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Menarche, Nutritional Status and Body Size in 10 to 12 Year-Old Girls from Kashipur, Purulia, West Bengal, India

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ABSTRACT

Introduction: Age at menarche (AM) is an important growth and maturity indicator in girls. Pre- and post-menarcheal age-peers differ in BMI-based nutritional status and growth of linear dimensions of body measurements. **Methods:** Using a cross-sectional approach, body size and nutritional status were evaluated in pre-menarcheal (n=50) and post-menarcheal (n=50) school-going Hindu girls aged 10.0 to 12.87 years. All were from socio-economically poor families in a rural area of Kashipur, Purulia district, West Bengal state, India. Anthropometric parameters included the following: height; body weight; body mass index (BMI); sitting height (SH); subischial leg length (SLL); knee height (KH); bi-acromial diameter (BAD); bi-iliocristal diameter (BILCD); and hip breadth (HB). Z-scores of height-for-age (HAZ) and BMI-for-age (BMIZ) were calculated following WHO to evaluate stunting (low HAZ) and thinness (low BMIZ) **Results:** The mean age was 11.12 years for pre-menarcheal girls and 11.32 years for post-menarcheal girls. Mean and median AM were 10.52 years and 10.80 years respectively. Post-menarcheal girls had higher mean anthropometric characteristics than pre-menarcheal girls with significant difference ($p < 0.05$). Undernutrition was frequent among girls, including stunting (pre-menarcheal 62%, post-menarcheal girls 38%), thinness or low BMI-for-age (pre-menarcheal 16%, post-menarcheal 28%), and composite burden of stunting and thinness (pre-menarcheal 14%, post-menarcheal girls 18%). Girls with low BMI-for-age had shorter SH, SLL, KH, BAD, BILCD, and HB. Linear combination of body dimensions significantly ($p < 0.05$) predicted post-menarcheal status through binary logistic regression analysis. **Conclusion:** Pre-menarcheal girls experienced a higher degree of chronic undernutrition (stunting). Post-menarcheal girls showed a greater body size than pre-menarcheal age-peers.

Key words: Biacromial diameter, height, hip breadth, leg length, menarche

INTRODUCTION

Age at menarche (AM), the prime indicator of growth and maturation, is viewed as a discriminating indicator of a population's bio-cultural and environmental attributes (Jones *et al.*, 2009), socio-economic background and nutritional status (Hernández *et al.*, 2007). This indicator is reported to vary between populations in India (Mukherjee & Datta Banik, 2009). Post-menarcheal girls are reported to have higher mean anthropometric characteristics (height, weight, sitting height, BMI) and body composition traits (fat mass and fat-free mass) than pre-menarcheal age-peers in

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Japanese and Caucasian samples (Sampei *et al.*, 2003), India (Datta Banik, 2011), and in Bangladesh (Rah *et al.*, 2009).

Studies on undernutrition among children in India have recorded high rates for urban slums (Ghosh & Shah, 2004) and for rural and tribal areas (Medhi, Barua & Mahanta, 2006; Mitra *et al.*, 2007). Undernutrition among girls is a serious problem in India (Dewan, 2008), but reports on the levels and causes of undernutrition, especially from underprivileged rural and tribal populations are scarce. Average nutrient intake of the adolescent girls in rural India is much below the recommended rates (Malhotra & Jain Passi, 2007). Svedberg (2000) proposed "anthropometric failure", a new aggregate indicator that incorporated all undernourished children: wasted and/or stunted and/or underweight and thereby constructed a "Composite Index of Anthropometric Failure" or CIAF. Studies have further supported and validated the use of CIAF (Nandy *et al.*, 2005; Nandy & Miranda, 2008).

