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RESEARCH

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Association between body composition and menarcheal status: a study among the institutionalized adolescent girls of South 24 Parganas, West Bengal, India

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Abstract

Background Menarche is a crucial stage among adolescent girls, and body composition differs significantly between pre-menarcheal and post-menarcheal females, with variations among different ethnic groups in India. The present study is an endeavor to assess the nutritional status of adolescent girls, compare the anthropometric and body composition measures between pre-menarcheal and post-menarcheal girls, and ascertain the impact of body composition on the attainment of menarche among the institutionalized adolescent girls of South 24 Parganas, West Bengal, India.

Method A total of 116 adolescent girls aged 11–16 years were purposively recruited from an institutional home named "Save the Children", located in Thakurpukur, South 24 Parganas, West Bengal, India. Data on age, menstrual status, and age at menarche were obtained via a self-administered pre-structured schedule. Anthropometric measurements were obtained following standard protocol, and indices were calculated accordingly. Kolmogorov-Smirnov test, T-test, Mann-Whitney test, Chi-square test, Principal Component Analysis (PCA), and binary logistic regression were performed using IBM SPSS version 26.

Results The median age at menarche was found to be 12.0 years. The majority of the variables related to overall, central adiposity, and bone mass significantly differ between the pre-menarcheal and post-menarcheal girls. The upper limb, upper trunk, and lower trunk subcutaneous fat deposition, total body fat, body mass, bone mass, and fat-free mass significantly influence the attainment of menarche.

Conclusion The present study has potential implications for understanding the involvement of regional adipose tissues in menarche, emphasizing the health of future mothers and the development of chronic illnesses in maturity.

Keywords Adolescent girls, Body composition, Body fat, Menarcheal status, Nutritional status, Principal Component Analysis (PCA).

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1 Background

Menarche is a crucial stage among adolescent girls that influences the reproductive health and well-being of women. The menstrual cycle is a physiological process characterized by periodic and cyclic shedding of pregestational endometrium, followed by blood loss and release of estrogens from the ovaries. It is a key indicator of women's reproductive health and is often connoted as a potential marker of puberty and entry into sexual relationships and reproduction [1–5]. For most females, it occurs between the ages of 9 and 16 years; however, it shows a remarkable range of variation in different populations as well as within the subgroups of the same populations [6–9]. The onset of maturation and age at menarche are influenced by several factors, such as ethnicity, genetics, height, weight, Body Mass Index (BMI), body fat accumulation, socioeconomic circumstances, nutritional status, environmental conditions, neuroendocrine disorders, psychological stress, and migration [8, 10–14]. Menarche is an important milestone in a woman's life and usually follows approximately 1 year after the growth spurt begins [15]. In many regions of the world, the age at menarche is earlier than it formerly was [16–18]. In most Western countries and the United States, the age at menarche is reducing over successive generations by about 2–3 months per decade [19]. Over the past 150 years, the average menarche age in Western European nations has decreased from 16 to under 14 years [20]. Studies from developed countries worldwide have shown a systematic decrease in the median age at menarche in the past 160 years [21]–[22]. Most Indian studies have also shown a similar trend of decreasing age at menarche [14, 23–26]. The definite reasons for the decrease in menarcheal age in developed and developing nations are still uncertain. However, this condition may be due to various factors like changes in dietary patterns, lifestyle, socioeconomic status, environmental change, stress, and excess intake of energy-rich food [27]–[28].

Body weight appears to have a link with the onset of menarche and sustaining a healthy menstrual cycle. It is believed that a minimum body fat of 17% is essential for menarche, while 22% body fat is necessary for sustaining regular menstruation [29]–[30]. Frisch and Revelle [31] proposed that accumulating an optimal quantity of body fat is necessary for sexual maturity, which is a crucial element in the onset of menstruation. Body mass index (BMI), being a traditional anthropometric index, cannot describe the distribution of adipose tissue; it is used as an indirect measure of body adiposity [32–34]. To evaluate adipose accumulation, additional anthropometric parameters are needed. Body circumference indicates regional obesity [35]. Percent body fat (PBF), fat mass (FM), fat-free mass (FFM), and fat mass index (FMI) are the extensively studied metrics of body composition [36–38]. Additionally, skinfold thickness measures regional subcutaneous adipose tissue distribution during adolescence based on maturity status [39]. Waist circumference (WC), Waist-hip ratio (WHR), and Waist-to-height ratio (WHtR) were revealed to be highly linked with abdominal or central fat distribution and are the best predictors of obesity-related disorders [35, 40–42]. Furthermore, the Body Adiposity Index (BAI) has frequently been utilized in epidemiological studies [43]–[44]. Body composition during puberty is a sign of the growth and maturation period, providing crucial information about current and future health [45]. Body composition differs significantly between pre-menarcheal and post-menarcheal females, with variations among different ethnic groups in India [32, 35, 46–49].

Adolescence is a crucial period in the human life cycle in which nutritional needs rise due to the adolescent growth surge [11]. Adolescents comprise 20% of India's population [50]. Adolescent girls, who make up over one-tenth of the Indian population, require special attention during their formative years as they undergo significant physical, psychological, and behavioral changes, and their current nutritional state will determine the well–being of present and future generations [51]–[52].

Very few studies have been done in India on the assessment of body composition among pre-menarcheal and post-menarcheal girls, but only a handful of studies are available from urban and semi-urban populations [32, 47, 53]–[54], and only a few have been published on rural, tribal, and underprivileged populations [12, 35, 49, 55]–[56]. Against this backdrop, the present study is an endeavor to assess the nutritional status of adolescent girls, compare the anthropometric, body composition measures, and relative fat distribution between pre-menarcheal and post-menarcheal girls, and ascertain the impact of body composition on the attainment of menarche among the institutionalized adolescent girls of South 24 Parganas, West Bengal, India.

2 Materials and methods

2.1 Study area and participants

The present study was conducted at an institutional home named "Save the Children", located in Thakurpukur, South 24 Parganas, West Bengal, India. This institutional home is a state-level Non-Governmental Organization (NGO) recognized by the Government of West Bengal, India. It operates as a residential facility providing good health care, protection, and education to the adolescent girls under the state's welfare framework. The cross-sectional data were collected from 116 adolescent girls aged between 11 and 16 years. The study participants were selected by a purposive sampling method based on the criteria: presently not in wedlock and aged between 10 and 19 years (following WHO criteria for being an adolescent). At the time of the interview, all participants had no prior medical or surgical history, physical deformity, or were suffering from any ailment. This study was conducted following the principles outlined in the Declaration of Helsinki. Before data collection, written consent was obtained from the home's administration. The purpose and nature of the study were explained to the participants clearly, and written and/or verbal consent was obtained from the participants. The participation was voluntary in nature. The study was approved by the Institutional Ethical Committee for Biomedical Research and Health Research, University of Calcutta (Ref. No. CUIEC/02/31/2022-23, Dated-05.01.2023.

