

## **Anthropometric characteristics and menarche among the Muslim children in Howrah, West Bengal, India**

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### **ABSTRACT**

**Background:** Menarche, the onset of reproductive ability, typically occurs approximately one year after the initiation of the adolescent growth spurt. The age at menarche (AAM) serves as an important clinical indicator of a girl's physical maturation, nutritional status, and reproductive health. AAM is associated with various anthropometric measures, such as weight, height, arm circumference, and body mass index (BMI). **Objectives:** This study aimed to determine the differences in anthropometric characteristics between the pre-menarcheal and post-menarcheal, as well as the earlier and later menarcheal Muslim Bengalee girls. **Materials and methods:** This community-based cross-sectional study included 103 Muslim Bengalee girls aged 11 to 13 years from the Howrah district of West Bengal, India. Anthropometric measurements were obtained using standardized procedures. Descriptive statistics were calculated for all anthropometric variables. Differences between pre- and post-menarcheal girls were assessed using independent sample t-tests. Pearson's correlation was used to assess associations. Differences in mean values of these measures between earlier and later menarcheal girls were conducted using independent samples t-tests and analysis of covariance (ANCOVA). **Results and conclusion:** Among the participants, 49 were pre-menarcheal, and 54 were post-menarcheal. The mean AAM was 11.72 (0.8) years. The post-menarcheal girls were heavier, taller, and had higher adiposity than their pre-menarcheal peers. AAM was negatively associated with weight, BMI, waist circumference (WC), and hip circumference (HC). Furthermore, earlier menarcheal girls showed significantly higher mean weight, BMI, MUAC, WC, and HC compared to their later menarcheal peers. Further longitudinal studies are required to better understand the relationship between anthropometric characteristics and AAM among this population.

**KEYWORDS:** Menarche, Anthropometry, Children, Muslim, Bengalee, India

## **INTRODUCTION**

Puberty represents the transition from childhood- to adult- body dimensions and sexual maturation. It is a complex process characterized by accelerated growth, weight gain, and the emergence of secondary sexual characteristics (Parent et al., 2003). The primary markers for the timing of female puberty are thelarche and menarche (Parent et al., 2003). Menarche refers to the onset of reproductive ability (Karapanou & Papadimitriou, 2010), typically occurring approximately a year after the initiation of the adolescent growth spurt (Hada et al., 2014).

Secular trends in several low- and middle-income countries have shown decreases in AAM over the past few decades (Canelón & Boland, 2020; Ibitoye et al., 2017). Accordingly, most Indian studies reported a decreasing trend in menarcheal age (Bagga & Kulkarni, 2000; Sengupta et al., 1996). The AAM among the Indian women declined at an average rate of approximately six months per decade as compared to three to four months, observed in some countries of Europe and North America. However, a study by Pathak et al. (2014) using Indian Human Development Survey (IHDS) data suggested a reduction in AAM of nearly one month per decade. An early AAM bears significant clinical concern, as it was found to be associated with various negative health outcomes, including increased cardiovascular risk (Feng et al., 2008), breast cancer (de Waard & Trichopoulos, 1988), depression (Kaltiala-Heino et al., 2003), and anxiety (Blumenthal et al., 2009). AAM is widely regarded as a key indicator for measuring the quality of life in a population (Mishra et al., 2010). Information on the AAM is essential for health policymakers to provide health services and menstrual health education to school-going girls (Afkhazadeh et al., 2018). Research on the AAM among the Muslim population in India remains limited (Asghar et al., 2014; Meher & Sahoo, 2024; Pathak et al., 2014; Tarannum et al., 2017). Furthermore, investigating the physical growth of children is vital for understanding the nature and extent of human biological variation, as these physiological processes are essential for overall well-being (Goyal et al., 2016).

