Differences in body composition between pre-menarcheal and menarcheal Bengalee Hindu girls of Madhyamgram, West Bengal, India

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Abstract  A study on 111 pre-menarcheal (PMG) and 123 menarcheal (MG) Bengalee Hindu girls was undertaken to compare differences in their anthropometric and body composition characteristics. The mean ages of the PMG (12.5 years, SD = 1.2) and MG (12.6, SD = 1.1) subjects were similar. Anthropometric measurements included height, weight, triceps, and calf skinfolds. Two derived indices (body mass index [BMI] and sum of skinfolds) and four body composition measures, percent body fat (PBF), fat mass (FM), fat free mass (FFM), and fat mass index (FMI) were also studied. The mean, 25th, 50th, and 70th percentile values of age at menarche were 12.0, 11.1, 12.0 and 12.9 years, respectively. Results showed that MG had significantly (P < 0.001) higher mean values for all anthropometric and body composition variables. The difference in mean height, weight, and BMI were 10.5 cm, 11.0 kg, and 3.0 kg/m², respectively. The differences between the two groups in mean PBF, FM, FFM, and FMI were 7.7%, 5.1 kg, 5.9 kg, and 2.0 kg/m², respectively. The percent difference (after attainment of menarche) in mean FM and mean FFM were 50.5% and 19.9%, respectively. Multivariate regression analyses revealed that attainment of menarcheal status had significant impact on all four measures of body composition (PBF: P < 0.0001; FM: P < 0.0001; FFM: P < 0.0001; FMI: P < 0.001) independent of BMI. Using BMI as a covariate, results of ANOVA revealed that the mean values of PBF, FM, FFM, and FMI were significantly higher among MG compared with the PMG subjects, even after adjustment for BMI. In conclusion, this study clearly indicated that there existed significant differences in body composition, irrespective of BMI, between MG and PMG Bengalee Hindus. It also demonstrated that relative difference in mean FM was significantly greater, compared to the relative difference in mean FFM, after the attainment of menarche.

Key words: India, Bengalee girls, menarche, body composition

Introduction

Menarche is one of the most noticeable biological events of puberty. Anthropometry provides the single most simple, universally applicable, inexpensive, and non-invasive technique for assessing the size, proportions, and composition of the human body (WHO, 1995).

Body mass index (BMI) is the most commonly used indirect measure of overall adiposity (Bose and Mascie-Taylor, 1997; Bhadra et al., 2001; Ghosh et al., 2001, 2003, 2004; Bose and Mukhopadhyay, 2004), while percent body fat (PBF), fat mass (FM), fat free mass (FFM), and fat mass index (FMI) are the most widely studied measures of body composition (VanItalie et al., 1990; Wang and Bachrach, 1996; Bose, 1998; Mueller et al., 2003). Prediction of PBF from skinfold thicknesses is an acceptable method for the assessment of body composition in children and adolescents (Deurenberg et al., 1990; Williams et al., 1992; Mueller et al., 2003).

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Bhadra et al., 2001). In view of this, the aim of the present study was to compare anthropometric and body composition characteristics between Bengalee Hindu PMG and MG girls. An attempt was also made to compare the differences in body composition observed between Bengalee PMG and MG girls with those observed in other ethnic groups.

**Materials and Methods**

**Subjects**

The investigation was carried out in a secondary school in Madhyamgram, North 24 Parganas, a suburb of Kolkata, West Bengal. Permission had been obtained from the school authorities prior to commencement of the study. Subjects were randomly selected from a total of 568 students enrolled at the school. The total sample size was 234 Bengalee Hindu girls aged 11–14 years: 111 pre-menarcheal (PMG) and 123 menarcheal (MG). All participants completed a questionnaire, which included specific questions on age, menarcheal status, and age at menarche. Age and age at menarche were recorded to the nearest month.

**Anthropometric measurements**

Anthropometric measurements were made by a trained female investigator (M.B.) using standard anthropometric techniques (Lohman et al., 1988). Height and weight were measured to the nearest 0.1 cm and 0.5 kg, using Martin’s anthropometer and weighing scale, respectively. Participants were requested to remove their shoes prior to taking measurements of both height and weight. Triceps and calf skinfolds were measured to the nearest 0.2 mm on the left side of the body using a Harpenden skinfold caliper. Body mass index (BMI) was computed following the standard formula (WHO, 1995):

\[
\text{BMI} = \frac{\text{Weight (kg)}}{\text{Height}^2 (\text{m}^2)}.
\]

