Relative fat distribution in relation to menarcheal status among Bengalee Hindu girls of West Bengal, India

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Abstract

Background: Menarche seems be related to the relative distribution rather than the total amount of body fat. Previous studies showed that the ratio between lower-body vs. upper-body fat was associated with the timing of menarche. **Aim:** To compare the relative distribution of subcutaneous fat among Bengali Hindu pre- and post-menarcheal girls. **Materials and Methods:** The participants were 234 Bengali Hindu girls aged 11-14 years: 111 pre-menarcheal and 123 post-menarcheal girls, randomly selected from a secondary school from a suburb of Kolkata, West Bengal, India. Triceps, abdominal, sub-scapular, and calf skinfolds were measured. For each skinfold site, ratio was calculated as follows: Log (one skinfold/sum of skinfolds). Principal components (PC) analysis was performed to derive components which express the maximum contrast among the log of ratios. *T*-test was employed to assess differences between individual scores of components between pre- and post-menarcheal girls. **Results:** The three identified PC suggested extremities-trunk, lower trunk-upper trunk, and an upper extremity-lower extremity contrasts, respectively. Scores for second and third components showed significant differences between pre- and post-menarcheal groups of girls. **Conclusion:** The attainment of menarche by Bengali girls aged 11-14 years was associated with characteristically more relative subcutaneous fat distribution in the upper trunk and in the lower limbs, in contrast to lower trunk and upper limbs, respectively.

Key words: India, menarche, regional adiposity, West Bengal

INTRODUCTION

Menarche, the first occurrence of menstruation, is one of the most important events in a woman's reproductive life. It is associated with various important events of adolescent growth and development. One hypothesis emphasizes that the timing of menarche is associated with the skeletal maturity represented by the peak height velocity.[1] The alternative "critical-fat theory" proposes that menarche depends on a critical amount of stored

fat, which provide additional energy during pregnancy and lactation.[2,3] However, later studies on menarche did not always support the "critical-fat theory." Menarche occurs even with a low fat level without demonstrating any clear threshold.[4] Height and bi-iliac breadth has been reported to predict the age of menarche much more importantly than the measures of total fat or body weight.[1,5] Further studies indicate, on the other hand, that menarche may be related to the relative distribution rather than to the total amount of body fat. In this respect, the ratio between lower-body versus upper-body fat has been found to be associated with the menarcheal onset.[6,7]

A significant differences in body composition has been reported between pre-menarcheal girls (PMG) and post-menarcheal girls (Post-MG) and these differences vary considerably across ethnic groups.[8-10] Hitherto, a

few investigations from India have compared the body composition profiles between PMG and Post MG.[11-13] The ethnic difference is also reflected in skinfold thickness,[14] which has been used to describe variation in the relative distribution of subcutaneous adipose tissue associated with maturity status during adolescence.[15] Truncal subcutaneous fat is also associated with menarcheal age.[16] However, no study till date has investigated the association between relative subcutaneous fat distribution and menarcheal status in Indian population, especially, among the Bengali girls. Using the same dataset used in this study, Bhadra *et al.*[13] demonstrated that the post-menarcheal Bengali girls had significantly greater amount of total body fat mass than their pre-menarcheal counterparts. However, it did not reveal the differences in the relative distribution of the fat across the body. It is also to be noted that the adult pattern of relative fat distribution emerges during adolescence and there are considerable inter-individual differences in this respect associated with variation in the timing and tempo of sexual maturation.[17] In view of the above considerations, the present study was undertaken to compare the relative distribution of subcutaneous fat over the body among Bengali Hindu PMG and Post-MG.

MATERIALS AND METHODS

Subjects and settings
The investigation was carried out in a secondary school at Madhyamgram, a suburb of greater Kolkata, West Bengal. Informed consent was obtained from the school authorities and the guardians prior to commencement of the study. The study, however, abided by the ethical guidelines as prescribed in the Helsinki Declaration. There were 868 enrolled students (aged 10-17 years) in the school, of which 257 girls fell in the target age-range of 11-14 years. Firstly, this short age range was designed to minimize the effect of age on anthropometric traits; secondly, to access the immediate effect of menarche on anthropometric parameters under study, and thirdly to reduce the error of recalling the age at menarche as it is evidenced that the typical menarcheal age-range of the Bengali girls was 11-14 years.[18-20] In actuality, the girls who attained at least 11 years of age (i.e., from 11 years or above) but less than 15 years (i.e., up to 14.9 years or less) were the target sample. A total of 245 reportedly healthy girls, without any current illness, voluntarily participated in this study. Thus, the participation rate was 95.3%. Initially, three menstruating girls, who could not recall their menarcheal month exactly, and eight others who did not belong to the Hindu caste population, were excluded. The final sample comprised 234 Bengali Hindu girls aged 11-14 years, of which 111 were PMG and 123 Post-MG. All participants were interviewed through a pre-tested questionnaire, which included specific questions on ethnicity, age, and menarcheal status. Age was recorded to the nearest month.