AAM was found to be associated with various anthropometric measures, such as weight, height, arm circumference, and BMI (Delgado & Hurtado, 1990; Karapanou & Papadimitriou, 2010). Anthropometric and body composition characteristics were explored in relation with early and late menarcheal females in plentiful of studies globally, although

limited in India, particularly, in respect of AAM (Bala et al., 2025). On the other hand, studies revealed contrasting evidences on the relationship between AAM and body height. A shorter adult height was observed in women experiencing menarche earlier, compared to those with later AAM (for the detailed references, see: Bala et al., 2025). For example, in European samples, earlier menarche was associated with a shorter final adult height (Onland-Moret et al. 2005). There were, however, several other studies those had shown that the early maturing females were taller and heavier in during puberty than those who matured later (Kim et al. 2010; Biro et al. 2001). It was proposed that such disparity in the association between height and AAM might be a result of diverse socio-demographic characteristic, such as small scale or industrial societies, etc (Mcintyre and Kacerosky 2011). Therefore, the currently available evidence warrants further exploration of the relationship between the anthropometric profile and menarche among diverse populations.

Similar studies, as described above, were conducted in the eastern part of India, to a limited extent, among the Hindu Bengalee populations (Bhadra et al., 2013; Bala et al., 2025). However, no comprehensive study is visible to explore the differences in anthropometric characteristics between pre- and post-menarcheal girls, as well as earlier and later menarcheal girls, among the Muslim Bengalee population of Howrah district, West Bengal. Therefore, the present study aimed to determine (i) the differences in anthropometric characteristics between the pre-menarcheal and post-menarcheal, as well as, the earlier and later menarcheal Muslim Bengalee girls with a narrow age range (11-13 years) in Howrah district of the state of West Bengal, India.

## **MATERIALS AND METHODS**

### **Study area and participants**

This community-based cross-sectional study was conducted among adolescent Muslim Bengalee girls residing in Bankra (census town), situated within the Howrah district of West Bengal, India. The primary study site was a higher secondary school within the Bankra II Gram Panchayat. Data collection was carried out during school hours in December 2024. A total of 103 girls, with a very narrow age range of 11 to 13 years, were recruited from the fifth, sixth, and seventh standards. Date of birth of each participant was recorded from the

school registers. Among them, the selection of this specific age range was designed to assess the immediate effect of menarche on anthropometric parameters in the study population. The study was approved by the Institutional Ethical Committee of Sidho-Kanho-Birsha University, Purulia, West Bengal (No: R/IEC/1580/SKBU/24). Before data collection, written consent was obtained from the school's headmistress. The purpose and nature of the study were clearly explained to the participants and verbal consent was obtained from each of them before measurements. Girls with no prior medical or surgical history, physical deformity, or any current illness, were recruited for the study.

### **Anthropometric measurements**

All anthropometric measurements were recorded by a single investigator (SK) following the standardized procedures (Lohman et al., 1988). Participants were measured wearing minimal clothing to ensure accuracy. Body weight was recorded to the nearest 0.1 kg using a calibrated digital weighing scale, while body height, sitting-height and height-acromion were measured to the nearest 0.1 cm using anthropometer. Tibial length and biacromial diameter were determined using a rod-compass. Head length and head breadth were measured using a Martin's spreading calliper. Leg length was subsequently derived by subtracting the sitting height from the body height. Mid-upper arm circumference (MUAC), WC, and HC were measured in centimetre to the nearest 0.1 cm using a non-stretchable measuring tape. Skinfold (SF) thicknesses were recorded at four sites: biceps, triceps, sub-scapular, and supra-iliac, on the left side of the body using a Lange skinfold calliper (nearest 1 mm). The mean value of the average of those four skinfolds was calculated to estimate overall subcutaneous adiposity for using in statistical analyses. BMI was calculated using the standard formula: body weight in kilograms divided by the squared height in meters ( $\text{kg}/\text{m}^2$ ).

### **Menarcheal age**

To find out whether the girls were menarcheal or not, they were simply asked if they had begun menstruating or not, and if yes, when did they do so. When exact dates were unavailable, only the month and year of menarche were recorded and middle of that month was assigned as the time of menarche (Zuraweicka & Wronka, 2022); if only the year was recalled, July the first was used (Freedman et al., 2002). The participants were first

categorized by menarcheal status into pre-menarcheal and post-menarcheal girls. The post-menarcheal girls were further subdivided into earlier menarcheal (AAM < 12 years) and later menarcheal (AAM ≥12 years) girls, following Lee's (2021) classification.