2.2 Data types

2.2.1 Age, menstrual status, and age at menarche

Data on age, menstrual status, and age at menarche were obtained via a self-administered pre-structured schedule. The date of first menstruation (menarche) was acquired by inquiring about the exact date, or the nearest month of any events or festivals around the time of menarche.

2.2.2 Anthropometric measurements

All Anthropometric measurements were recorded using the standard procedure [57], with care taken to prevent potential systematic errors, including those related to instrumentation or landmark definition. Height was measured to the nearest 0.1 centimetre by using Martin's anthropometric rod. Weights were measured in minimum clothing and reported to the nearest 0.5 kg. Mid Upper-Arm Circumference (MUAC), waist circumference (WC), and hip circumference (HC) were measured in centimetres with a non-stretchable measuring tape and reported to the nearest 0.1 cm. Biceps (BSF), triceps (TSF), sub-scapular (SSF), supra-iliac (SISF), and abdominal (ABSF) skin folds were measured using a Harpenden skinfold caliper nearest to 0.1 mm. While measuring the anthropometric measurements, the participants were made to stand in a fully erect position on a levelled surface, barefoot, with heels together and toes apart, and with heads oriented in the FH plane.

2.2.3 Anthropometric indices and body composition measures for body fat distribution

1) Body mass index (BMI) was calculated in the standard way as:

$$BMI = \frac{Weight\,(kg)}{Height(m)^2}$$

According to the World Health Organisation [58] classification criteria, BMI was classified for age. Participants with a BMI < 5th percentile were considered underweight, participants with a BMI ranging from 5th – <85th percentile were considered normal, participants with a BMI ranging from 85th – <95th percentile were considered to be overweight, and participants with a BMI ≥ 95th percentile were considered obese.

2) Waist-hip ratio (WHR) was calculated from the formula [59]

$$WHR = \frac{Waist\,Circumference\,(cm)}{Hip\,Circumference\ (cm)}$$

Classification of nutritional status of females based on the Waist-hip ratio (WHR) followed the World Health Organisation classification [59]. Participants with a Waist-hip ratio < 0.80 were considered normal, and participants with a Waist-hip ratio ≥ 0.80 were considered to have central obesity.

3) Waist-to-Height (WhtR) ratio calculated from the formula [60]

$$WHtR = \frac{Waist\,Circumference\,(cm)}{Height\ (cm)}$$

4) The following equations were used to estimate Percent Body Fat (PBF) [61]

$$PBF = 1.33\,(TSF + SSF) - 0.013(TSF + SSF)^2 - 2.5$$

5) The following equations were utilized to assess the proportion of Fat mass (FM), Fat-free mass (FFM), Fat Mass Index (FMI), and Fat-free Mass Index (FFMI) [36]

$$FM\ (kg)\ = \left(\frac{PBF}{100}\right) \times\ weight\,(kg)$$

$$FFM\ (kg) = Weight\ (kg) - FM\,(kg)$$

$$FMI = \frac{FM\,(kg)}{Height\,(m)^2}$$

$$FFMI = \frac{FFM\,(kg)}{Height\,(m)^2}$$

6) Body Adiposity Index was calculated according to the following equation [44]

$$BAI = \frac{Hip\,Circumference\,(cm)}{Height\,(m)^{1.5}} - 18$$

7) Bone mass and body muscle percentage were recorded from the Rossmax Body Fat Monitor (WF 260) following the standard technique as per the instruction manual. The participants were made to stand erect and barefoot in light clothing. Each measurement was taken twice to ensure the reliability of the instrument.

2.3 Statistical analyses

The data were analysed in IBM-SPSS (version 26, Armonk, NY, USA). The Kolmogorov-Smirnov test was applied to examine the distribution of the continuous variables. Variables like height, weight, Body Mass Index (BMI), hip circumference, supra-iliac skinfold, bone mass, fat-free mass, fat-free Mass Index, Waist-hip ratio, Waist-to-height ratio, and body adiposity index followed a normal distribution. Variables like age at menarche, waist circumference and mid-upper arm circumference, bicep, tricep, subscapular and abdominal skinfolds, percent body fat, body muscle percentage, fat mass, and Fat Mass Index showed skewed distribution. One-way Analysis of variance (ANOVA) (for normally distributed variables) and the Kruskal-Wallis test (for skewed variables) were applied to compare anthropometric variables across age groups. T-test and Mann-Whitney U test were applied to compare anthropometric and body composition measures between menarcheal (pre-menarche and post-menarche) categories, respectively. For the t-test, the Levene test for equality of variances was used to determine the variances of the two groups within menarcheal categories. Weight, fat-free mass, and Fat-free Mass Index didn't indicate homogeneity of variance when comparing menarcheal categories. Hence, corresponding t-statistic values and p-values have been incorporated following the results of Levene's test. Fisher's exact test for the 2*2 contingency table and the Chi-square test were applied to understand the distribution of categorical variables. The significance level was set at $p \leq 0.05$. A two-tailed test of significance has been used for the analysis.

To identify the most significant variable influencing the attainment of menarche, Principal Component Analysis (PCA) was used. PCA transformed the correlated variables (overall and central adiposity variables and bone mass) into sets of linearly uncorrelated principal components (PCs), reducing the dimensionality of the data set while preserving as much variability as possible [62]. Varimax rotation was used on principal components to increase high- and low-value factor loadings while minimizing mid-value factor loadings [63]. PCs with Eigenvalues ≥ 1 were considered to be the most representative components as eigenvalues ≥ 1 indicate that more common variance than unique variance is explained by that factor [64]. Thus, PCs with eigenvalues < 1 were excluded from further analysis. The Rotated Component Matrix provides the factor loadings

Table 1 Distribution of the participants based on age and menarcheal stages

			Age of the participants (in years)						n & % of total
			11	12	13	14	15	16	
Menarcheal stages	Pre-menarche	n	23	21	10	1	2	0	57
		% within age	100	80.8	55.6	6.3	10.0	0	49.1
	Post- menarche	n	0	5	8	15	18	13	59
		% within age	0	19.2	44.4	93.8	90.0	100.0	50.9
Total		n	23	26	18	16	20	13	116
		% of total	19.8	22.4	15.5	13.8	17.2	11.2	100.0

Median age at menarche: 12.0 (11–13)

Figures in the parentheses are the interquartile range

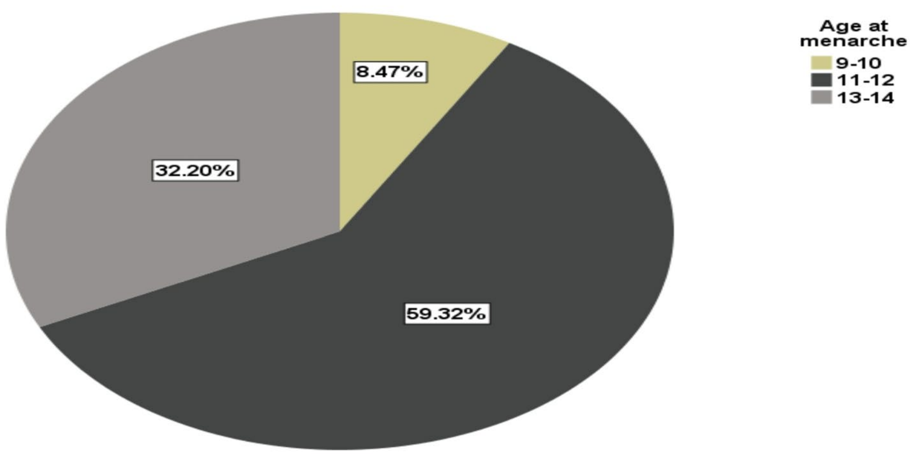

Fig. 1 Distribution of participants based on age at menarche

or component loadings (Pearson correlation coefficient depicting a linear correlation between each observed variable and its corresponding components), which identify the variables that are represented by the components [65]. The statistical software generated PC scores for each participant and significant component. These PC scores were employed in the binary logistic regression analysis (method: enter) as independent variables to ascertain the impact of central and overall obesity variables and bone mass on the attainment of menarche.