**Estimation of body composition measures**

Four measures of body composition were estimated: percent body fat (PBF), fat mass (FM), fat free mass (FFM), and fat mass index (FMI). PBF was computed following the standard sex-specific equation of Slaughter et al. (1988) for percent body fat (%)

\[
PBF (%) = 0.106 \times (\text{Triceps skinfold} + \text{Calf skinfold})
\]

\[
\text{PBF} (\text{kg}) = \frac{\text{PBF}}{100} \times \text{Weight (kg)}
\]

\[
\text{FFM} (\text{kg}) = \text{Weight (kg)} - \text{FM (kg)}
\]

\[
\text{FMI} (\text{kg/m}^2) = \frac{\text{FFM (kg)}}{\text{Height}^2 (\text{m}^2)}
\]

**Statistical analyses**

Technical errors of measurement (TEM) were calculated on 15 randomly selected girls and the results were found to be within reference values (Ulijaszek and Kerr, 1999). Therefore, TEM were not incorporated in statistical analyses. Student’s t-tests were undertaken to check differences in anthropometric and body composition characteristics between PMG and MG. The distributions of anthropometric and body composition variables were normal. The impact of menarcheal status (yes, no) on PBF, FM, FFM, and FMI, after controlling for the effect of BMI, was tested using multivariate regression analyses. ANOVA was undertaken to determine the effect of menarcheal status (yes, no) on body composition variables as well as the differences in mean values of these parameters between PMG and MG after controlling for BMI (Mascie-Taylor, 1994a, b; Ghosh et al., 2003). In ANOVA, body composition variables were utilized as dependent variables, menarcheal status as an independent variable and BMI as a covariate. All statistical analyses were performed using the Statistical Package for Social Sciences (SPSS) Program.

**Results**

The mean ages of PMG (12.5 years, SD = 1.2) and MG (12.6, SD = 1.1) were similar. The 25th, 50th and 75th percentiles of menarcheal age were 11.1, 12.0 and 12.9 years, respectively. The mean age at menarche was 12.0 years (SD = 1.0) which was similar to the age at menarche reported among Bengalee girls in previous studies (Sharma, 1990; Chakraborti and Sinha, 1991; Bharati and Bharati, 1998). Thus, the age at menarche of the girls of the present study can be considered to be representative of the general Bengalee Hindu population.

Mean values of anthropometric (height, weight, BMI, triceps and calf skinfolds, sum of skinfolds) and body composition characteristics (PBF, FM, FFM, and FMI) of PMG and MG are presented in Table 1. MG had significantly (P < 0.001) higher mean values for all anthropometric and body composition variables and indices. The differences between PMG and MG in mean height, weight and BMI were +10.5 cm, 11.0 kg, and 3.0 kg/m², respectively. The differences between the two groups in mean PBF, FM, FFM, and FMI were +7.7%, +5.1 kg, +5.9 kg, and 2.0 kg/m², respectively. The percent differences (between PMG and MG) in mean FM and mean FFM were 50.5% and 19.9%, respectively.

**Table 1. Anthropometric and body composition characteristics of the subjects**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pre-menarche (n = 111)</th>
<th>Menarche (n = 123)</th>
<th>Difference (+)</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Anthropometric</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Height (cm)</td>
<td>137.5 (7.7)</td>
<td>148.0 (5.6)</td>
<td>10.5</td>
<td>11.81*</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>28.7 (5.4)</td>
<td>39.7 (6.6)</td>
<td>11.0</td>
<td>14.09*</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>15.1 (1.8)</td>
<td>18.1 (2.5)</td>
<td>3.0</td>
<td>10.77*</td>
</tr>
<tr>
<td>Triceps skinfold (mm)</td>
<td>9.3 (2.7)</td>
<td>14.6 (4.6)</td>
<td>5.3</td>
<td>10.87*</td>
</tr>
<tr>
<td>Calf skinfold (mm)</td>
<td>10.2 (3.5)</td>
<td>17.5 (6.2)</td>
<td>7.3</td>
<td>11.15*</td>
</tr>
<tr>
<td>Sum of skinfolds (mm)</td>
<td>19.5 (5.9)</td>
<td>32.1 (10.3)</td>
<td>12.6</td>
<td>11.62*</td>
</tr>
<tr>
<td><strong>Body composition</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent body fat (%)</td>
<td>17.0 (3.6)</td>
<td>24.7 (6.3)</td>
<td>7.7</td>
<td>11.62*</td>
</tr>
<tr>
<td>Fat mass (kg)</td>
<td>5.0 (2.0)</td>
<td>10.1 (4.1)</td>
<td>5.1</td>
<td>12.40*</td>
</tr>
<tr>
<td>Fat free mass (kg)</td>
<td>23.7 (3.7)</td>
<td>29.6 (3.2)</td>
<td>5.9</td>
<td>13.12*</td>
</tr>
<tr>
<td>Fat mass index (kg/m²)</td>
<td>2.6 (0.8)</td>
<td>4.6 (1.7)</td>
<td>2.0</td>
<td>11.67*</td>
</tr>
</tbody>
</table>