Relatively few studies have been done on nutritional status and body size in pre-menarcheal and post-menarcheal girls in India. Some reports are available for urban and semi-urban populations (Rao, Joshi & Kanade, 1998), and fewer have been published on rural, tribal and/or under-privileged populations (Chatterjee, Chanda & Bandyopadhyay, 2005; Das & Datta Banik, 2011). In an effort to address this shortcoming, the present study objectives were to:

1. Compare body dimensions (height, bi-acromial diameter, bi-iliocristal diameter, hip breadth, sitting height and knee height) between pre-menarcheal and post-menarcheal girls (age-peers) in Kashipur, Purulia District, West Bengal, India.
2. Compare rates of stunting, thinness and their composition (stunting and thinness) between pre- and post-menarcheal age-peers, and distribution of body dimensions by BMI-based nutritional status.
3. Test if the body size or their linear combination(s) could predict or be associated with menarcheal status (pre or post).

METHODS

A cross-sectional study was carried out from April to December 2010 in Kashipur, Purulia District, about 197 km west of Kolkata, the capital of West Bengal state. Initially, a probabilistic sample included 9 to 15 year-old 238 girls (119 pre menarcheal). However, for the present study, 100 participants (50 pre-menarcheal and 50 post-menarcheal girls) aged 10.00 to 12.87 years of age were selected from that sample. The sample included pre-menarcheal (Prem) and post-menarcheal (Pm) girls at 10 years (Prem = 18, Pm = 15); 11 years (Prem = 21, Pm = 21); and 12 years (Prem = 11, Pm = 14) of age. Participants were Bengali-speaking, from Hindu social groups attending schools in the Kashipur area. Girls in the studied age range were selected at random from attendance rosters at five schools within the *Panchakote-Raj* Block (an administrative jurisdiction) in Kashipur: Kashipur *Namopara* Junior High School; Kashipur Board *Balika* Primary School; *Panchakote-Raj Bhagini Nibedita Vidyapith*; *Panchakote-Raj* High School; and J.K.M. Girls' High School. All participants lived in the vicinity of their schools. Based on local information sources and government data, none of the participants dropped out of school during the study period. The sample represented approximately 80% of girls within this age group belonging to Hindu castes or social groups in this rural area.

No participant had acute or chronic illness six months prior to data collection, and none had any physical deformities or handicap (examined by a physician of the Block Health Centre). School authorities provided mid-day meals, and the girls were observed to follow similar physical activity patterns during weekdays and holidays at school or home. All belonged to families of low socio-economic status as indicated by their holding a Below Poverty Line (BPL) identity card issued by the Government of West Bengal. Participant's date of birth was recorded, and verified using health centre immunisation cards, birth certificates and school records. Decimal age was calculated by subtracting the survey date from the date of birth.

Age at menarche (AM) was determined retrospectively using pre-tested, validated questionnaires with a follow-up interview. Participants were asked about their first menstruation and their responses cross-checked with their mothers and/or nearest female relatives (e.g. elder sisters and aunts). The same procedure was followed closely for participants of all ages (10 to 12 years). Girls experiencing a menstrual cycle during the study were not recruited for participation. Written informed consent was obtained from school authorities and parents and/or legal guardians. Ethical approval was obtained from the appropriate committee of Calcutta University before commencing the study. Participant names were replaced by a folio number.

In all cases, anthropometric measurements were taken by the same, trained, female PhD student (see Acknowledgements). When measured, participants wore light clothes, were bare-footed, and wore no jewelry or adornments. All measurements were taken using standard, validated equipment and following standard protocols (WHO, 1995): a Martin anthropometer for height and a standard measuring tape (measurements to the nearest tenth of a centimeter); and an electronic scale (Seca, Hamburg, Germany, model no. 872) to record body weight (measurements to the nearest 0.05 kg). Seven measurements were taken: stature or height (cm); body weight (kg); sitting height (cm); knee height (cm); bi-acromial diameter (cm); bi-iliocristal diameter (cm); and maximum hip breadth (cm) across the hips. Knee height was measured in a seated position of the participant, using a sliding broad-blade caliper. It was the distance from the sole of the foot to the most anterior surface of the femoral condyles of the thigh (medial being more anterior), with the ankle and knee each flexed to a 90° angle. Pressure was applied to the two blades to compress the soft tissues (Teichtahl *et al.*, 2012). Linear measurements were recorded to the nearest 0.1 cm. Lower extremities were measured on the left side of the body. Each measurement was taken in triplicate and the values averaged to generate a final value for analysis.