3 Results

3.1 Distribution of the participants based on age and menarcheal stages

49.1% of girls were in the pre-menarcheal stage, while 50.9% of girls had attained menarche (Table 1). All the adolescent girls aged 11 years were found to be in the pre-menarcheal stage, whereas all girls aged 16 were in the post-menarcheal stage. The median age at menarche was found to be 12.0 years. Figure 1 represents the distribution of participants based on age at menarche. The lowest and highest age of menarche was found to be 9 and 14 years in the present study. Most participants attained menarche in the age range of 11–12 years (59.3%).

3.2 Distribution of anthropometric and body composition measures stratified by age groups

All the anthropometric and body composition measures showed a significant rise ($p < 0.05$) with the participants' chronological age (Table 2). Body Muscle Percentage (BMP) showed an increasing trend in the 13–14 years age group but declined in the 15–16 years age group. In comparison to the preceding age group (11–12 years), the age group 13–14 years showed a decline in Waist-hip ratio (WHR); nevertheless, the age group 15–16 years again showed an increasing trend. In the 11–12 and 13–14 year age

Table 2 Distribution of anthropometric and body composition measures stratified by age groups

Variables	Age groups (in years)			Age combined	F value/ H value & *p*-value
	11–12 (*n* = 49)	13–14 (*n* = 34)	15–16 (*n* = 33)	11–16 (*n* = 116)	
Height (cm)[a]	138.58 ± 5.6	145.05 ± 6.4	146.99 ± 2.61	142.87 ± 6.4	F = 29.848, *p* = 0.000*
Weight (kg)[a]	31.30 ± 4.16	36.53 ± 5.52	42.34 ± 5.04	35.97 ± 6.63	F = 51.604, *p* = 0.000*
Body Mass Index (kg/m^2)[a]	16.28 ± 1.8	17.32 ± 1.92	19.6 ± 2.27	17.53 ± 2.4	F = 27.994, *p* = 0.000*
Mid-upper Arm Circumference (cm)[b]	18.8 (17.8–20.3)	19.95 (19.05–21.13)	21.7 (21.25–22.35)	20.1 (18.7–21.6)	H = 40.567, *p* = 0.000*
Hip Circumference (cm)[a]	71.8 ± 4.34	77.28 ± 5.76	79.78 ± 5.66	75.67 ± 6.19	F = 25.756, *p* = 0.000*
Waist Circumference (cm)[b]	58.8 (56.3–61.35)	59.95 (57.15–64.13)	66.4 (61.1–71.7)	59.85 (57.2–64.58)	H = 23.981, *p* = 0.000*
Biceps skinfold (mm)[b]	5.7 (4.7–7.2)	6.55 (5.48–8.35)	8.7 (7–10.7.7)	6.55 (5.1–8.85)	H = 22.790, *p* = 0.000*
Triceps skinfold (mm)[b]	9.2 (7.45–11.25)	9.45 (7.83–11.43)	12.2 (9.5–13.85)	9.8 (7.9–12.2)	H = 14.405, *p* = 0.001*
Sub-scapular skinfold (mm)[b]	8.7 (7.45–11.1)	9.4 (8.03–11.68)	12.1 (10.5–13.6)	9.85 (8.1–12.18)	H = 20.554, *p* = 0.000*
Supra-iliac skinfold (mm)[a]	9.46 ± 2.87	10.51 ± 2.66	12.48 ± 3.0	10.63 ± 3.09	F = 11.131, *p* = 0.000*
Abdominal skinfold (mm)[b]	10.3 (8.1–13.1)	10.6 (9.7–12.9)	14.2 (11.75–15.6)	11.3 (9.7–14.75)	H = 17.79, *p* = 0.000*
Percent body fat (%)[b]	16.88 (14.52–19.85)	18.12 (15.7–21.12)	22.28 (18.61–23.81)	18.82 (15.57–21.83)	H = 19.688, *p* = 0.000*
Body muscle percentage (%)[b]	43.4 (41.65–46.15)	44.2 (42–45.95)	43.9 (40.8–45.5)	43.95 (41.53–45.8)	H = 0.546, *p* = 0.761
Bone mass(kg)[a]	2.99 ± 0.39	3.35 ± 0.5	3.36 ± 0.34	3.2 ± 0.46	F = 10.648, *p* = 0.000*
Fat mass (kg)[b]	5.6 (4.0–6.59)	6.45 (5.35–8.3)	8.99 (7.51–10.75)	6.49 (5.18–8.68)	H = 39.900, *p* = 0.000*
Fat-free mass (kg)[a]	25.73 ± 2.81	29.54 ± 3.56	33.20 ± 3.24	28.97 ± 4.42	F = 55.713, *p* = 0.000*
Fat Mass Index[b]	2.72 (2.16–3.4)	3.15 (2.49–3.62)	4.25 (3.44–4.93)	3.26 (2.51–3.98)	H = 29.334, *p* = 0.000*
Fat-free Mass Index[a]	13.4 ± 1.23	14.02 ± 1.22	15.36 ± 1.4	14.14 ± 1.51	F = 23.579, *p* = 0.000*
Waist-hip ratio[a]	0.82 ± 0.04	0.79 ± 0.04	0.82 ± 0.05	0.81 ± 0.05	F = 4.435, *p* = 0.014*
Waist-to-height ratio[a]	0.42 ± 0.03	0.42 ± 0.03	0.45 ± 0.04	0.43 ± 0.04	F = 5.074, *p* = 0.008*
Body Adiposity Index[a]	26.07 ± 2.77	26.27 ± 2.76	26.77 ± 3.13	26.32 ± 2.87	F = 0.600, *p* = 0.551

[a] Values represent mean and standard deviation

[b] Values represent median and interquartile range

*Significant at 0.05 level of probability

Table 3 Distribution of nutritional status and prevalence of central obesity among the participants