### **Statistical analysis**

Descriptive statistics (mean ± SD) were derived for all anthropometric measures. Differences in mean values of the measures between pre-and post-menarcheal girls were assessed using independent sample t-test. Pearson's correlation coefficient was calculated to investigate associations between AAM and anthropometric measures. Significance of differences in mean values of this measures between earlier and later menarcheal girls were assessed employing independent samples t tests and analyses of covariance (ANCOVA). A p<0.05 was considered statistically significant. All the statistical analyses were performed in IBM SPSS 26.0 version software.

## **RESULTS**

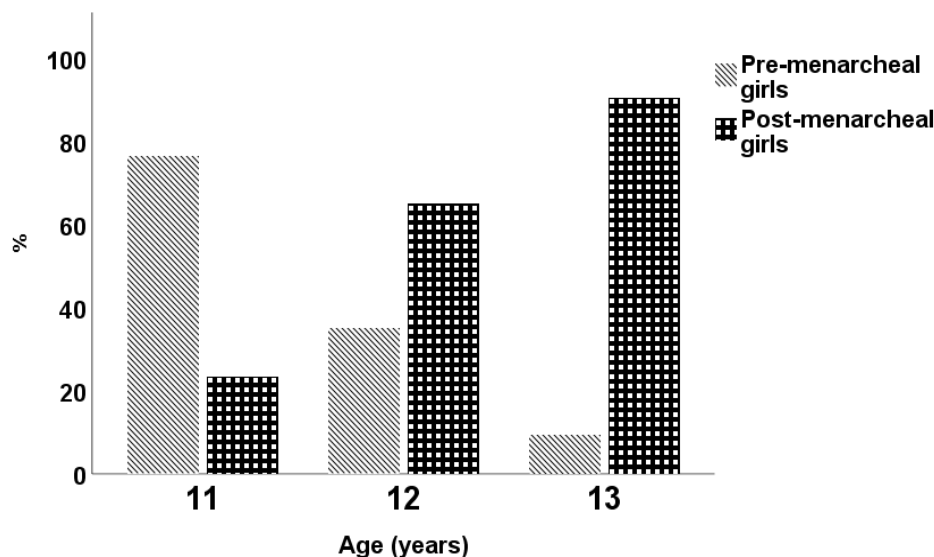
### **Sample characteristics and menarcheal status**

The mean (SD) age of the participants was 12.27 (0.9) years, with ages ranging from 11.01 to 13.98 years. The mean AAM for the post-menarcheal girls was 11.72 (0.8) years. Out of the 103 girls, 49 were pre-menarcheal, and 54 were post-menarcheal. The distribution of age by menarcheal status is summarized in Table 1 and illustrated in Figure 1. At the age of 11, the majority of participants (n = 39) were pre-menarcheal. At age 12, 7 were pre-menarcheal, and 13 were post-menarcheal. By age 13, 3 girls remained pre-menarcheal, while 29 experienced menarche.

**TABLE 1 | Age distribution and menarcheal status of the study population**

<b>Age in years (range)</b>	<b>Total participants</b>	<b>Pre-menarcheal</b>	<b>Post-menarcheal</b>
11 (11.00 – 11.99)	51	39	12
12 (12.01 – 12.99)	20	7	13
13 (13.01 – 13.99)	32	3	29
<b>All age</b>	<b>103</b>	<b>49</b>	<b>54</b>

**FIGURE 1 | Percentage distribution of pre- and post-menarcheal girls within each age**



### **Anthropometric comparisons between pre- and post-menarcheal girls**

Descriptive statistics and comparative analyses of anthropometric measurements between pre- and post-menarcheal girls are summarized in Table 2. The mean age differed significantly between the two groups ( $t = 7.073$ ,  $p < 0.001$ ), with post-menarcheal girls being older.