Standard deviations are presented in parentheses.  
1 Percent difference between the two groups in mean FM = 50.5%.  
2 Percent difference between the two groups in mean FFM = 19.9%.  
* P < 0.001.
Since there were significant differences in overall adiposity (BMI) between PMG and MG, multivariate regression analyses were undertaken which tested for the impact of menarcheal status (used as a discrete variable: yes, no) on PBF, FM, FFM, and FMI, after controlling for the effect of BMI. Results (Table 2) revealed that attainment of menarcheal status had significant impact on all four (PBF: \( P < 0.0001 \); FM: \( P < 0.0001 \); FFM: \( P < 0.0001 \); FMI: \( P < 0.0001 \)) measures of body composition, independent of BMI.

To further test the impact of menarcheal status, independent of BMI, ANOVA was undertaken on PBF, FM, and FMI with BMI as a covariate (i.e. after controlling for BMI). Results (Table 3) revealed that attainment of menarcheal status had significant impact on all measures of body composition, even after controlling for BMI. The mean values of PBF, FM, FFM, and FMI were significantly higher (Table 3) among MG compared with the PMG, even after adjustment for BMI.

### Discussion

In the present study, Bengalee MG girls had significantly greater mean height, weight, BMI, triceps and calf skinfolds, and sum of skinfolds, compared with PMG girls. Similar differences between PMG and MG have been reported by Deurenberg et al. (1990) in a study from the Netherlands. The results of the present study are also consistent with those of Wang and Bachrach (1996) who reported in a study conducted in USA that, in general, Asian, African, and Hispanic American MG subjects had significantly greater mean anthropometric and body composition characteristics compared with PMG subjects of their own ethnic group. The largest difference in mean PBF (Table 4) was observed among African-Americans (6.8%) followed by Hispanics (5.1%), and Asian-Americans (2.8%). Only among White Americans (−0.6%) was this trend reversed. In a more recent investigation, Sampei et al. (2003) had also reported that MG subjects of Japanese and Caucasian ethnicity in Brazil had significantly greater mean values of anthropometric and body composition characteristics compared with their PMG counterparts. The difference in mean PBF (Table 4) was greater among Japanese (7.5%) than among Caucasian (5.5%) Brazilians. Compared with these studies, it can be concluded that difference in mean PBF between Bengalee MG and PMG girls (+7.7%) was more similar to the Japanese girls (7.5%) in Brazil (Sampei et al., 2003), followed by African-Americans (6.8%) in the USA. In conclusion, these studies clearly indicate that, in general, there exist higher adiposity levels among MG girls compared with PMG girls in different ethnic groups, including Bengalees. However, the differences in adiposity levels between PMG and MG subjects are not the same in all ethnic groups. These ethnic dissimilarities in differences in adiposity between MG and PMG are of value in biological anthropological studies of human variation (Richardson et al., 1983; Wang and Bachrach, 1996; Kimm et al., 2001, 2002; Sampei et al., 2003).

BMI reflects only relative overweight, and not actual body fat mass (Heitmann, 1990). Although BMI and body composition measures relating to adiposity (PBF, FM, and FMI) are related, assessment of body fat from skinfolds gives a more direct estimate of body fat mass (Heitmann, 1990), especially more so in children and adolescents (Deurenberg et al., 1990), and may be useful in field studies (Heitmann, 1990). The present study clearly indicated that relative difference in amount of body fat (mean FM increased by 50.5%) was significantly greater than the difference in mean FFM (FFM increased by 19.9%) when comparisons are made between PMG and MG Bengalees. Thus, the rate of increase in FM was significantly greater than that of FFM. This implied that among Bengalees, these two vari-

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### Table 2. Multivariate regression analyses of menarcheal status with PBF, FM, FFM, and FMI, after controlling for BMI

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>B</th>
<th>seB</th>
<th>Beta</th>
<th>t</th>
<th>( P )</th>
</tr>
</thead>
<tbody>
<tr>
<td>PBF</td>
<td>2.626562</td>
<td>0.588635</td>
<td>0.204534</td>
<td>4.462**</td>
<td>( &lt; 0.0001 )</td>
</tr>
<tr>
<td>FM</td>
<td>1.497793</td>
<td>0.310249</td>
<td>0.181143</td>
<td>4.828**</td>
<td>( &lt; 0.0001 )</td>
</tr>
<tr>
<td>FFM</td>
<td>2.271303</td>
<td>0.356263</td>
<td>0.250013</td>
<td>6.374**</td>
<td>( &lt; 0.0001 )</td>
</tr>
<tr>
<td>FMI</td>
<td>0.395316</td>
<td>0.111534</td>
<td>0.118621</td>
<td>3.544*</td>
<td>( 0.001 )</td>
</tr>
</tbody>
</table>

B refers to sample regression coefficient, SeB refers to standard error of B, Beta refers to estimated population regression coefficient.