Anthropometric parameters were derived from the basic data: body mass index (BMI); and subischial leg length (WHO, 1995). BMI was computed following the standard equation: BMI = weight (kg)/height (m^2). Subischial leg length was derived by subtracting sitting height from height.

Nutritional status was estimated using z-scores of height-for-age (HAZ) and BMI-for-age (BMIZ) (de Onís *et al.*, 2007). Rates of stunting (low height-for-age), and thinness (low BMI-for-age) between pre- and post-menarcheal age-peers were recorded. Individual or combined rates of different types of nutritional status were estimated and comparisons made between pre- and post-menarcheal girls (Table 1). In addition to the estimation of overall rates of nutritional status in the sample, an attempt was made to identify nutritional burden (malnutrition or anthropometric failure) separately or combined at individual level. This proposed approach, called the Composite Nutritional Burden Model or CNBM, involves eight groups (A to H). Group A indicates individuals with no anthropometric failure. This model might be viewed as a modified version of CIAF (Nandy *et al.*, 2005; Nandy & Miranda, 2008; Svedberg, 2000).

Normality tests (Shapiro-Wilk tests) of the anthropometric measurement data showed it to meet $p > 0.05$. Data normality

Table 1. Composite Nutritional Burden Model (CNBM), the proposed classification of anthropometric indices evaluating nutritional status (following the CIAF proposed by Nandy *et al.*, 2005; Nandy & Miranda, 2008)

Group	*Anthropometric indices*	*Stunting*	*Thinness*	*Overweight*	*Obesity*
A	No nutritional burden	No	No	No	No
B	Stunting	Yes	No	No	No
C	Thinness	No	Yes	No	No
D	Overweight	No	No	Yes	No
E	Obesity	No	No	No	Yes
F	Stunting + thinness	Yes	Yes	No	No
G	Stunting + overweight	Yes	No	Yes	No
H	Stunting + obesity	Yes	No	No	Yes

was also evident in the frequency histogram, normal probability plot and quantile plots. Anthropometric characteristics distribution was not significantly skewed, and data transformation was therefore not required. Student's *t*-tests were run to identify differences in mean anthropometric data between pre- and post-menarcheal girls. Principal Component Analysis (PCA) was run to produce a small number of linear combinations among the anthropometric variables of body dimensions which accounted for most of the data variability and to improve the interpretations of the relationships between variables that are being handled. Binary logistic regression analysis was done to predict menarcheal status (pre or post) from body size [Factor(s) extracted in PCA]. All statistical analyses were done using the SPSS statistical package (version 13.00). A 5% rejection level of the null hypothesis ($p < 0.05$) was fixed for all analyses.

RESULTS

Descriptive statistics (mean values with standard deviations or SD in parentheses) of pre- and post-menarcheal girl anthropometric characteristics (measurements and derived ratios and indices) (Table 2) shows mean age in pre-menarcheal girls (11.12 years ± 0.59 SD, ranging between 10.0 and 12.06 years) to be lower than in post-menarcheal girls (11.32 years ± 0.72 SD, ranging between 10.62 and 12.87 years) with no significant ($p > 0.05$) difference. Overall mean age at menarche (AM) was 10.52 years (± 0.83 SD). Median age at menarche was 10.8 years. All mean anthropometric parameters differed ($p < 0.05$) between pre- and post-menarcheal girls. Post-menarcheal girls were taller (height and sitting height), heavier, had a longer knee height and subischial leg length, broader shoulders (bi-acromial diameter), a wider waist (bi-iliocristal diameter) and larger hip breadth. Post-menarcheal girls had overall greater body size than their pre-menarcheal age-peers (10 to 12 years) based on differences in mean height (11.64 cm); weight (5.76 kg); BMI (0.79 kg/m^2); sitting height (5.19 cm); subischial leg length (6.45 cm); knee height (3.05 cm); bi-acromial diameter (1.62 cm); bi-iliocristal diameter (1.74 cm) and hip breadth (1.71 cm) (Table 2).