Results from independent sample t-tests revealed that post-menarcheal girls exhibited significantly greater linear segments, including body height ( $t = 4.401$ ,  $p < 0.001$ ), height acromion ( $t = 4.085$ ,  $p < 0.001$ ), sitting height ( $t = 6.013$ ,  $p < 0.001$ ), and tibial length ( $t = 2.391$ ,  $p < 0.05$ ). Biacromial diameter was also significantly wider in the post-menarcheal girls ( $t = 3.765$ ,  $p < 0.001$ ). However, no significant differences were observed for leg length, head length, and head breadth. As regards other dimensions, the post-menarcheal girls demonstrated significantly higher mean values for body weight ( $t = 4.966$ ,  $p < 0.001$ ), BMI ( $t = 3.948$ ,  $p < 0.001$ ), mid-upper arm circumference (MUAC) ( $t = 4.349$ ,  $p < 0.001$ ), and the average of four skinfolds ( $t = 4.473$ ,  $p < 0.001$ ). Furthermore, WC ( $t = 2.767$ ,  $p < 0.01$ ) and hip circumference ( $t = 4.788$ ,  $p < 0.001$ ) were significantly larger in the post-menarcheal group.

**TABLE 2 | Descriptive statistics of age and anthropometric measures of pre- and post-menarcheal girls.**

Variable	All participants (N = 103)	Pre-menarcheal (N = 49)	Post-menarcheal (N = 54)	t
	Mean (SD)	Mean (SD)	Mean (SD)	
Age (years)	12.27(0.9)	11.69(0.6)	12.80(0.8)	7.073***
Weight (kg)	36.38(9.1)	32.13(6.8)	40.23(9.3)	4.966***
MUAC (cm)	20.75(3.1)	19.46(2.7)	21.92(2.9)	4.349***
Biacromial diameter (cm)	31.16(2.4)	30.27(2.4)	31.96(2.0)	3.765***
Head length (cm)	16.43(0.6)	16.31(0.6)	16.54(0.5)	1.849
Head breadth (cm)	13.15(0.6)	13.04(0.7)	13.25(0.5)	1.680
Height (cm)	142.41(6.7)	139.51(7.7)	145.05(4.4)	4.401***
Height acromion (cm)	115.94(6.3)	113.39(6.9)	118.25(4.8)	4.085***
Sitting height (cm)	74.80(4.1)	72.59(4.4)	76.81(2.5)	6.013***
Leg length (cm)	67.60(3.9)	66.92(4.1)	68.23(3.6)	1.711
Tibial length (cm)	33.19(2.0)	32.69(2.4)	33.65(1.5)	2.391*
BMI (cm)	17.79(3.6)	16.41(2.7)	19.40(3.9)	3.948***
Avg. of 4SF (mm)	12.89 (4.4)	11.04(3.5)	14.57(4.4)	4.473***
WC (cm)	64.42(8.0)	62.19 (7.1)	66.43(8.2)	2.767**
HC (cm)	77.48(8.4)	73.66(7.1)	80.94(8.1)	4.788***