Indicator	Category	Pre-menarche n = 57		Post-menarche n = 59		Median age at menarche (years)	χ^2 square/Fisher exact test, df, and p-value
		No.	%	No.	%		
Body Mass Index (BMI) (kg/m^2)	Underweight	11	19.3	9	15.3	12 (11–12.5)	χ^2=0.332, df = 1, p = 0.564
	Healthy weight	46	80.7	50	84.7	12 (11–13)	
Waist-hip ratio (WHR)	Normal	21	36.8	20	33.9	12 (11–12.75)	χ^2=0.110, df = 1, p = 0.740
	Central obesity	36	63.2	39	66.1	12 (11–13)	

Figures in the parentheses are the interquartile range

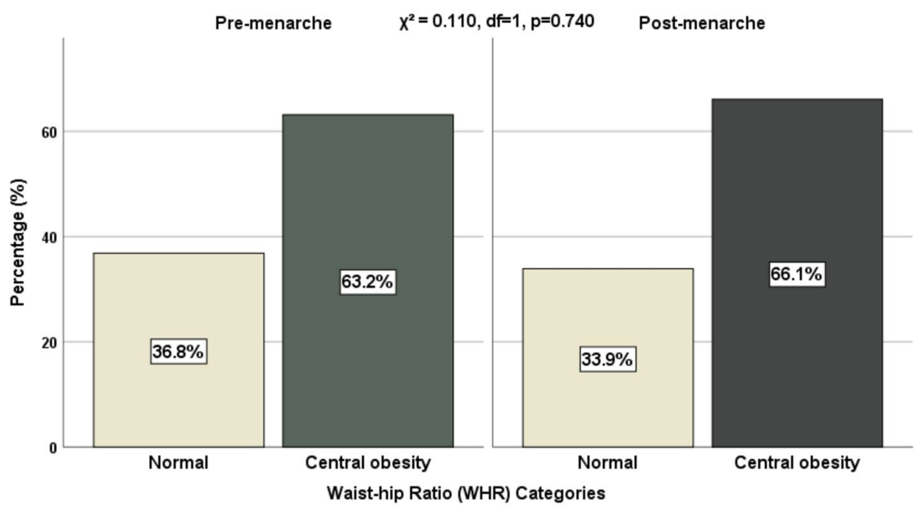

Fig. 2 Prevalence of central obesity among the studied participants

groups, Waist-to-height ratio (WHtR) remained unchanged; however, in the 15–16 year age group, it was found to increase. BAI also showed minimal variation across all the age groups. A statistically significant age-specific difference was observed for all the anthropometric and body composition measures except Body Muscle Percentage (BMP) and Body Adiposity Index (BAI) ($p > 0.05$).

3.3 Distribution of nutritional status and prevalence of central obesity among the participants across menarcheal stages

Most of the pre-menarcheal (80.7%) and post-menarcheal (84.7%) girls were in the healthy weight category as detected by Body Mass Index (BMI) (Table 3). On the other hand, 19.3% of pre-menarcheal girls and 15.3% of post-menarcheal girls were found to be underweight (Fig. 2). The waist-hip ratio (WHR) detected the prevalence of central obesity in 63.2% of pre-menarcheal girls and 66.1% of post-menarcheal girls (Fig. 3). The association between the nutritional status and prevalence of central obesity across menarcheal stages was found to be non-significant ($p > 0.05$). The median age at menarche was found to be similar among the underweight and healthy participants (according to BMI categorization) and normal and centrally obese participants (as per WHR classification).

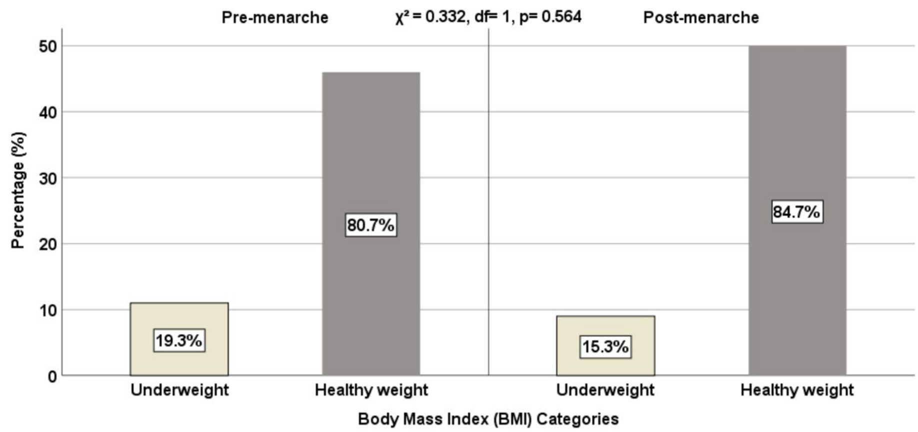

Fig. 3 The distribution of nutritional status across the menarcheal stages of the studied participants

3.4 Distribution of pre-menarcheal and post-menarcheal participants based on overall adiposity, central adiposity variables, and bone mass

Except for Body Muscle Percentage (BMP), Waist-hip-ratio (WHR), and Body Adiposity Index (BAI), all the variables related to overall and central adiposity and bone mass significantly differ ($p < 0.05$) between the pre-menarcheal and post-menarcheal adolescent girls (Table 4). Thus, adiposity was found to be higher in post-menarcheal girls than in pre-menarcheal girls.

3.5 Principal Component Analysis

Four Principal Components (PC) were selected based on eigenvalues > 1. The four PCs cumulatively explained 82.023% of the total variance (Table 5). The first Principal Component (PC1) accounted for the majority of the variance i.e., 59.358% of the total variance, and was determined to be the most desirable principal component since it explained more variance than the other PCs, retaining the most information about the variation in the variables. PC2, PC3, and PC4 accounted for 8.637%, 8.081%, and 5.948% of the total variance, respectively. According to Hair et al. [66], loadings ≥ ± 0.40 are considered more relevant, while loadings ≥ ± 0.50 are practically significant. Loadings shown in bold for rotated components indicated the highest correlation between variables and their corresponding PCs. The higher loadings indicated they were more effective in forming the PC scores. Positive loading values implied a positive correlation, whereas negative loading values implied a negative correlation. The variables that provided higher practically significant loadings for PC1 were biceps, triceps, sub-scapular, supra-iliac, abdominal skinfold, percent body fat, fat mass, and Fat Mass Index (FMI). For PC2, highly loaded variables were weight, Body Mass Index (BMI), mid-upper arm circumference, hip circumference, waist circumference, fat-free mass, Fat-free Mass Index (FFMI), and bone mass. For PC3, highly loaded variables were waist-hip ratio (WHR) and waist-to-height ratio (WHtR). For PC 4, only the body muscle percentage and Body Adiposity Index (BAI) depicted a high loading value. A negative correlation was observed between Body Muscle Percentage (BMP) and PC4.

