Research Article

Physical Determinants of Early Menarche: Study of Age at Menarche and Anthropometric Measures in Bengali Girls

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Abstract: Menarche is a milestone in a woman's life denoting the start of reproductive capacity. The age at menarche has been getting earlier all over the world with varying rate. The abnormally in menarcheal time is associated with higher risk of poor health. The aim of this study was to find out the present age at menarche among Bengali Indian girls and to correlate with physical variables. This study was performed from April 2013 to December 2014 at five girls' high schools which approved the survey. The inclusion criterion was adolescent girls aged between 10 to 16 years who underwent menarche not more than 1 year prior to the survey. Status quo method was applied for estimation of age at menarche. Subjects were categorized into three groups according to their menarcheal age: early menarcheal age group ($<$ mean menarcheal age - SD), mid or ideal menarcheal age group (between mean menarcheal age $\pm$ SD) and late menarcheal age ($>$ mean menarcheal age + SD). Every girl was subjected to anthropometric assessment including weight, height, mid upper arm circumference (MUAC), waist circumference and hip circumference. Body mass index (BMI), body fat percentage (BF%), waist-height ratio, waist-hip ratio and hip-height ratio were calculated. Median age at menarche was 12.2 years. 21% girls were early matured. Age at menarche was inversely correlated with weight, BMI, MUAC, waist circumference, hip circumference, body fat percentage (BF%), waist-height ratio, waist-hip ratio and hip-height ratio and positively correlated with height. Girls with high class BMI, waist circumference, waist-height ratio, hip circumference, hip-height ratio, body fat percentage and MUAC are prevalent to attained early menarche. It is important to control the occurrence of obesity, particularly central obesity through monitoring the change of waist circumference, hip circumference, body fat percentage, BMI and MUAC.
Keywords: Menarche, BMI, MUAC, BF%, Waist circumference, Hip circumference.

INTRODUCTION

Menarche is an essential event of sexual maturation. It is the major indicator of female maturity. The menarcheal age is known to be affected by various parameters such as body fat accumulation, nutrition, socio-economic status, environmental conditions, genetic cause and neuro-endocrine disorders [1, 2]. The average age of menarche in Western European countries appears to have declined over the past 150 years over 16 to under 14 years [3]. In the United States, the normal age range of menarche is 9.1 to 17.7 years with a median of 12.8 years [4, 5]. The menarche age has been reported downward tendency worldwide, with a reduction of 2-3 month per decade in Western countries and the United States [6] and this has been termed secular trend in the declining age of menarche. This secular trend was also noted in developing country like India [7].

Age at menarche is an important indicator for certain diseases. Early age at menarche has been reported to be associated with several health complications including higher risk of obesity [8], cardiovascular disease [9], breast cancer [10], ischemic heart disease 11], type-2 diabetes and uterine fibroid [12]. On the other hand delayed menarche has been indicated as a high risk factor for irregular menstrual cycle, low peak bone mass [13] and osteoporosis [14]. Early menarche has also been found to be related to depression, anxiety symptoms, premature intercourse and violent behavior [15]. Early menarcheal age causes precocious shutdown of the plates. Girls undergoing early menarche have a shorter final adult height when compared to late menarche group [16]. Thus anomalies in pubertal timing (early or delayed pubertal development) could be associated with higher risk of poor health.

Age at menarche is strongly correlated with body size parameters, such as weight or BMI and height [14]. Frisch and Revelle proposed a critical body weight and weight gain for the onset of menarche [17]. Current evidence does not support critical weight hypothesis [7]. Higher subcutaneous fat levels and BMI at

prepubertal ages are reported to be associated with early menarche [18]. Ellison had related menarcheal age to height rather than weight [19]. A positive correlation had been reported between menarche and height [7]. It has been observed that the mean Mid-Upper Arm Circumference (MUAC), triceps skin fold thickness, hip circumference and waist circumference were higher among menstruating girls when compared to non-menstruating girls [20].

Early pubertal development is of particular medical interest in terms of care, management and prevention implications [21]. The present study attempts to find out the variation of age at menarche among the Bengali Indian girls and its relationship with anthropometric index. The study further attempts to investigate physical determinants of early age at menarche.

