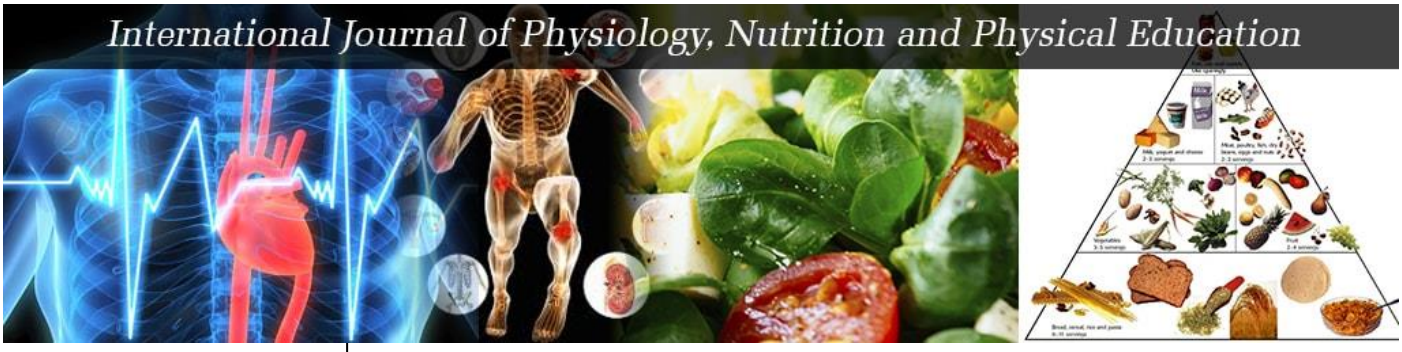

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Age at menarche in relation to nutritional status among urban and rural school going girls in West Bengal, India

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Abstract
Background: Menarcheal age is influenced by hereditary, socioeconomic status (SES) and nutrition. The aim was to determine the mean age at menarche of urban and rural girls and its connection to SES status, nutritional and body composition.
Methods: This was a cross-sectional study conducted in rural and urban Bengali school going girls. SES, 24 hours dietary information and anthropometries were collected. Upper arm fat (UAFA) and muscle areas (UAMS), fat free mass (FFM) and fat mass (FM) were estimated. Mann-Whitney U test for median test, Chi-squire or Fisher exact for frequency test and Spearman rank correlation were performed to find association between maternal variables and menarcheal age.
Result: A total 463 girls (232 of rural area and 231 of urban area) participated in this study. The menarcheal age of rural girls was significantly higher than urban girls (12.7 vs 12.2 years; $P< 0.001$). Consumption of protein, fat and energy were higher and carbohydrate was lower in urban girls compared to rural girls (both $P< 0.05$). Fat mass and UAFA were positively associated with age at menarche only in urban girls ($P< 0.05$). In urban girls, 10% increment of MUAC and fat percent caused an increase of 0.34% and 0.21% menarche age respectively (both $P< 0.0001$). Energy was inversely related with menarche age and 10% increment of energy intake menarcheal age decreased by 2.42% ($P< 0.0001$).
Conclusion: This study indicated that urban girls have had early menarcheal age compared to rural girls. Nutrition and body composition are associated with age at menarche only in urban area.

Keywords: School girls, menarche, body composition, nutritional status, India

Introduction
Menarche is called the first menstrual bleeding and age at menarche is the most significant period of a girl's life. In this period, an adolescent girl has been recognized as a special period which signifies the transition from girlhood to womanhood and various physiological, social and mental changes occur in this age group [1]. Early menarche is associated with higher risk of breast-cancer, increased endometrial cancer and adult obesity [2-7]. On the other hand, delayed menarche is a risk factor for adult oligomenorrhea and cardiometabolic abnormalities, irregular menstrual cycles and lower peak bone mass [8, 9].
Menarche is influenced by hereditary [10], race, natural conditions, nourishment, physical movement, geographic area, metropolitan or rustic habitation, wellbeing status, mental variables, weight record, family size, financial status, parental instructive level, control of guardians, loss of guardians, youngster sexual maltreatment, physical pressure and inactive smoking [11]. High SES is also related with early period of menarche [12, 13]. The fluctuation in mean period of menarche likewise exists dependent on nation, recommending the potential for hereditary or potentially ecological causes [14].
Investigations of menarcheal patterns have zeroed in principally on single components. Some are available at the singular level, for example, physical factors like body mass index (BMI) and tallness [15], and ecological factors like financial status. Other single-factor contemplates have assessed factors present at a more extensive scale, utilizing atmosphere factors like local temperature [16, 17] and elevation [18, 19] in a research work concluded that increasing rates of obesity in United States of America may result in earlier average age of onset of puberty for US girls.