Results identified a high prevalence of severe stunting (22.0% < -3SD of HAZ) and moderate stunting (28.0% between -2 and >-3SD of HAZ) and thinness (22.0% < -2SD BMIZ) in the sample (Table 3). Rate of stunting was higher in pre-manrcheal girls (62%) than their post-menarcheal age-peers (38%). However, more post-menarcheal girls were suffering from low BMI for age or thinness (28.0%) than pre-menarcheal girls (16.0%). Significant differences (χ^2 with Yates' correction) between pre-menarcheal

Table 2. Descriptive statistics of anthropometric characteristics and nutritional status of pre-menarcheal (n= 50) and post-menarcheal (n= 50) Hindu girls in Kashipur, Purulia

Variables	*Pre-menarche*			*Post-menarche*			
	Minimum	Maximum	Mean (SD)	Minimum	Maximum	Mean (SD)	*t*
Age (years)	10.00	12.06	11.12 (0.59)	10.62	12.87	11.32 (0.72)	1.52
Height (cm)	110.30	156.30	126.06 (10.57)	101.40	157.00	137.70 (11.54)	5.26*
Body weight (kg)	13.00	49.00	22.72 (7.01)	13.00	44.00	28.48 (7.30)	4.02*
Body mass index (kg/m^2)	10.09	20.06	13.99 (1.86)	11.83	22.38	14.78 (2.18)	1.95*
Sitting height (cm)	57.80	79.10	65.84 (4.63)	54.00	80.10	71.02 (5.60)	5.05*
Sub-ischial leg length (cm)	50.70	77.30	60.22 (6.63)	47.40	80.90	66.67 (7.06)	4.71*
Knee height (cm)	25.00	46.50	36.87 (4.04)	31.40	50.00	39.92 (4.25)	3.68*
Biacromial diameter (cm)	20.40	33.90	26.85 (2.66)	22.60	34.90	28.47 (3.20)	2.75*
Bi-iliocristal diameter (cm)	14.00	27.30	19.30 (2.86)	15.70	26.70	21.04 (2.66)	3.15*
Hip breadth (cm)	17.80	29.40	21.56 (2.38)	17.00	40.70	23.27 (3.53)	2.83*

Standard deviations (SD) are given in parentheses. * $p < 0.05$

Table 3. Nutritional status category rates (%) following WHO (de Onís *et al.*, 2007) and the proposed Composite Nutritional Burden Model (CNBM) for pre-menarcheal (n= 50) and post-menarcheal (n= 50) Hindu girls in Kashipur, Purulia (Following the CIAF proposed by Nandy *et al.*, 2005; Nandy & Miranda, 2008)

Nutritional burden	*Nutritional status*	*All (%)*	*Pre-menarche (%)*	*Post-menarche (%)*
Height for age	Severe stunting	22.00	24.00	20.00
	Moderate stunting	28.00	38.00	18.00
	Normal height for age	50.00	38.00	62.00
BMI for age	Undernutrition (thinness)	22.00	16.00	28.00
	Normal BMI	78.00	84.00	72.00
CNBM-A*	No burden	44.00	36.00	52.00
CNBM-B*	Stunting	34.00	48.00	20.00
CNBM-C*	Thinness	6.00	2.00	10.00
CNBM-F*	Stunting + Thinness	16.00	14.00	18.00

* Groups of CNBM described in the methods section.

and post-menarcheal girls were identified for stunting (χ^2=10.58, p< 0.05) but not for thinness (χ^2=3.53, p>0.05). The CNBM identified a prevalence of nutritional burden (i.e. stunting and thinness) (16.0%), stunting (34.0%), thinness (6.0%), and no anthropometric failure or 'no burden' (44.0%) in the sample. Rate of stunting was higher in pre-menarcheal girls while post-menarcheal exceeded in thinness (low BMIZ) and composite burden (stunting and thinness).