3.5.1 Binary logistic regression analysis (Classification table of cases)

Binary logistic regression was used to ascertain the impact of central and overall adiposity variables, as well as bone mass, on the attainment of menarche. The model

Table 4 Distribution of pre-menarcheal and post-menarcheal participants based on overall adiposity, central adiposity variables, and bone mass

Variables	Menarcheal status		t value/Mann-Whitney U value & *p*-value
	Pre-menarche (*n* = 57)	Post-menarche (*n* = 59)	
Overall adiposity			
Weight (cm)[a]	32.17 ± 5.19	39.64 ± 5.78	t = − 7.320, *p* = 0.000*
Mid-upper arm circumference (cm)[b]	19.1 (18.15–20.6)	21.2 (19.7–21.8)	U = 862.000, *p* = 0.000*
Body Mass Index (kg/m^2)[a]	16.46 ± 1.97	18.56 ± 2.33	t = − 5.214, *p* = 0.000*
Biceps skinfold (mm)[b]	5.8 (5.1–7.55)	7.8 (5.6–9.9)	U = 1053.000, *p* = 0.001*
Triceps skinfold (mm)[b]	9.2 (7.65–11.25)	11.2 (8.3–12.9)	U = 1198.500, *p* = 0.008*
Sub-scapular skinfold(mm)[b]	8.8 (7.55–11.15)	11.2 (9.1–13.1)	t = 1080.500, *p* = 0.001*
Supra-iliac skinfold (mm)[a]	9.71 ± 2.82	11.52 ± 3.11	t = − 3.281, *p* = 0.001*
Abdominal skinfold (mm)[b]	10.4 (8.25–13.15)	12.5 (9.9–15.2)	U = 1150.000, *p* = 0.003*
Percent body fat (%)[b]	17.4 (14.76–20.4)	20.09 (16.35–23.49)	U = 1116.500, *p* = 0.002*
Body muscle percentage (%)[b]	44 (41.65–46.65)	43.9 (41.1–45.8)	U = 1642.000, *p* = 0.827
Fat mass (kg)[b]	5.67 (4.27–6.79)	7.75 (6–10.2)	U = 798.000, *p* = 0.000*
Fat-free mass (kg)[a]	26.34 ± 3.58	31.51 ± 3.62	t = − 7.722, *p* = 0.000*
Fat Mass Index[b]	2.77 (2.32–3.45)	3.55 (2.9–4.76)	U = 950.000, *p* = 0.000*
Fat-free Mass Index[a]	13.5 ± 1.33	14.76 ± 1.41	t = − 4.948, *p* = 0.000*
Body Adiposity Index[a]	26.30 ± 2.73	26.35 ± 3.01	t = − 0.102, *p* = 0.919
Central adiposity			
Hip circumference (cm)[a]	73.0 ± 5.41	72.5 ± 5.83	t = − 5.023, *p* = 0.000*
Waist circumference (cm)[b]	58.4 (56.2–60.7)	62.7 (59.4–68.4)	U = 842.500, *p* = 0.000*
Waist-hip ratio[a]	0.81 ± 0.05	0.82 ± 0.05	t = − 0.737, *p* = 0.462
Waist-to-height ratio[a]	0.42 ± 0.03	0.44 ± 0.04	t = − 2.075, *p* = 0.040*
Bone mass			
Bone mass (kg)[a]	3.01 ± 0.43	3.38 ± 0.41	t = − 4.670, *p* = 0.000*

[a] Values represent mean and standard deviation

[b] Values represent median and interquartile range

*Significant at 0.05 level of probability

incorporated regression factor scores of each participant derived from 4 Principal Components (PCs) as dependent variables. The Omnibus test for model coefficients was significant (χ^2= 49.678, df = 4, $p = 0.000$), indicating a significant improvement in fit compared to the null (baseline) model. The Hosmer and Lemeshow test was not significant (χ^2=6.090, df = 8, $p = 0.637$), which meant the independent variables accurately predicted the actual probabilities, indicating a good-fitting model. The model accounted for 34.8% (Cox and Snell R square) to 46.5% (Nagelkerke R square) of the total variance in menarcheal status, and the correct prediction rate was 81.0% of cases overall, reflecting a high discriminatory power and accuracy rate (Table 6).

3.5.2 Binary logistic regression analysis (Results)

Table 7 shows the results of binary logistic regression. PC 1 and PC 2 made a statistically significant contribution to the model ($p < 0.05$). PC 2 was found to be the most predictive variable (OR: 5.100), followed by PC 1 (OR: 1.900). PC 1 represents skinfold measurements (biceps, triceps, sub-scapular, supra-iliac, abdominal), body fat (percent body fat, fat mass, and Fat Mass Index). PC 2 represents body mass, body circumference, fat-free mass, and bone mass (weight, Body Mass Index, mid-upper arm circumference, fat-free mass, Fat-free Mass Index, waist circumference, hip circumference, and bone mass). Participants who had experienced menarche were more likely to have significantly higher skinfold measurements, body fat, body mass, circumferential measurements, fat-free

Table 5 Results of the principal component analyses (PCA)

	PC1	PC2	PC3	PC4
Eigenvalues	11.872	1.727	1.616	1.190
Individual variance (%)	59.358	8.637	8.081	5.948
Cumulative variance (%)	59.358	67.994	76.075	82.023
Component or factor loadings (after rotation)				
Weight (cm)	0.507	**0.837**	0.100	0.083
Body Mass Index (BMI) (kg/m$^{2)}$	0.495	**0.714**	0.298	0.217
Mid–upper arm circumference (MUAC) (cm)	0.583	**0.584**	0.123	0.365
Biceps skinfold (BSF) (mm)	**0.709**	0.279	0.185	0.065
Triceps skinfold (TSF) (mm)	**0.901**	0.179	0.114	0.066
Sub-scapular skinfolds (SSF) (mm)	**0.887**	0.246	0.044	0.189
Supra-iliac skinfold (SISF) (mm)	**0.694**	0.339	0.249	0.201
Abdominal skinfold (ABSF) (mm)	**0.729**	0.268	0.209	0.159
Percent body fat (PBF) (%)	**0.945**	0.230	0.090	0.129
Body muscle percentage (BMP) (%)	−0.104	−0.052	0.239	**−0.565**
Fat mass (FM) (kg)	**0.800**	0.553	0.119	0.112
Fat-free mass (FFM) (kg)	0.293	**0.932**	0.081	0.059
Fat Mass Index (FMI)	**0.826**	0.459	0.194	0.166
Fat-free Mass Index (FFMI)	0.181	**0.799**	0.331	0.223
Body Adiposity Index (BAI)	0.163	0.131	0.332	**0.842**
Hip circumference (HC) (cm)	0.370	**0.634**	0.031	0.527
Waist circumference (WC) (cm)	0.444	**0.530**	0.529	0.316
Waist-hip-ratio (WHR)	0.219	−0.012	**0.858**	−0.225
Waist-to-height ratio (WHtR)	0.355	0.268	**0.754**	0.446
Bone mass (kg)	0.248	**0.637**	−0.284	−0.061

Significant loadings are shown in bold

Table 6 Classification table of cases based on binary logistic regression analysis

Classification table				
Observed		**Predicted**		
		Menarcheal Category of the Participants		**Percentage Correct**
		Pre-menarche	**Post-menarche**	
Menarcheal category of the participants	Pre-menarche	45	12	78.9
	Post-menarche	10	49	83.1
Overall percentage				81.0
The cut value is 0.500				