Anthropometric measurements
Anthropometric measurements were made by a trained female investigator (Dr. Mithu Bhadra) following standard techniques.[21] Triceps, abdominal, sub-scapular, and calf skinfolds were measured to the nearest 0.2 mm on the left side of the body using a Harpenden skinfold caliper.

Statistical analysis
Intra-observer technical errors of measurement were found to be within acceptable limits (Ulijaszek and Kerr, 1999)[22] and therefore not incorporated in subsequent analyses. Ratios of skinfolds taken at various sites on the trunk and extremities and their principal components analysis (PCA) were the more commonly used methods for estimating relative fat distribution.[7,15] Both the methods were applied to the present study. To adjust for variation of the overall subcutaneous fatness, four ratios, one for each skinfold site, were calculated as follows: Log (one skinfold/ sum of skinfolds). Then, PCA was performed to derive components which express the maximum contrast among the log of ratios. Scores for each individual subject were saved as raw data and subsequently, individual scores for the identified principal components were used in further analysis. Student's *t*-test was employed to assess differences between individual scores of components between PMG and Post-MG. The scores did not change significantly with chronological age and thus age-adjustment was not performed in the analyses. All analyses were performed using the statistical package STATISTICA 7.1.[23]

RESULTS

The median age at menarche was 12 years. Table 1 presents the mean (SD) values of the skinfolds measurements for the PMG and Post-MG. All the measurements had significantly ($P < 0.001$) higher values in Post-MG than in PMG.

Results of the PCA for four skinfolds are presented in Table 2. Three meaningful and informative components

Table 1: Mean standard deviation of skinfold measure in pre- and post-menarcheal Bengali girls aged 11-14 years

| Skinfold	Pre-menarcheal (*N*=111)	Post-menarcheal (*N*=123)	*T**
Triceps	9.29 (2.69)	14.59 (4.60)	10.87
Sub-scapular	9.26 (3.03)	16.22 (6.27)	12.36
Abdominal	14.53 (5.13)	23.41 (8.16)	9.98
Medial calf	10.24 (3.53)	17.50 (6.18)	11.15

*P<0.001

were derived. Two of them had eigenvalues higher than 1.0, and one of them slightly below. All those three components had accounted for 99.4% of the variation in the sum of four skinfolds. PC3 was included because it had eigenvalues very similar to PC 2 and it explained a large variation (22.61%). PC4 explained a very little variation and thus excluded.[7] For the first component (PC1), sub-scapular and abdominal skinfolds had positive loadings (0.39 and 0.87 respectively), and triceps and calf skinfolds had negative loadings (–0.69 and –0.78 respectively). The PC1 thus suggested an extremities-trunk contrast in relative subcutaneous fat distribution in girls. The second component (PC2) had a positive loading for the sub-scapular skinfold (0.92) and a negative for the abdominal skinfold (–0.47), thus suggesting a lower trunk-upper trunk contrast in relative subcutaneous fat distribution. Finally, the third component (PC3) showed a positive loading for the calf skinfold (0.62) and a negative loading for the triceps skinfold (–0.72), which implied for an upper extremity-lower extremity contrast in relative subcutaneous fat distribution in girls.

The scores did not show any significant change with chronological age. The age therefore was not included in the analysis. The individual scores for three components between PMG and Post-MG were compared by Student's *t*-tests. The *t*-tests revealed the significance of differences in the fat distribution contrasts between the PMG and Post-MG. The results are shown in Table 3. Scores for second and third components showed significant differences between two contrasting maturity groups of girls. Those results are summarized graphically on Figures 1 and 2. The results suggested that the menarcheal girls did accumulate significantly more fat in upper trunk and lower extremity than their pre-menarcheal peers.

