. Our study clearly
shows the increasing trend in Bengali boys and girls. Measuring BMI on US centiles (or Indian affluent children) gives unrealistic evidence of thinness(6). It is well known that children of Indian parentage residing in the US have smaller BMI(9) and Bengali middle class boys fare poorly in comparison to Western counterparts(5). Our study demonstrates similar deviation and points to the importance of developing locally based centiles.

We devised mean curves from our group of middle income Bengali adolescents. The numbers of children in each age group (11 to 17 years) are not comparable to some of the larger cross-sectional studies(3). The coefficient of variation in our adolescents appear rather high (12-13%) suggesting wider
dispersion of data due to smaller numbers. However these values are very similar to that of larger data in Dutch children (3) in the same age range, indicating that variability is a feature of adolescence itself.

We used one trained observer to measure height, thereby reducing inter-observer differences. The stadiometer and beam balance were calibrated before use thereby reducing bias from instrumental errors. There remains possible bias in selection of children and staging of puberty. Further, intra-observer variability and precision estimates were not performed. However, BMI is a derived number (a ratio) and therefore unlikely to be altered significantly by minor errors. In fact this is why BMI is an effective epidemiological tool for use in the community.

Though formal dietary intake was not recorded, a rough assessment was made at the medical examination and dietary patterns were found to be similar in all children. All children in the database were healthy at the time of entry. Though the possibility of chronic malnutrition and its sequelae remain (10,11), it is unlikely that the population was “malnourished” enough to skew the data. It is therefore likely that Bengali children are genetically determined to have lower BMI and hence the importance of local data.

A criticism of our study is that we chose children of middle income and not affluent families. Data based on affluent children provide normative data against which the performance of other children is judged. This is important when a section of the population is significantly malnourished. The improved socio-economic situation has reduced severe malnutrition in the community and it is less important to consider affluent children as the

<table>
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<tr>
<th>Age (years)</th>
<th>Boys</th>
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<th>Girls</th>
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<td>14.73</td>
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A “middle of the road” approach is therefore more appropriate, as that practiced in the developed nations like the United States, United Kingdom and Japan.

On national cross-sectional data, BMI appears to be similar in the same SMR subgroup. With advancing age and pubertal hormonal changes, fat (and muscle mass) is deposited to give rise to higher BMI. It is therefore possible that SMR subgroups are independent variables in predicting BMI. We however could not demonstrate an influence of advancing SMR on increasing BMI. From a practical standpoint, SMR is subjective and prone to error when performed by non-experienced individuals.

BMI is a derived measurement and does not provide objective evidence of adiposity. It does not discriminate between fat mass and lean body mass. It is seen as an abstract index of nutritional status than as a measure of body composition(12). Though a reasonable tool for community use(2), we must exercise caution in laying too great an emphasis on its interpretation. The real importance of BMI is in documenting emerging trends with economic prosperity and energy-dense food intake to correlate with an increase in insulin resistance(13,14).

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**Contributors:** IB analysed the data and wrote the manuscript. NG contributed in data collected and edited the paper. SB was involved in data collection and drafting. HNS was the study director for concept, design and execution. DM was the chief investigator responsible for design, planning and editing.

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**REFERENCES**


**Key Messages**

- Boys and girls from Bengali middle income families have lower BMI than affluent Indian or US children
- Bengali adolescent BMI smoothed mean curves may be useful tools in the local population