Table 7 Results of the binary logistic regression analysis using principal component scores as independent variables

Principal Component (PC) Scores	Beta Regression Weight	Std. Error	Wald	df	Sig	Odds Ratio (95% Confidence Interval)
PC 1	0.642	0.255	6.326	1	0.012	1.900 (1.152–3.132)
PC 2	1.629	0.308	26.934	1	0.000	5.100 (2.787–9.332)
PC 3	0.052	0.244	0.046	1	0.830	1.054 (0.653–1.700)
PC 4	−0.340	0.244	1.937	1	0.164	0.712 (0.441–1.149)
Constant	0.075	0.239	0.100	1	0.752	1.078

Dependent variable: Menarcheal Status; Independent variable: Four Principal Components (PCs) scores mass, and bone mass. Thus, the attainment of menarche is significantly influenced by the upper limb, upper trunk, and lower trunk subcutaneous fat deposition, total body fat (both subcutaneous and visceral fat), body mass, bone mass, and fat-free mass (non-fat body tissue).

4 Discussion

India's population has a varied range of lifestyles and cultural practices. Several research studies are being conducted on growth studies and nutritional status. It was observed that adolescent growth and development are affected due to disparities in nutrition, social position, and other factors [67]. Menarche is the most commonly remembered milestone of puberty for most women during adolescence [68]. Therefore, the present study aims to evaluate the nutritional status of adolescent girls, compare the anthropometric and body composition parameters between pre-menarcheal and post-menarcheal girls, and investigate the impact of body composition on the attainment of menarche among the institutionalized adolescent girls of South 24 Parganas, West Bengal, India.

The median age at menarche of the present adolescent girls was found to be 12 (11–13) years, which is in close agreement with other studies conducted in the Indian context [28, 32, 48]– [49, 67, 69–74]. The adolescent girls of the present study have an earlier menarcheal age than other Indian ethnic groups (Table 8) except for rural girls of Paschim Medinipur [12], Santal girls [35], and Bengali-speaking urban girls [70]. This can be due to genetics, improved nutrition, food habits, socio-economic status, and excess intake of energy-rich food, which can accelerate puberty. This combination of factors may explain the observed secular trends in the population. Menarcheal ages of adolescent girls in different parts of India are presented in Table 8.

In the present study, all the girls of 11 years of age were still in the pre-menarcheal stage, whereas all the girls of 16 years had already attained menarche. Similarly, cent percent of Assamese girls aged 10–11 years and Bengali girls of age 10 years were in the pre-menarcheal stage, and cent percent of girls belonging to age groups 14, 15, and 16 years of both ethnic groups were reported to be in the post-menarcheal stage [83]. Dambhare et al. [90] reported that the majority of the girls in the age range 10–14 years had not attained menarche, which is in contrast with the present study.

Studies across India reported age at menarche ranging from 10 to 19 years, indicating late attainment of menarche [13, 52, 76, 80–82, 88, 90, 97, 98, 100, 101]. In the present study, the age at menarche of the participants ranged from 9 to 14 years, which is in accordance with John et al. [25], Radha and Chellapan [71], and Bachloo et al. [73]. These studies depict an earlier age of attainment of menarche. The earlier age of attainment of menarche reflected in the present study can be attributed to genetics, improved socio-economic status, increased access to health care, and excess intake of energy-rich food among the present study participants. In other words, as the nutritional state improves, the age at menarche is lowered. It was observed that 96.6% of the adolescent girls in the present study experienced menarche between 9 and 13 years, and all girls experienced menarche by the age of 14 years. None of the girls in the present study had primary amenorrhea. This corroborates with findings of the other studies [87, 96, 102].

Among the girls in the present study, all the anthropometric variables significantly increased with age. This finding is corroborated by the study of De [49] and Das et al.

Table 8 Menarcheal age of adolescent girls in different parts of India

Sl. No	Area of study	Population	Age range (in years)	Mean/Median age at Menarche (in years)	Reference[a]
1.	Central Delhi	Urban slum girls	–	13.5	Garg et al. [75]
2.	Madhyamgram, North 24 Parganas	Bengalee Hindu girls	11–14	12.0	Bhadra et al. [32]
3.	Nellore, Andhra Pradesh	College-going girls	18–22	13.83	Reddy and Radhika [76]
4.	Ambajogai	School-going girls	10–19	Urban: 12.99 Rural: 13.38	Deo and Ghattarji [77]
5.	Galudih, Jharkhand	Santal Girls	12–19	11.47	Chatterjee et al. [35]
6.	Ajmer district, Rajasthan	Rural-urban school-going girls	13–19	Rural: 13.3 Urban: 13.1	Khanna et al. [1]
7.	Jammu and Kashmir	Rural school-going girls	9–15	Brahmin: 13.85 Rajput: 13.86	Sharma et al. [7]
8.	New Delhi	Urban girls	10–19	14.42	Acharya et al. [78]
9.	Ghazipur, East Delhi	Rural girls	10–19	13.6	Nair et al. [79]
10.	Singur Block, West Bengal	School-going girls	14–17	12.8	Dasgupta and Sarkar [80]
11.	Pune city, Maharashtra	Maharashtrian school-going girls	9–15	12.62	Rokade and Mane [81]
12.	Meerut, Uttar Pradesh	Urban girls	10–19	13.16	Jain et al. [82]
13.	Guwahati, Assam	School-going girls	10–16	Assamese: 12.45 Bengali: 12.25	Deb [83]
14.	North Kolkata, West Bengal	Bengalee college students	18–23	12.04	Ghosh et al. [69]
15.	Haldwani, Uttarakhand	Students	17–26	Plain area: 13.18 Hilly region: 14.21	Prakash et al. [84]
16.	West Bengal	Bengali-speaking Hindu girls	10–19	Rural: 12.10 Urban: 11.42	Ray et al. [70]
17.	Saoner, Nagpur district	School–going girls	12–17	12.85	Thakre et al. [85]
18.	East Khasi Hill, Meghalaya	Adolescent girls	–	13.22	Deb [86]
19.	Lucknow	Urban and Rural school-going girls	10–19	12.43	Khatoon et al. [87]
20.	Purulia district, West Bengal	Bengalee speaking low-caste Hindu girls	6.01–14.63	12.60	Dutta Banik [55]
21.	Lucknow	School-going girls	10–19	Rural:13.19 Urban:12.67	Sachan et al. [88]
22.	Barnala and Mansa districts, Punjab	–	11–16	13.25	Goyal et al. [89]
23.	Dharwad and Bijarpur districts, Karnataka	Kanjarbhat and Lamani girls	11–18	Kanjarbhat: 13.0516 Lamani: 13.129	Mane et al. [8]
24.	Wardha town	Students from the peri-urban area	10–19	15.45	Dambhare et al. [90]
25.	Siliguri City, West Bengal	Slum girls	10–19	12.6	Bhattacharjee et al. [91]
26.	Western Maharashtra	Urban slum girls	–	12.8	Mohite et al. [52]
27.	Varanasi	School-going children	13–18	12.98	Verma et al. [92]
28.	Madhyamgram, West Bengal	School-going Bengali girls	11–14	12	Bhadra et al. [48]
29.	Udupi Taluk, Karnataka	School-going girls	13–16	Rural: 12.31 Urban: 12.39	Kamath et al. [93]
30.	South 24 Parganas, West Bengal	School-going girls	13–18	Rural:12.31 Urban:12.18	Paria et al. [95]
31.	Ludhiana, Punjab	School-going girls	–	12.38	John et al. [25]