DISCUSSION

The median age at menarche in our sample was 12 years. Same age (around 12 years) was reported among Bengali girls in many previous studies also.[18,19] Thus, the girls in the present study could be representative of the general Bengali girls, at least, in respect of age at menarche. The results of the present study showed that the pre- and post-menarcheal Bengali girls had contrasting relative subcutaneous fat distributions. The three identified significant contrast sets as represented by the three PCs, respectively, were: Extremities to trunk, lower to upper trunk, and upper to the lower extremities. There was no significant difference between PMG and MG in overall truncal subcutaneous fat relative to extremities (as represented by PC1). However, the Post-MG had more fat deposition in upper trunk, in contrast to lower trunk (represented by PC2) than
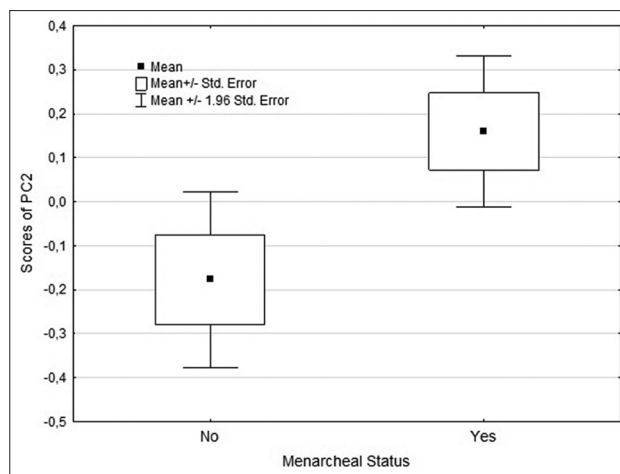
Figure 1: Mean, standard error, and standard deviation of the scores of principal component 2 among the pre- and post-menarcheal Bengali girls

Figure 2: Mean, standard error, and standard deviation of the scores of principal components 3 among the pre- and post-menarcheal Bengali girls

Table 2: Principal components analysis of the four skinfold thicknesses in Bengali girls

Skinfold/Quotient	PC1	PC2	PC3
Sub-scapular	0.39	0.92	−0.01
Abdominal	0.87	−0.47	−0.01
Triceps	−0.69	−0.02	−0.72
Calf	−0.78	−0.03	0.62
Eigen value	1.998	1.073	0.904
% variance	49.95	26.83	22.61

Table 3: *T*-tests for the three identified components between pre- and post-menarcheal Bengali girls

Principal components	*T*	*P*
PC1	0.506	0.6132
PC2	2.510	0.0127
PC3	3.127	0.0020

the PMG. In a study at Amsterdam, the early and late maturing girls, as per the skeletal age, did not differ in relative subcutaneous fat distribution during adolescence and in young adulthood. However, with the menarcheal age as the criterion, early maturing girls have proportionally more subcutaneous fat on the trunk.[16] Moreover, this study did not differentiate between the lower and upper trunk. However, there were evidences, on the other hand, that the fat at the lower-trunk measured by waist line was negatively associated with menarcheal timing, whereas, the higher hip circumference was associated positively.[24] In the present study, the relatively more fat deposition at the upper trunk in the MG, might be a reflection of development of breasts. A record of chest or mid-axillary skinfolds might be more informative.

Our results also demonstrated that the Post-MG had relatively thicker subcutaneous fat deposition at the lower limbs, in contrast to the upper ones. A study among the US girls, aged 10-14 years, showed that the menarcheal status was associated to relatively more fat deposition in the gluteofemoral region.[25] The gluteofemoral fat including its subcutaneous components was proposed to play the most distinct role in predicting menarche, via its ability to produce more leptin than abdominal fat.[25,26] A longitudinal study, in contrast, revealed that the redistribution of subcutaneous fat from extremities to trunk during adolescence is mainly driven to lower parts of the trunk among the Polish boys and girls aged 8-16 years.[7] The fat deposition in the lower extremities in females is the typical gynoid pattern, and the adipose tissue in this region is predominantly subcutaneous in nature. The thicker subcutaneous fat in the lower limb, in contrast to the upper limbs (as represented by the PC3), might have reflected this gynoid pattern which was about to be established in association with the event of menarche, among the Bengali MG under the present study.

The present study had its obvious limitations. Firstly, the data being cross-sectional in nature, could not account for the temporal change in fat redistribution in the same set of girls. Secondly, the sample size did not allow us to estimate the differences at different ages within the range. Further studies with larger samples should investigate the differences in fat distribution in different ages of attainment of menarche. It also seems that involvement of more skinfold sites, e.g., abdominal and mid-thigh, would reveal more insights. Although skinfold thicknesses are valid and reliable estimation of body fat percentage,[27] skinfolds measured at different bodily sites do not necessarily reflect visceral adiposity.[7] The ratio of trunk to extremity skinfolds, for example, is not related to abdominal visceral fat in adolescent girls.[28] Therefore, incorporation of circumferences in future studies would be more revealing. It is also necessary to correlate skeletal maturity along with the changes of fat distribution in relation to menarche at different ages. Future studies should also be directed towards unraveling the associations of variation in development of fat distribution patterns with the differential predisposition to various chronic diseases in adolescence and their subsequent development in adulthood.

CONCLUSION

In conclusion, the attainment of menarche in Bengali girls aged 11-14 years was associated with characteristically more relative subcutaneous fat distribution in the upper trunk and lower limbs, in contrast to lower trunk and upper limbs, respectively. Implications of this finding may extend from the relative role of regional adipose tissues in attainment of menarche to the assessment of risk of cardiovascular diseases and metabolic syndrome in the adolescents.

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