It is reported that the age at menarche is positively associated with anthropometric measures such as weight, height, arm circumference and body composition [20].

There are various investigations with respect to age at menarche in India and everywhere on over the world. The age at menarche was reported for 13.5 years in Burma and 13.2 years in metropolitan regions of Markazi area of Iran [21], 11.8 years in Sri Lankan young ladies [22]. Studies in India reported the mean age at menarche to fluctuate from 12.3 years to 15.4 years in Bengali girls of lower SES status of Western India [23, 24].

Many researchers in India have studied to find relationship between age at menarche and nutritional status in different areas [25], however, the present study aimed to determine the mean age at menarche in urban and rural Bengali school going girls and its relation to the SES and nutritional status and body composition.

Subjects and Methods

The present cross-sectional study was conducted in Bengali school going girls both in urban and rural area of Paschim Medinipore district of West Bengal, India. Fifty percent data were collected from Medinipore town and rest of the 50% data were taken from rural area. The data were collected from January 2018 to December 2019. In this present study, random sampling method was applied to select the Narayan Vidyabhaban for Girls Schools in urban and Belda Proavati Balika Vidyalaya School in rural area. The inclusion of a specific institution depends on the judgment or decision of the researcher and the inclusion criteria of subject selection were 9 to 16 years girls. In this study, all subjects participated voluntarily in response to the appeal made by administrations of the respective academic institutions. Data were collected in a private area at their respective schools only during day time usually between 9 am and 4 pm. A written consent was obtained from their parents as subjects were minor and a short assent including study objective, times, measurements etc was informed to the subjects. The study was approved by the Ethical Committee of Vidyasagar University prior to data collection.

Data collection

Determination of age at menarche: It is a verbal method by which the age of menarche was asked to the every selected girl of urban and rural areas and verified from the mother of the girls.

Socioeconomic status (Kuppuswamy scale): This scale was devised by Kuppuswamy in 1976 [26]. Several ways of measuring SES have been suggested for categorizing different rural and urban populations in last decades but the most widely used scale is Kuppuswamy's socioeconomic scale. Kuppuswamy scale is a composite score of education and occupation of the head of the family along with monthly income of the family, which yields a score of 3-29. This scale classifies the study populations into high, middle, and low SES. Usually education and occupation of head of family are not changeable with time.

Food intake assessment by 24 hours recall method: A 24-hour dietary recall is a structured interview intended to capture detailed information about all foods and beverages consumed by the respondent in the past 24 hours, most commonly, from morning 6 o' clock to 6 o' and clock of the previous day. It helped to know the detailed information about all foods and beverages consumed on a given day. A key feature of the 24 hours was that, when appropriate, the respondent was asked for more detailed information than first reported. A survey data sheet was improved from a survey paper conducted for the Food and Environmental Hygiene Department by the Chinese University of Hong Kong [27].

Anthropometric data collection*:* Girl's weight with school dress and barefooted was measured using digital weight measuring scale with accuracy of ±500 g (model No – OMRON HN 286 Ultra-thin). Standing height without shoes was taken to the nearest 0.1 cm using portable anthropometer. Mid upper arm (MUAC) and hip circumferences were measured to the nearest 0.1 cm by a non-stretchable tape. The skinfold thicknesses (biceps, triceps, subscapular and supra-illiac) were taken within 0.2 mm precision using Holtain skinfold caliper. All measurements except weight were taken thrice and mean values were used in the analysis. Standard procedures were performed following the protocol of International Biological Programme [28].