\*\*\*p<0.001, \*\*p<0.01, \*p<0.05

**Correlation between AAM and anthropometric measures**

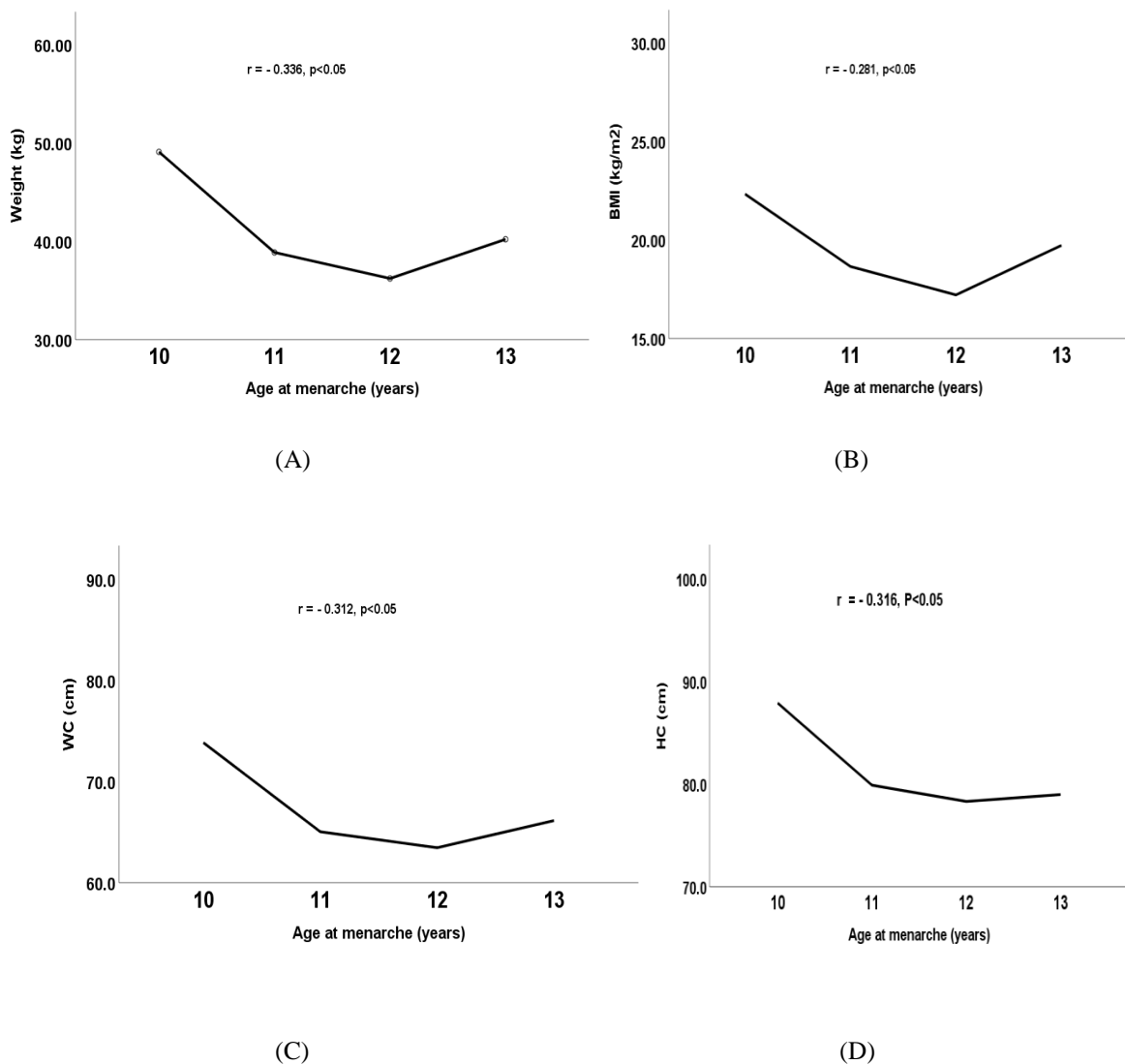
The relationships between AAM and anthropometric measures were evaluated using Pearson’s correlation coefficient (r), as summarized in Table 3. Significant inverse correlations were observed between AAM and body weight (r = -0.336, p<0.05), BMI (r = -0.281, p<0.05), waist (r = -0.312, p<0.05), and hip circumference (r = -0.316, p<0.05) (Figure 2). In contrast, total height, height acromion, sitting height, leg length, tibial length, head length, head breadth, biacromial diameter, MUAC, and average of four skinfolds did not show statistically significant correlations with AAM (p > 0.05).