Table 8 (continued)

Sl. No	Area of study	Population	Age range (in years)	Mean/Median age at Menarche (in years)	Reference[a]
32.	Dehradun district, Uttarakhand	School-going girls	11–17	12.74	Sharma et al. [95]
33.	Nashik	Slum girls	10–19	13.7	Khopkar et al. [96]
34.	Thiruvananthapuram, Kerala	School-going girls	9–16	12.1	Radha and Chellapan [71]
35.	Hooghly, West Bengal	School-going Bengali girls	10–16	12.2	Pramanik et al. [72]
36.	Ambala district, Haryana	Rural and urban school-going girls	13–19	12.21	Bachloo et al. [73]
37.	Maharashtra	Rural girls	15–19	14.02	Kanotra et al. [97]
38.	Salboni block, Paschim Medinipur	Rural girls	10–19	11.88	De [12]
39.	Kerala	–	18–25	12.34	Gopalakrishna et al. [28]
40.	Salboni block, Paschim Medinipur	Rural girls	10–19	12	De [49]
41.	Punjab	School-going Baniya girls	11–14	12.3	Goyal et al. [67]
42.	Ranga Reddy district, Andhra Pradesh	Village girls	14–16	12.6	Meda and Kamalaja [13]
43.	Gangtok, Sikkim	School-going girls	10–19	13.64	Pandey and Pradhan [14]
44.	Karnataka	Urban girl students	10–19	13	Omidvar et al. [9]
45.	Duttabad, North 24 Parganas	Peri-urban slum girls	16–18	12.52	Samanta et al. [98]
46.	Belagavi City, Karnataka	School-going girls	12–16	12.4	Belavaneki and Kour [99]
47.	Paschim Medinipur district, West Bengal	Bengali school-going girls	9–16	Rural: 12.7 Urban: 12.2	Mallick et al. [74]
48.	Puruliya district, West Bengal	Sabar girls	10–18	12.87	Mahata et al. [56]
49.	Thakurpukur, South 24 Parganas, West Bengal	Institutionalized adolescent girls	11–16	Median: 12.00	Present study

[a]The authors were listed chronologically (from earliest to latest) as per year of publication

[103], where anthropometric measurements progressively increased with age and showed statistically significant variation across ages.

The majority of the adolescent girls in Kerala (54%) [71] and Maharashtra (84.4%) [90] were underweight with a BMI below 18.5 [90], and mostly thin in Punjab [89]. However, the majority of the adolescent girls in Karnataka (69.4%) had a normal BMI [28]. The majority of the participants of the present study were healthy in both the pre-menarcheal (80.7%) and post-menarcheal (84.7%) groups. The present study was carried out at an institutionalized home, where improved access to healthcare facilities, healthy lifestyles, and a sustained diet resulted in good health. Dambhare et al. [90] reported that the mean BMI of those girls who had attained menarche was higher (17.15 kg/m^2) compared to those who had not attained menarche (14.83 kg/m^2). The overall prevalence of underweight was 51.1% for pre-menarcheal adolescent girls and 18.1% for post-menarcheal girls studying in government schools of Hooghly and Bankura districts, West Bengal [11] indicating that the prevalence of undernutrition was greater among pre-menarcheal girls. This is in congruence with the present study, where a higher percentage of pre-menarcheal girls (19.3%) were found to be underweight than their post-menarcheal counterparts (15.3%). Thus, the prevalence of undernutrition is considerably lower among post-menarcheal females.

The association between nutritional and menarcheal status was not significant ($p > 0.05$), which was in contrast with the findings of Dambhare et al. [90] and Gupta et al. [104], but was in support of the findings of Belavaneki and Kour [99]. The median age at menarche was similar in underweight and overweight girls, which is contrary to the findings of Pramanik et al. [11], Radha and Chellappan [71], Khatoon et al. [87], and Goyal et al. [89]. In cases of better nutrition and more weight (obese), the mean age at menarche is earlier as compared to cases of undernutrition and less weight, indicating a significant association between an increase in BMI and a decrease or lowering of the age at menarche [71, 87, 89, 105]. However, John et al. [25] showed that females with a higher BMI experienced delayed menarche. Thus, the findings of the present study might indicate a better health condition than the other studies, but the possibility of sample bias cannot be ruled out in the present study.

The majority of participants had a high prevalence of central obesity according to the Waist-hip ratio (WHR) classification ($p > 0.05$), which detected central obesity among 31.0% of pre-menarcheal girls and 33.6% among post-menarcheal girls. The median age at menarche was found to be similar between normal and centrally obese participants. One of the most effective markers of problems associated with obesity is the Waist-hip ratio (WHR) [40, 42]. The present study was the first of its kind to examine the prevalence of central obesity across menarcheal status. Lifestyle and behavioral changes during adolescence could have contributed to these outcomes. To prevent health-related issues and long-term metabolic complications, morbidity, and mortality associated with central obesity in later life, early detection and management, consistent monitoring, additional screening, and sufficient preventative actions must be executed.

The importance of body composition for the commencement and maintenance of the normal cycle of menstruation is widely established worldwide [45]. In the present study, all anthropometric and body composition variables assessing overall and central fat distribution differed significantly between pre- and post-menarcheal groups, except for body muscle percentage (BMP), Waist-hip Ratio (WHR), and Body Adiposity Index (BAI). Adiposity was found to be higher in post-menarcheal girls than in pre-menarcheal girls. This finding was supported by Chatterjee et al. [35], De [12, 49], Sil [54], Dutta Banik [55], Mahata et al. [56], Gupta et al. [104], and Raje [106], who found that post-menarcheal girls exhibited higher anthropometric measures associated with adiposity than pre-menarcheal girls. Similarly, Bhadra et al. [32] found that, except for waist-hip ratio (WHR), all other variables assessing regional adiposity and central fat distribution were greater in post-menarcheal girls than their pre-menarcheal counterparts, validating the present study's findings. The present study also found that post-menarcheal females had greater skinfold measurements compared to pre-menarcheal girls ($p < 0.05$). Bhadra et al. [32, 47]–[48] and Mahata et al. [56] found that post-menarcheal girls have larger subcutaneous fat deposition on their upper trunks than pre-menarcheal girls.