We estimated upper arm muscle area (UAMA) and upper arm fat area (UAFA) based on mid upper arm circumference and triceps skinfold thickness using established equations [29] which have been used in Bengali population previously [30-32]. Body fat percent was estimated using Siri equation. First, body density was estimated using skinfolds thicknesses and then fat percent was derived using Siri equation [33, 34].

$$\text{UAMA } (cm^2) = \{\text{MUAC} - (\text{TSF} \times \pi)\}\ 2/(4 \times \pi) \quad (1)$$

$$\text{UAFA } (cm^2) = \{(\text{MUAC})^2/(4 \times \pi)\} - \text{UAMA} \quad (2)$$

$$\text{Density: } (c-m) \times \log(\text{biceps}+\text{triceps}+\text{subscapular}+\text{suprailiac}) \quad (3)$$

('c' and 'm' are coefficient and constant respectively)

$$\text{Fat mass } (\%) = \{(4.95/\text{density}) - 4.50\} \times 100 \quad (4)$$

Statistical Analysis

Data was not normally distributed and hence median with inter quartile range (IQR) and frequency with percent were used for continuous variable and categorical variables respectively. Body mass index was calculated weight in kg divided by height in meter square. Fat free mass and fat mass were derived using skinfold thicknesses and mid upper arm muscle and fat area were estimated using MUAC and triceps skinfold thickness. Mann-Whitney U test was performed to find the significantly difference between urban and rural girls. Chi-squire or Fisher exact test was used to compare categorical data between urban and rural girls. Spearman correlation coefficient was calculated to find relation between age at menarche and physical parameters of participants. Log value of dependent variable (menarche age) and independent variables was calculated and used in linear regressions to find the trend of change of menarche age. Significant level was set at $P < 0.05$. STATA Version 14 was used to conduct the analysis.

Results

A total 463 girls (232 of rural area and 231 of urban area) participated in this study and their median age (IQR) at interview was 14.5 years (13.2, 15.8) and age at menarche was 12.3 years (12.2, 12.9). Stratified by area of residence, age at menarche and anthropometries were compared (table 1). Age at menarche of rural girls (12.7 years) was significantly higher than urban girls (12.2 years) ($P < 0.001$). However, weight (40.35 vs 41.90; P= 0.005) and height (149.8 vs 150.0; P=0.010) were lower in rural girls compared to urban girls respectively. Only subscapular skinfold thickness was significantly higher in rural girls compared to

urban girls (P=0.012). Non-significant difference was also found in body mass index and triceps skinfold thickness ($P>$ 0.05).

Socioeconomic status (SES), body composition and nutrients consumption are illustrated in table 2. SES was classified by Kuppuswamy scale and found that most of the rural girls (92.67%) were in middle class, however, SES status of urban girls were in lower and upper classes ($P<$ 0.001). The prevalence of underweight was higher in rural girls compared to urban girls (p= 0.023). There was no difference of fat mass between urban and rural girls, however, fat free mass was higher in urban than rural girls ($P<$ 0.001). Nutrients consumption was recorded and found that intake of protein, fat and energy were higher and carbohydrate was lower in urban girls compared to that of rural girls (all $P<$ 0.05).

According to nature of data, Spearman rank correlation was performed between age at menarche and physical parameters and foods consumption by area of residence (table 3). There were significant positive correlation between age at menarche and physical parameters and foods consumption only in urban girls but not in rural girls. Body composition was estimated and correlated with age at menarche. Fat mass and UAFA were positively associated with age at menarche only in urban girls ($P<$ 0.05), however, FFM% was inversely associated with age at menarche (r= -0.216; p=0.001).

Log values was calculated of menarche age (dependent variable) and MUAC, fat percent, and carbohydrate and energy intake (independent variable) were calculated and used in linear regression models. About 1.80% of cases showed an increased in menarche age when carbohydrate intake was increased by 10% (p=0.017). Similarly, 10% increment of MUAC and fat percent showed an increase of menarche age 0.34% and 0.21% respectively (both $P<$ 0.0001). However, energy was inversely related with menarche age and it was found that 10% increase of energy intake caused a decreased of the menarche age by 2.42% ($P<$ 0.0001). This changed was noticed only in urban girls but not in rural girls.