MATERIALS AND METHODS
Subject
This study was performed from April 2013 to December 2014 at five girls' high schools. The prior written permission of school authority was taken. Written consent from the parents of the students experimented in the study was obtained. The inclusion criterion was adolescent girls aged between 10 to 16 years undergone menarche not more than 1 year prior to the survey. Subjects were categorized into three groups according to their menarcheal age: early menarcheal age group (younger than one standard deviation of the mean menarcheal age), mid or ideal menarcheal age group (between standard deviation of mean menarcheal age) and late menarcheal age (older than standard deviation of mean menarcheal age [22, 23].

Assessment of menarcheal age
Status quo method was applied. In this method, data regarding menarcheal age can be obtained by asking a girl (or her parents) of her 'current status' i.e. her first menses by the time of assessment and her date of birth [14].

Anthropometric measurements
Body weight was measured using bathroom scale accurate to 0.5 kg. It was kept on a flat surface and adjusted with '0' mark. After that the subject was requested to step on it in bare feet. Weights were taken in light cloth and recorded to the nearest 0.5kg [24].

Height was measured using anthropometric rod. It was recorded in bare feet and expressed to the nearest 0.1cm [24].

MUAC was measured in centimeter with non-stretched measuring tape with right arm hanging relaxed. The measurement was taken in the midway between the tip of acromian and olecranon process. The tape was placed gently but firmly around the arm avoiding compression of soft tissues [25].

Waist circumference was measured at a point midway between the lower border of the ribs and the highest point of iliac crest using a non-stretchable flexible tape in horizontal position at the end of normal expiration, with the subject standing erect and looking straight forward.

Hip circumference was measured over light clothing at the widest point over the buttocks when viewed from the side. Measurement was recorded to the nearest 0.1 cm

Estimation of body mass index (BMI)
BMI was calculated from the height and weight using the equation: BMI (kg / m^2) = weight (kg) / height^2 (m) [24]. Weight status was determined using BMI.

Estimation of body fat percentage (BF %)
BMI strongly correlate with BF% estimated by bioelectrical impedance. This relationship was curvilinear in nature and was significantly influenced by age and gender. Thus age and gender should be considered when BMI was used to predict body fat percentage [26]. Body fat percentage was calculated on the basis of BMI on consideration of age and gender using Deurenberg equation [27].

Body fat% = (1.51 x BMI) + (0.70 x age in year) – (3.6 x gender) – 1.4

Where male = 1; female = 0

Estimation of waist- hip ratio
Waist hip ratio was obtained by dividing the waist circumference by hip circumference.

Estimation of waist height ratio
Waist height ratio was obtained by dividing the waist circumference by height.

Estimation of hip height ratio
Hip height ratio was obtained by dividing the hip circumference by height.

Statistical analysis
All the anthropometric values obtained were expressed as mean $\pm$ standard deviation. Study subjects were divided into three groups on the basis of their age at menarche. Menarcheal age was also expressed as mean $\pm$ standard deviation. Age at menarche was correlated with the anthropometric parameters using Pearson's correlation test. Anthropometric parameters were compared between the groups using t- test. A 'p' value of less than 0.05 was considered as significant.

RESULTS

Mean anthropometric values of study subjects were represented in Table 1. Mean menarcheal age of study subjects was 146 ± 14 month.

Table 2 represents the distribution of study subject on the basis of their age at menarche. Lowest age at menarche was 110 month and highest age was 192 month.

**Table 1: Anthropometric data of school going adolescent who already attained menarche**

Variable	Value
Age (years)	14.25 ± 1.65
Height (cm)	152.30 ± 5.78
Weight (kg)	45.55 ± 9.39
BMI (kg/m^2)	19.57 ± 3.58
MUAC (cm)	22.81 ± 2.79
Waist circumference (cm)	71.53 ± 9.04
Hip circumference (cm)	84.00 ± 8.17
MUAC/height	0.150 ± 0.018
Waist circumference/height	0.468 ± 0.056
Hip circumference/height	0.551 ± 0.048
Body fat percentage	20.99 ± 5.49
Age at menarche (month)	146 ± 14

Table 2: Distribution of study subjects by age at menarche

Age at menarche (month)	Frequency	Percent	Cumulative percent
≤ 132	74	21.33	21.33
133-144	114	32.86	54.19
145-156	102	29.39	83.58
157-168	44	12.68	96.26
169-180	10	2.88	99.14
>180	3	0.86	100
Total	347	100	