Linear body measurements were used to explain how body size related to BMIZ scores (Table 4). Mean values for all anthropometric characteristics were consistently higher in girls with normal BMIZ than in those suffering thinness or low BMIZ. Post-menracheal girls had higher mean body size compared to the pre-menarcheal age-peers of either low or normal BMIZ, with significant difference except for a few cases (Table 4).

Component matrix in PCA showed that one component (factor) had been extracted out of the variables of linear body dimensions. Factor loading indicated variables had weight > 0.75. Interestingly, loading of variables had weight rankings of low to high (or reverse) and were opposite in pre- and post-menarcheal girls. Hip breadth had the highest loading in pre-menarcheal girls (0.935) while in post-menarcheal girls, loading of the same variable was lowest (0.756). On the contrary, bi-iliocristal diameter was observed to have the lowest loading in pre-menarcheal girls (0.864) and highest among post-menracheal girls (0.890). The other component weights in pre-menarcheal (Prem) and post-menarcheal (Pm) girls were sub-ischial leg length (Prem = 0.903, Pm = 0.759), biacromial diameter (Prem = 0.880, Pm = 0.807), and sitting height (Prem = 0.876, Pm = 0.853).

A binary logistic regression analysis was run to determine the fit of a model predicting post-menarcheal status from the explanatory variables age and linear body dimensions extracted as the component in PCA (Table 5). All cases were included and no data was missing. In the Omnibus test, the Nagelkerke R Square showed 24% of variation in the outcome variable 'menarcheal status' to be explained by the logistic model. Age was not found to be significant (p> 0.05) as a factor contributing to participants being post-menarcheal. However, linear dimension as another factor was significant (p < 0.05) in explaining post-menarche in the model . The analysis of deviance (p< 0.05) showed a statistically significant relationship between the variables at a 95.0% confidence level. In addition, the residuals p-value (>0.05) indicated the model to be acceptable for the data at a 95.0% or higher confidence level. The Hosmer-Lemeshow goodness-of-fit (Chi-squared) fulfilled the assumption (p> 0.05) and explained that the observed and predicted probabilities matched the sample size.

The two independent variables (age and linear dimension as a factor) were continuous (Table 5). Odds ratios, as explained by Exp(B) in the model, indicated that an increase of one cm in linear body dimension substantially increased the odds of being post-menarcheal. Overall model accuracy for prediction of post-menarcheal status was 65%. Sensitivity (60%), specificity (70%), and the Youden Index value (1.29) were calculated accordingly. Based on these results, the equation for calculating the probability of a girl being post-menarcheal was:

Probability (post-menarcheal status) = $1 / (1+ e^{-z})$ where

$z = -6.07 + 0.54^* \text{ Age} + 0.68^* \text{ Linear body dimensions}$

DISCUSSION

Growth and nutritional status were different in the studied sample of pre-menarcheal and post-menarcheal girls. Mean AM in the present study (10.52 years) was lower than the reported 11.47 years for Santal girls aged 9 to 13 years (Chatterjee, Chanda &

Table 4. Distribution of anthropometric characteristics compared to nutritional status based on BMI-for-age z-scores (BMIZ) for pre-menarcheal (n= 50) and post-menarcheal (n= 50) Hindu girls in Kashipur, Purulia