**TABLE 3 | Pearson’s correlation coefficient (r) between AAM and anthropometric measures**

Variable	r	Variable	r
Weight (kg)	-0.336*	Sitting height (cm)	-0.211
MUAC (cm)	-0.193	Leg length (cm)	-0.134
Biacromial diameter (cm)	-0.134	Tibial length (cm)	-0.060
Head length (cm)	-0.122	BMI (cm)	-0.281*
Head breadth (cm)	0.055	Avg. of 4SF (mm)	-0.206
Height (cm)	-0.229	WC (cm)	-0.312*
Height acromion (cm)	-0.265	HC (cm)	-0.316*

\*p<0.05

**Figure 2 | Mean line plots illustrating the correlation between AAM and weight (A), BMI (B), waist, (C) and hip circumference (D) among post-menarcheal girls**



### Comparison between earlier and later menarcheal girls

The mean AAM for the earlier menarcheal girls was 11.17 (0.5) years and 12.54 (0.4) years for the later menarcheal girls. The independent sample t-tests showed that the earlier menarcheal girls had significantly higher mean values for body weight ( $t=2.321$ ,  $p<0.05$ ), BMI ( $t=2.170$ ,  $p<0.05$ ), and hip circumference ( $t=2.157$ ,  $p<0.05$ ) compared to the later menarcheal girls. No significant differences were found in any other anthropometric measures ( $p>0.05$ ).

The two groups differed significantly in chronological age ( $t=3.033$ ,  $p<0.01$ ), and an ANCOVA was performed to control for age as a covariate (Table 3). After adjusting for age, significant differences were maintained for body weight ( $F=9.724$ ,  $p<0.01$ ), BMI ( $F=8.317$ ,  $p<0.01$ ), and hip circumference ( $F=9.428$ ,  $p<0.01$ ). Notably, differences in WC, ( $F=4.711$ ,  $p<0.05$ ) and MUAC ( $F=4.611$ ,  $p<0.05$ ) reached statistical significance only after adjusting for age, whereas they were non-significant in the independent sample t-tests (Table 3).

**TABLE 3 | Results of independent sample *t*-test between AAM groups (earlier vs. later) and ANCOVA (with age as covariate) for anthropometric measures as dependent variables, AAM category (earlier vs. later) as the main factor and age as covariate.**

	<b>Earlier menarcheal girls (AAM &lt; 12 years) N = 32</b>	<b>Later menarcheal girls (AAM ≥ 12 years) N = 22</b>		
	Mean (SD)	Mean (SD)	t	F
Age (years)	12.53(0.9)	13.20(0.6)	3.033**	-
Weight	42.37(10.6)	37.11(5.8)	2.321*	9.724**
MUAC	22.24(3.4)	21.45(2.1)	1.033	4.611*
Biacromial diameter	32.08(2.1)	31.80(2.0)	0.489	0.324
Head length	16.57(0.4)	16.49(0.7)	0.517	0.765
Head breadth	13.21(0.6)	13.31(0.5)	0.615	0.081
Height	145.42(5.0)	144.51(3.3)	0.736	2.231
Height acromion	118.82(5.7)	117.43(3.1)	1.032	3.769
Sitting height	77.06(2.7)	76.45(2.1)	0.867	1.417
Leg length	68.35(4.2)	68.05(2.4)	0.329	0.932
Tibial length	33.62(1.6)	33.70(1.4)	0.174	0.025
BMI	19.91(4.4)	17.78(2.7)	2.170*	8.317**
Avg. of 4SF	14.83(5.1)	14.21(3.2)	0.542	3.102
WC	68.06(9.5)	64.06(5.3)	1.962	4.711*
HC	82.64(9.6)	78.45(4.3)	2.157*	9.428**

\*\*\* $p<0.001$ , \*\* $p<0.01$ , \* $p<0.05$

## **DISCUSSION**

Menarche serves as a vital clinical indicator of the onset of reproductive capacity. The AAM showed a secular trend of decrease in several low- and middle-income countries (Canelón & Boland, 2020; Ibitoye et al., 2017). The mean AAM in the present study was 11.72 (0.8) years, which was lower than values previously reported for other Muslim populations, such as 12.52 (1.4) years in Uttar Pradesh (Tarannum et al., 2017) and 12.86 years in Manipur (Asghar et al., 2014). Furthermore, the mean AAM in the current study was consistently lower than values reported from other districts of West Bengal, including the means of 12.87 years in Purulia (Mahata et al., 2022), 12.3 years in Paschim Medinipur (Mallick et al., 2022), and 12 years in the South 24 Parganas district (Deori et al., 2026).