The menarcheal age was correlated positively with height and was correlated negatively with weight, BMI, MUAC, Waist circumference, hip circumference, waist-hip ratio and body fat percentage (Fig. 1-3 and Table 3). Maximum correlation was noted with body fat percentage and minimum with height.
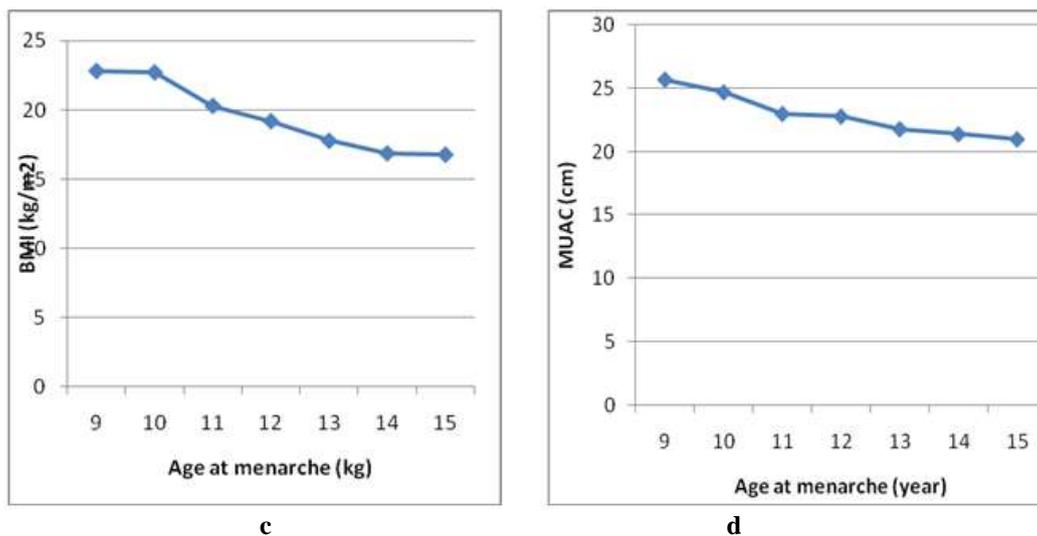