Table 1: Physical parameters of participants by area of residence [1]

Variable	Rural girls (n= 232)	Urban girls (n= 231)	P-value
Age at measurement, years	14.58 (13.25, 15.83)	14.42 (13.08, 15.83)	0.374
Age at menarche, years	12.7 (12.3, 12.9)	12.2 (12.1, 12.3)	<0.001
Weight, kg	40.35 (38.95, 48.2)	41.90 (40.00, 48.30)	0.005
Height, cm	149.8 (148.6, 151.1)	150.0 (149.2, 151.2)	0.010
Body mass index, kg/m^2	18.06 (17.34, 21.57)	18.67 (17.67, 21.49)	0.072
Mid upper arm circumference, cm	20.20 (19.05, 22.45)	20.00 (18.90, 22.40)	0.448
Hip circumference, cm	58.50 (55.00, 61.80)	58.80 (56.00, 61.4)	0.325
Biceps skin fold thickness, mm	10.00 (8.80, 12.90)	10.00 (9.00, 14.00)	0.342
Triceps skinfold thickness, mm	9.80 (7.05, 12.70)	8.20 (6.32, 13.2)	0.104
Subscapular skinfold thickness, mm	8.80 (6.60, 10.20)	8.20 (6.10, 10.20)	0.012
Supra-iliac skinfold thickness, mm	10.60 (9.80, 15.80)	10.40 (9.80, 16.20)	0.388

[1]Data are presented as median and interquartile range

Mann-Whitney U test was performed to find significant level between urban and rural girls

Table 2: Socio-economic status, body composition and nutrients consumption by area of residence

Variable	Rural girls (n= 232)	Urban girls (n= 231)	P-value
Socio-economic status			
Lower class	13 (5.60)	71 (30.74)	<0.001
Middle class	215 (92.67)	39 (16.88)	
Upper class	4 (1.72)	121 (52.38)	
Nutritional status			
Underweight	136 (58.62)	111 (48.05)	0.023
Normal	96 (41.38)	120 (51.95)	
Fat mass, kg	10.66 (8.48, 14.86)	9.87 (8.07, 16.35)	0.455
Fat mass, percent	25.92 (21.46, 33.65)	23.55 (20.16, 35.15)	0.066
Fat free mass, kg	30.85 (27.65, 32.27)	32.14 (29.75, 33.56)	<0.001
Fat free mass, percent	74.08 (66.35, 78.54)	76.45 (64.85, 79.84)	0.066
Arm muscle area, cm^2	23.61(20.32, 26.71)	23.33 (20.54, 26.93)	0.700
Arm fat area, cm^2	9.38 (6.35, 12.40)	8.50 (5.72, 13.23)	0.104
Carbohydrate, gm	404.6 (377.1, 425.6)	377.7 (363.1, 406.3)	<0.001
Protein, gm	87.16 (53.47, 109.36)	87.34 (69.10, 144.93)	<0.001
Fat, gm	37.01 (27.69, 42.59)	38.82, 33.60, 41.02)	0.044
Energy, kcal	2321.3 (2118.5, 2337.1)	2327.0 (22.95.0, 2425.0)	0.002

Categorical variables are presented as number (%) and continuous variables are presented as median and interquartile range

Fisher exact test was performed to find significant level for categorical data and Mann-Whitney U test was performed to find significant level for continuous data between urban and rural girls.

Table 3: Spearman rank correlation between age at menarche and parameters of participants

Variable	Rural girls		Urban girls	
	Correlation coefficient	P-value	Correlation coefficient	P-value
Weight, kg	0.038	0.566	0.161	0.014
Body mass index, kg/m^2	0.005	0.937	0.136	0.039
Mid upper arm circumference, cm	-0.004	0.951	0.179	0.006
Triceps skinfold thickness, mm	-0.019	0.773	0.207	0.002
Supra-iliac skinfold thickness, mm	0.098	0.138	0.206	0.002
Carbohydrate, gm	0.033	0.619	0.197	0.003
Protein, gm	-0,022	0.738	0.066	0.318
Energy, kcal	0.011	0.868	0.228	0.001
Fat mass, kg	-0.026	0.699	0.211	0.001
Fat mass, percent	-0.045	0.491	0.216	0.001
Fat free mass, percent	0.045	0.493	-0.216	0.001
Arm fat area, cm^2	-0.007	0.917	0.208	0.001