** \( P < 0.0001 \), * \( P < 0.001 \).

### Table 3. ANOVA of menarcheal status and PBF, FM, FFM, and FMI with BMI as a covariate

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>F</th>
<th>Grand mean</th>
<th>Mean Covariate Menarcheal status</th>
<th>Unadjusted</th>
<th>Adjusted</th>
</tr>
</thead>
<tbody>
<tr>
<td>PBF</td>
<td>455.410*</td>
<td>19.911*</td>
<td>21.04%</td>
<td>PM = 4.03</td>
<td>PM = −1.38</td>
</tr>
<tr>
<td>FM</td>
<td>799.812*</td>
<td>23.307*</td>
<td>7.71 kg</td>
<td>FM = −2.69</td>
<td>FM = −0.79</td>
</tr>
<tr>
<td>FFM</td>
<td>693.368*</td>
<td>40.645*</td>
<td>26.78 kg</td>
<td>FFM = −3.12</td>
<td>FFM = −1.19</td>
</tr>
<tr>
<td>FMI</td>
<td>528.888*</td>
<td>12.562*</td>
<td>3.64 kg/m²</td>
<td>FMI = −1.04</td>
<td>FMI = −0.21</td>
</tr>
</tbody>
</table>

\( PM = \) Pre-menarcheal, \( M = \) Menarcheal.

* \( P < 0.001 \).

### Table 4. Differences in mean PBF between MG and PMG girls in different ethnic groups

<table>
<thead>
<tr>
<th>Study</th>
<th>Ethnic group</th>
<th>Difference (%) in mean PBF between MG and PMG girls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wang and Bachrach</td>
<td>Asian</td>
<td>+2.8</td>
</tr>
<tr>
<td></td>
<td>Black</td>
<td>+6.8</td>
</tr>
<tr>
<td></td>
<td>Hispanic</td>
<td>+5.1</td>
</tr>
<tr>
<td></td>
<td>White</td>
<td>−0.6</td>
</tr>
<tr>
<td>Sampei et al. (Brazil)</td>
<td>Japanese</td>
<td>+7.5</td>
</tr>
<tr>
<td></td>
<td>Caucasian</td>
<td>+5.5</td>
</tr>
<tr>
<td>Present study (India)</td>
<td>Bengalee</td>
<td>+7.7</td>
</tr>
</tbody>
</table>
able (FM and FFM) increase at different rates at menarche. Future research should be undertaken to compare the rate of increase in FM and FFM between PMG and MG girls in different ethnic groups. If ethnic variation is found in these rates, they would be of interest to biological anthropology particularly in the study of ethnic variation.

Although there is a concomitant significant increase in BMI at menarche, the significant increase in body fat (PBF and FM) is independent of the former. The implication of this is that a significant increase of body fat is independent of BMI, i.e., at any given level of BMI, MG girls have significantly enhanced level of body fat compared with PMG girls. Further studies are needed to ascertain the likely cause(s) of this significant increase in body fat. A particularly important question to be addressed in future studies among Bengalees is whether there is a cause–effect relationship between attainment of menarche and significant increase in body fat or whether it is mediated by other confounding effects.

There is little comparative data available on ethnic differences in body composition (Yanovski et al., 1996). It has been suggested that ethnic disparity in adiposity evolves during adolescence, although the specific age at which this occurs and the underlying factors are yet to be identified because of the paucity of current longitudinal cohort data among different ethnic groups (Kimm et al., 2001). Thus, ethnic variation in the adiposity difference between PMG and MG girls is of great interest to biological anthropologists investigating human variation (Beunen, et al., 1994; Brown et al., 1996; Kimm et al., 2001, 2002). India is a large country with vast ethnic heterogeneity. Future studies should be undertaken on other ethnic populations from diverse parts of India to determine differences in adiposity levels between MG and PMG girls. Lastly, another important area of future research is to study this phenomenon among the Indian diaspora in comparison with the native populations in countries where there exists a sizable number of people of Indian origin. Such studies would not only generate information on ethnic differences but also identify the relative contributions of genetic and environmental factors associated with the significant increase in adiposity at menarche.

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