In the present study, the post-menarcheal status was associated with higher mean values across nearly all anthropometric measures, and thus, a bigger body size, in general, compared to their pre-menarcheal peers. They were significantly taller, heavier and exhibited higher BMI, greater WC, and higher subcutaneous fat deposition compared to the pre-menarcheal girls. These findings aligned with two independent previous studies among the Bengalee Hindu girls in the neighbouring district of North 24 Parganas (Bala et al., 2025; Bhadra et al., 2005), the adolescent girls from the Sabar tribal population in Purulia (Mahata et al., 2022), as well as, from the general population in the South 24 Parganas (Deori et al., 2026) districts of West Bengal. It was proposed in earlier studies that a "critical weight" or a specific percent of body fat must be achieved to trigger the onset of menarche (Frisch & Revelle, 1970; Onland-Moret et al., 2005). The critical weight might have been gained at an earlier age due to the changed dietary habits in children following modernisation (Onland-Moret et al., 2005). Leg length is widely recognized as a reliable biomarker of living conditions during early childhood (Wadsworth et al., 2002). In the present study, however, neither leg length nor tibial length exhibited significant differences between pre-menarcheal and post-menarcheal girls. This result stands in contrast to the findings of Bala et al. (2025).

In particular, the results of the present study revealed a significant inverse association between body weight and the AAM, even after allowing for the effects of all the other measures, including BMI, earlier menarcheal girls had higher body weight compared to the later menarcheal girls. While these findings are consistent with a subset of literature (Karim et al., 2021; Kim et al., 2010), they contrast with studies that found no significant correlation

between weight and menarcheal onset (Demerath et al., 2004; García Cuartero et al., 2010). The present study showed a negative correlation of BMI with the AAM, thereby indicating that, perhaps, girls with higher BMI attained menarche earlier as compared to girls with lower BMI. Similar findings were reported in previous studies (Karim et al., 2021; Wang et al., 2024). Earlier studies suggested that a specific level of body fat was required for puberty to begin, which explained why the lean girls experienced menarche later than heavier ones. Another factor involved in the early beginning of menarche in cases of higher end of body weight, including overweight or obesity, could be a role of leptin in the early activation of the hypothalamic-pituitary-gonadal (HPG) axis, leading to sexual maturity (Karapanou & Papadimitriou, 2010).

In the present study, more than 59.3% of the participants attained menarche at an 'early' age of less than 12 years (Lee, 2021). Our results showed that earlier menarcheal girls were heavier and had higher mean BMI, MUAC, WC, and HC compared to their later menarcheal peers. Several studies reported similar findings (Bharati & Bharati, 1998; De, 2016). Kim et al. (2010) reported that earlier menarcheal Korean girls became taller and heavier in early adolescence than their later menarcheal counterparts (Kim et al., 2010). Labayen et al. (2009) reported that earlier menarcheal girls in Spain also showed higher BMI and WC than their later menarcheal peers (Labayen et al., 2009). WC and HC are anthropometric predictors of visceral adipose tissue and associated with the risk of metabolic and cardiovascular diseases (Biro et al., 2001; Freedman et al., 2002).

This study had several limitations. The sample size was small, and the study design was cross-sectional. However, the age range of the participants was rather narrow (3 years), and thus they were nearly an age matched sample. This might have minimised the effect of differential tempo of growth and increased the generalisability of the results across the ages. However, further longitudinal studies are urgently required to better understand the relationship between anthropometric characteristics and AAM in this population.

## **CONCLUSION**

The mean AAM in the present participants of Muslim Bengalee girls was 11.72 (0.8) years, which is considerably earlier than findings reported by previous studies conducted in West Bengal. This study demonstrates that anthropometric characteristics differ significantly

between pre- and post-menarcheal girls, with post-menarcheal girls exhibiting heavier, taller and had higher adiposity than pre-menarcheal girls. Furthermore, a significant negative correlation was observed between the AAM and body weight, BMI, WC, and HC. These results indicate that early-maturing girls are characterized by higher body weight and increased adiposity at a younger age.

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