Discussion

The overall mean age at menarche in the present study was 12.3 years. A community based cross-sectional study conducted in south India reported the average age of menarche was 12.33 years which represented similar value with that of the present study [25]. Apart from this study, several others study have been conducted in different parts of India and shown that the mean age of menarche in Andhra Pradesh, Maharashtra and West Bengal was 12.78 years, 12.6 years and 12.3 years respectively which were also similar to the present study. The results of the present study may be compared with other studies in abroad. In Brazil [35], it was found that the mean age of menarche was 11.7 years which was lower than that of the present study. Lee *et al*. [36] reported that the mean age of menarche in Korean girls was 12.7 years and in America, the mean age at menarche was 12.8 years in white girls and 12.2 years in black girls [37]. It may be noticed that the age of menarche of black girls was more or less same with the present study results, whereas it was higher among white American girls. Similarly, the mean age at menarche in present study was close to that found 12.6 years in Colombian girls [18]. The mean age at menarche found in the present study was higher than the age at menarche of Mexican girls (11.4 years) [38]. Most of the studies reported the mean age at menarche was more or less the same but in some of the cases in different countries it was found different which might be due to some factors like SES, ethnic, culture etc. factors [39-41].

In the present study the age at menarche was significantly higher in rural girls (12.7 years) compared to that of urban girls (12.2 years). In a study in Bangladesh it was reported that the mean age at menarche in rural area was 13.0 years which was higher than Indian rural girls [42]. Similar finding was reported by [40] in China. They found that median menarcheal age was higher in rural girls (13.2 years) compared to that of urban girls (12.8). Another study conducted in urban and rural area in Poland found that the mean age at menarche was 12.73 years and 13.4 years in urban and rural girls respectively which were higher from the results of present study [43]. A cross-sectional study conducted in rural and urban areas in Northern Nigeria [44] did not find difference of age at menarche between rural and urban school girls (15.3 years vs 15.2 years),whereas our study reported the difference of menarche age between urban and rural girls. The mean age at menarche was also higher in Nigerian girls compared to the present study. It is evidenced that SES influences living standards and nutritional intake in urban population compared to rural population and therefore delay menarcheal age in rural girls and early menarcheal age in urban girls was found [45 ,46].

The age of menarche was found to be affected by nutritional status [38, 47] and it is well known that under-nutrition delayed the menarcheal age [48]. Several studies suggested that higher intake of fat was associated with early menarche [49, 50]. The relationship between higher BMI and early menarcheal age was established by different investigators [51-55]. In the present study, weight, BMI, MUAC, skinfold thicknesses and intake of macronutrients such as carbohydrate and energy intake were positively associated which was in conformity with the previous finding. The fat percent was negatively associated with menarcheal age only in urban girls but not in rural girls in the present study, however, several studies reported opposite findings [49, 50]. In urban area, SES was high which was indirectly related to nutritional status and affected the menarcheal age. A study from South India [10] indicated the trend of age at menarche and SES scale is quite similar with that of the present study.

The weakness of the study was small sample size and cross sectional design. The adolescent growth spurt was not considered in the current study. Also we did not evaluate the effect of other important variables such as parents' education or mothers' menarcheal age, media effect etc. However, the study has also strengths such as the random selection of investigation areas and participants.

In conclusion, the findings of this study indicated that urban girls have had early menarcheal age compared to rural girls. Nutritional status was associated with the age at menarche only in urban area. Fat percent was a strong predictor of early age at menarche, however, in the present study fat percent was higher in rural girls compared to urban girls.

Conflict of interest: The authors declared no conflict of interest

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Contribution

AM and SS designated and implemented the study. AM collected data. SS analyzed the data. AM and SS drafted the manuscript. PD revised the manuscript. Finally, all authors have checked and approved it.

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