Variables		*Under-nutrition*		*Normal*		
	Menarche	*Mean*	*t-value*[1]	*Mean*	*t-value*[2]	*t-value*[3]
Height (cm)	Pre-menarche	122.33 (7.61)	1.67	126.77 (10.98)	5.74*	1.09
	Post-menarche	130.37 (12.26)		140.55 (10.04)		3.02*
Body weight (kg)	Pre-menarche	17.88 (3.10)	2.32*	23.64 (7.19)	4.77*	2.22*
	Post-menarche	21.68 (3.99)		31.13 (6.56)		5.02*
Body mass index (kg/m^2)	Pre-menarche	11.85 (0.83)	2.94*	14.39 (1.72)	2.87*	4.07*
	Post-menarche	12.65 (0.46)		15.60 (2.01)		5.41*
Sitting height (cm)	Pre-menarche	64.41 (3.61)	0.84	66.11 (4.79)	6.42*	0.95
	Post-menarche	66.24 (5.45)		72.89 (4.48)		4.43*
Sub-ischial leg length (cm)	Pre-menarche	57.91 (4.55)	2.08*	60.66 (6.92)	4.53*	1.08
	Post-menarche	64.14 (7.66)		67.66 (6.66)		1.61
Knee height (cm)	Pre-menarche	35.86 (1.74)	1.85	37.06 (4.34)	3.50*	0.76
	Postmenarche	38.36 (3.57)		40.53 (4.38)		1.64
Biacromial diameter (cm)	Pre-menarche	25.33 (1.11)	1.13	27.14 (2.77)	3.21*	1.81
	Post-menarche	26.41 (2.58)		29.27 (3.09)		3.07*
Bi-iliocristal diameter (cm)	Pre-menarche	17.05 (3.28)	2.20*	19.73 (2.61)	3.06*	2.55*
	Post-menarche	19.77 (2.48)		21.53 (2.60)		2.18*
Hip breadth (cm)	Pre-menarche	19.83 (1.83)	1.24	21.90 (2.34)	3.25*	2.36*
	Post-menarche	22.35 (5.56)		23.63 (2.35)		1.15

* $p < 0.05$; 1) *t*-test between pre- and postmenarche (low BMIZ); 2) *t*-test between pre- and postmenarche (normal BMIZ); 3) *t*-test between low and normal BMIZ.

Table 5. Variables in the binary logistic regression equation predicting menarche status by knee height among pre-menarcheal (n= 50) and post-menarcheal (n= 50) Hindu girls in Kashipur, Purulia

Predictors	*B*	*S.E.*	*Wald*	*df*	*p*	*Exp(B)*	*95.0% C.I. for Exp(B)*	
							Lower	*Upper*
Constant	-6.07	4.91	1.53	1.00	0.22	0.00		
Age (years)	0.54	0.43	1.54	1.00	0.21	1.71	0.73	3.98
Factor (linear dimensions)	0.68	0.31	4.90	1.00	0.03	1.98	1.08	3.62

Bandyopadhyay, 2005). It was also lower than the mean AM reported in the rural samples from Delhi (13.57 years), Haryana (14.0 years), Rajasthan (14.0 years) and Uttar Pradesh (14.61 years) (Malhotra & Jain Passi, 2007).

In the present study, post-menarcheal girls had greater body size and proportions than pre-menarcheal age-peers; weight and other body dimensions were also greater in the post-menarcheal girls across the studied age range (10 to 12 years). Post-menarcheal girls, be they low or normal BMI-for-age, were consistently taller, had higher body weight, and BMI, compared to their pre-menarcheal age-peers. It appears that menarche (in connection with puberty) acts as a principal factor influencing growth in body size and proportions among the studied girls. Both upper body (sitting height) and lower body (knee height, subischial leg length) measurements were greater in the post-menarcheal girls. Post-menarcheal girls had broader shoulders (bi-acromial diameter), a wider pelvis (bi-iliocristal diameter) and greater hip breadth. Their broader hips and pelvis indicated that the post-menarcheal girls had advanced towards reproductive maturity. Our results agree with a previous study of 417 girls aged 11 to 16 years (59.23% post-menarcheal) from the Barnala and Mansa districts, Punjab, India, in which post-menarcheal girls exhibited taller height, and better nutritional status with respect to weight, BMI, arm muscle circumference and body fat (Goyal, Mehta & Kaur, 2012). In this same sample, median AM was delayed in undernourished girls (13.5 years) versus normal girls (12.7 years), and high rates of thinness (64.51%) and stunting (44.36%) were recorded.