Principal component analysis and binary logistic regression analysis revealed that the attainment of menarche is significantly influenced by the upper limb, upper trunk, and lower trunk subcutaneous fat deposition, total body fat (both subcutaneous and visceral fat), body mass, bone mass, and fat-free mass (non-fat body tissue). This finding corroborated the findings of Mahata et al. [56], where menarcheal status was significantly influenced by the Percent body fat (PBF) of the body composition parameters. In the present study, participants who had experienced menarche were more likely to have significantly higher skinfold measurements, body fat, body mass, circumferential measurements, fat-free mass, and bone mass. Menarche is associated with hormonal and metabolic changes, notably those involving sex hormones, which bring about a significant increase in adiposity and result in changes in body composition. Sex hormones in females appear to operate synergistically to encourage the storage of extra calories as fat, i.e., estrogen increases fat deposition in peripheral adipose tissue depots [35, 54, 107].

During puberty, total body fat and lean body mass both rise along with bone mineral content [45]. Fat-free mass and Fat-free Mass Index, an indicator of the nutritional and health status of the population, were found to be a significant predictor of the attainment of menarche as per the results of multivariate analysis, and were significantly higher among the post-menarcheal girls. This was in accordance with the findings of Mahata et al. [56]. Fat-free mass refers to the quantity of non-body fat tissue, including muscle, bones, and organs, and is composed of water, protein, minerals, and carbohydrates [108]–[109]. The present study also revealed that, in addition to body fat and body mass-related variables, bone mass was significantly higher among the post-menarcheal girls than the pre-menarcheal ones. Multivariate analysis also concluded that bone mass was a significant predictor of menarcheal status. The findings of the present study revealed the necessity for micronutrients for the attainment of menarche; further inquiry is required in future research. Accumulating an optimal quantity of body fat is necessary for sexual maturity, which is a crucial element in the onset of menstruation [31]. Additionally, menarche could be linked to fat distribution rather than total fat [110]. Since the difference in body muscle percentage (BMP) between girls of differential menstrual status was found to be non-significant and even though it displayed higher factor loadings in PC4 in Principal Component Analysis (PCA), binary logistic regression revealed PC4 was not a significant predictor of menarcheal status, the role of skeletal muscle in the onset of menstruation must be further explored.

The present study introduces a novel and methodologically rigorous approach, combining Principal Component Analysis (PCA) with binary logistic regression to identify the most significant variable influencing the attainment of menarche. The present study utilized Principal Component Analysis (PCA) to transform the 20 sets of correlated predictor variables (overall and central adiposity variables and bone mass) into sets of linearly uncorrelated principal components (PCs), reducing the dimensionality of the data set while preserving as much variability as possible. This dimension reduction technique yielded statistically robust and independent predictors. The uniqueness of the present study lies in using these four Principal Component scores, which represent distinct biological axes, as independent variables in the binary logistic models. This approach not only created a more stable model but also offers a multidimensional framework for identifying the most significant anthropometric and body composition variables influencing the attainment of menarche than is available in the literature. Findings of the present study also provide a powerful explanation that it is not the individual accumulation of one type of body fat, but rather the overall systemic pattern of body size and adiposity that significantly influences the attainment of menarche. The present study provides a refined understanding of how individual anthropometric indicators are associated with a unified developmental trajectory during adolescence. By examining these metrics within an integrated biological framework, the study elucidates the complex interplay between growth patterns and maturational timing. Moreover, it systematically evaluates the nutritional status of adolescents across different menarcheal categories, offering insights into how variations in nutritional well-being may correspond with stages of pubertal maturation. In doing so, the study contributes valuable evidence to the growing body of literature on determinants of menarcheal age and its broader implications for the health and development of adolescent girls.

4.1 Limitations

The findings of this study should be interpreted in light of several potential limitations. Since the study was restricted to adolescent girls from an institutional home, the generalizability of the findings is limited. Hence, the sample was highly selective, which is not representative of the general population. The results should be interpreted with caution and viewed as specific, indicative of the adolescent girls of an institutional home. Another potential limitation of the present study is the smaller sample size. To mitigate the risks associated with a smaller sample size, such as model instability, biased coefficients, over-fitting, and reduced power, specific statistical measures were undertaken to ensure the reliability of the findings. Principal Component Analysis (PCA) was employed to reduce the variables into several uncorrelated Principal Component Scores. By using the resulting principal component scores as predictors in the Binary Logistic Regression, the number of estimated parameters was reduced, thereby enhancing the stability and validity of the model without systematic error despite the sample size constraints. While this study provides valuable insights, it is limited by the absence of data on dietary habits, caloric intake, and specific physiological biomarkers. Furthermore, the analysis did not account for socioeconomic status or underlying health conditions, both of which are critical determinants of nutritional outcomes. The inclusion of these multifaceted variables, alongside the anthropometric measures used here, would have provided a more robust and comprehensive understanding of the nutritional status of adolescent girls in this population.

5 Conclusion and future implications

The present study adds to the existing data on the menarcheal age of adolescent girls as well as addresses the nutritional status across menarcheal categories. The impact of body composition on the attainment of menarche was another area of attention in the present study. Thus, the present study has potential implications for understanding the involvement of regional adipose tissues in menarche. Future research should investigate the association between differential fat distribution patterns throughout adolescence, emphasizing the health of future mothers and the development of chronic illnesses in maturity. The immense ethnic heterogeneity of India is a feature of its size. Studies should be conducted among adolescent girls from different ethnic groups of India with larger sample sizes, including other potential factors that influence menarcheal age and health status, which will not only expand the findings of the present study but will also provide a more detailed assessment of the reproductive health and nutritional status of the adolescent girls, who certainly will be the mothers of the next generation. Such studies will also provide significant information on the relative contribution of genetic and environmental interaction in the process of attainment of menarche as well as increment of adiposity at menarche and data can be further generalized to the Indian statistics which will further aid in the development of nutritional intervention strategies that will target the susceptible adolescent females and provide them with a healthy life.

Abbreviations

SD Standard deviation

IBM-SPSS International Business Machines-Statistical Package for the Social Sciences

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Author contributions

Samiparna Deori (SD) – Study design, data collection, and writing- original draft; Nairrita Bhattacharjee (NB) – Data analysis, data interpretation, and writing- original draft; Priyanka Kanrar (PK) – Study design and methodology; Baidyanath Pal (BP) – Data analysis and data interpretation; Monali Goswami (MG) – Conceptualization, methodology, supervision, and writing-review editing . All authors have approved the final version for publication.

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Data availability

The dataset used and/or analysed during the present study is available from the corresponding author on reasonable request. The authors would prefer not to share the data for public access due to ethical issues.

Declarations

Ethics approval consent to participate

This study was conducted following the principles outlined in the Declaration of Helsinki. The study was approved by the Institutional Ethical Committee for Biomedical Research and Health Research, University of Calcutta (Ref. No. CUIEC/02/31/2022-23, Dated-05.01.2023. Before data collection, written consent was obtained from the home's administration. The purpose and nature of the study were explained to the participants clearly, and written and/or verbal consent was obtained from the participants. The participation was voluntary in nature.

Consent for publication

Not Applicable.

Competing interests

The authors declare no competing interests.

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