According to World Health Organization recommendations (WHO, 1995), the girls suffered a severe degree of under-nutrition as measured by stunting (> 50%) and thinness (> 15%). The sample contained remarkably high rates of composite burden of stunting and thinness. The proposed Composite Nutritional Burden Model (CNBM) for classifying anthropometric failure rates effectively identified girls suffering from a high degree of chronic and acute under-nutrion. Prevalence of stunting was higher in pre-menarcheal girls. This coincides with a study in western Kenya in which pre-menarcheal girls were more stunted than their post-menarcheal age-peers (Leenstra *et al.*, 2005). In the present study, the girls suffered from either acute or chronic energy deficiency, meaning none of them was overweight or obese. However, the CNBM can encompass complex nutritional burdens such as rates of overweight, obesity, excess weight (overweight plus obesity), stunted/overweight, stunted/excess weight, etc. Combinations of thinness with excess weight are not possible in this index. The CNBM is based on a composite of rates beginning at the individual level and extending to the societal level. Using its full structure, the CNBM could be very useful in the studies analyzing different age cohorts in relatively underdeveloped and developing countries (Varela-Silva *et al.*, 2012) where stunting, underweight, wasting, thinness, overweight and obesity (in dual or other forms) coexist. CNBM needs further verifications with further research. In this model, rates of underweight or wasting (for children below 10 years of age) could also be added in future investigation in this line. The results of the present study further show that pre-menarcheal girls in rural Kashipur suffered from a higher rate of chronic undernutrition (stunting) compared to their post-menarcheal age-peers. This might indicate that girls who suffered from a higher degree of under-nutrition were pre-menarcheal or had delayed menarche. However, an overall high rate of acute undernutrition or thinness among girls led to higher rates of thinness among post-menarcheal girls. These issues need further verification.

Body size and proportions (upper or lower extremities) were lower in stunted girls, be they pre- or post-menarcheal. Lower extremity or body size (i.e. subischial leg length, knee height were affected by chronic undernutrition as defined by stunting; this was more acute among pre-menarcheal girls. Linear measurements of lower extremities, represented by sub-ischial leg length and knee height, showed a lower mean in girls suffering from BMI-based under-nutrition or thinness, be they pre- or post-menarcheal. These results agree with earlier reports in which short stature is attributed to relatively short legs and is also a general indicator of an adverse environment (Bogin & Varela-Silva, 2010). In the present context, menarche may have relations with growth. Post-menarcheal status was significantly related to linear combination of body dimensions.

The present sample of Hindu girls from Kashipur was found to have a high degree of undernutrion (chronic or acute). This is a reflection of their sub-optimal health, probably caused by a high degree of malnutrition in the girls, who belonged to registered BPL families. Similarly high rates of undernutrition have been reported previously among boys and girls from Kashipur, with the girls having higher rates than boys (Mahato, 2009). A primary reason for this discrepancy is discrimination between male and female children. Sons are preferred in many societies in India, meaning female children frequently face negligence, and are given a lower priority for education, food and nutrients. Girls are also often overburdened with housework, including childcare, leading to undernutrition, delayed growth and maturation. This is a scenario common to many societies in South-East Asia, including India. It can be found in different religious and ethnic groups, and is more common in rural than urban areas of low-income countries of South Asia (Miller, 1997; Pitt, Rosenzweig & Hassan, 1990) including Bangladesh (Chen, Hug & D'Souza, 1981; Fauvea, Wojtyniak & Koenig, 1989). From a public health perspective, this could evolve into a major crisis that would hamper medium- and long-term national development. Confirming the extent and ubiquity of this health challenge will require extensive further research.

CONCLUSION

The present study compares body size and nutritional status between pre- and post-menarcheal age-peers of a Hindu community in a particular rural area of West Bengal. The results confirm that menarche in connection with puberty distinguishes pre- and post-menarcheal age-peers with respect to body size. Much broader data, representing different ethnic groups from this region of India and others, as well as larger sample sizes and more extensive genetic data, will help to better understand how menarche is linked to nutritional status.

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Conflict of interest

The authors declare that there is no competing interest of any kind in this study.

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