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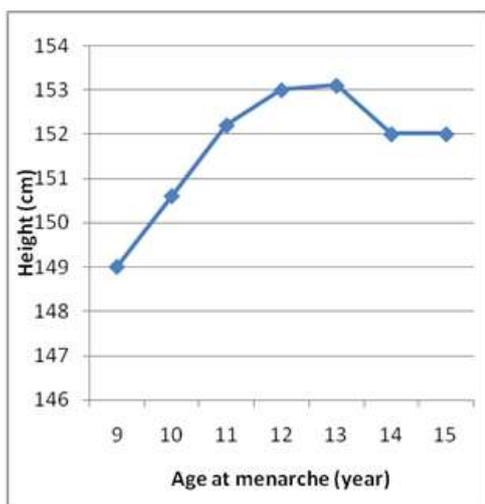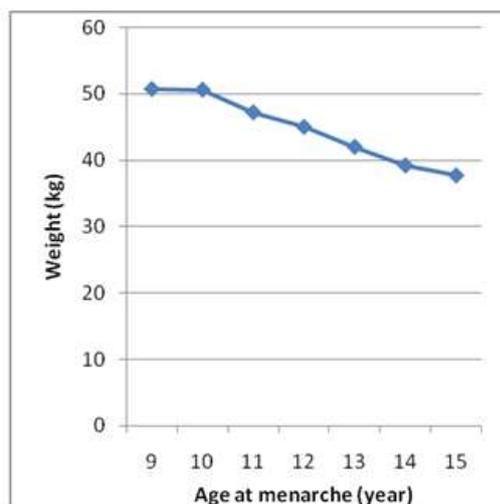
Fig.1: Relationship between age at menarche and height (a), weight (b), BMI (c) and MUAC
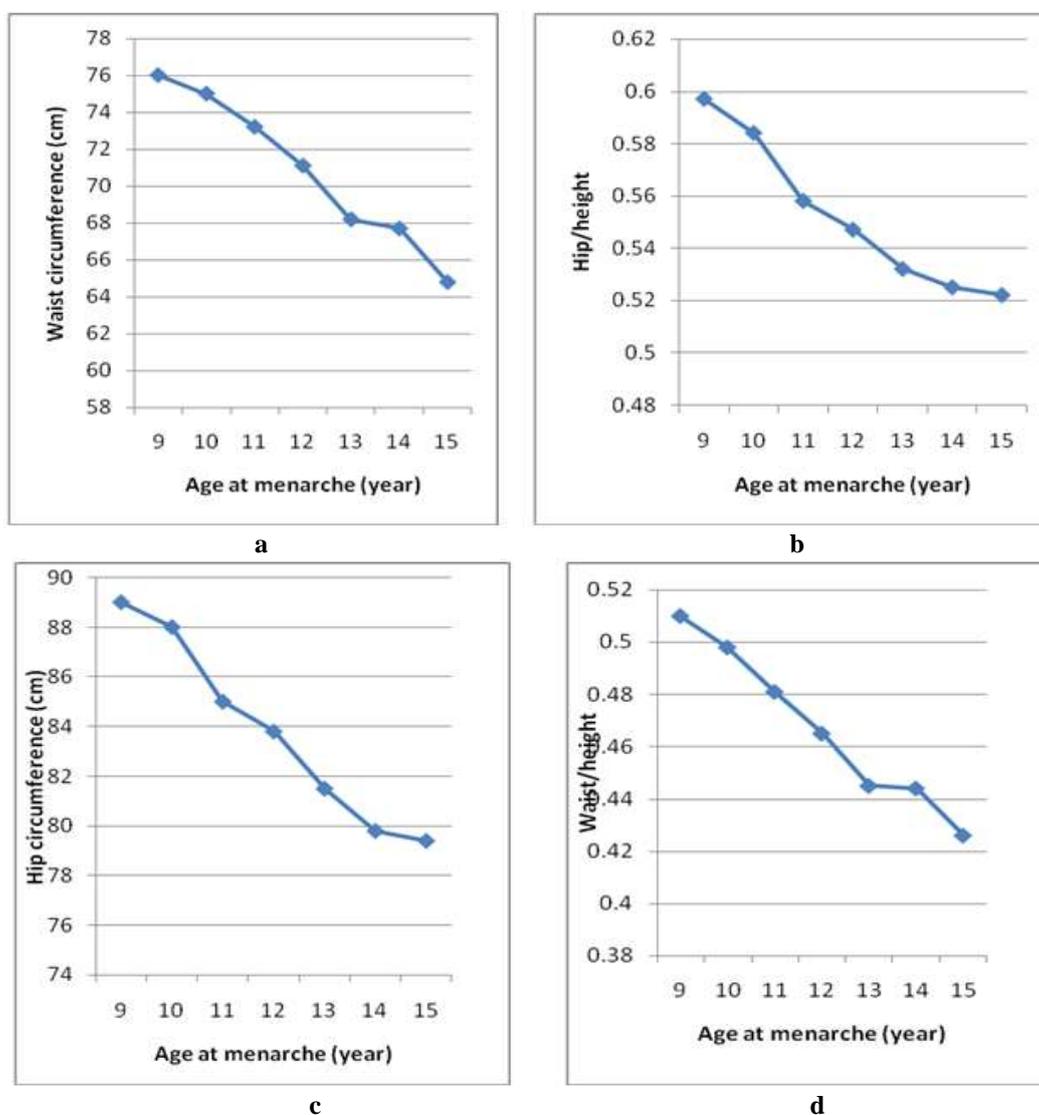

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Fig.2: Relationship between age of menarche and waist circumference(a), hip/height (b), hip circumference(c) and waist/height(d)
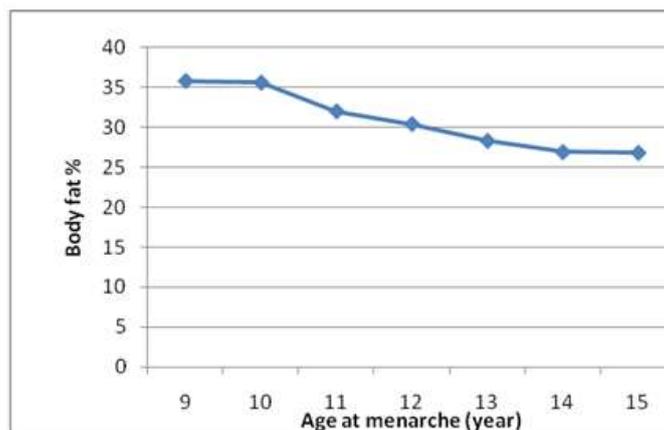
Fig.3: Relationship between age at menarche and body fat percentage

Table 3: Correlation of age at menarche and physical variables

Variable	r	p
Height (cm)	(+) 0.053	>0.05
Weight (kg)	(-) 0.367	<0.001
BMI (kg/m2)	(-) 0.437	<0.0001
MUAC (cm)	(-) 0.352	<0.001
Waist circumference (cm)	(-) 0.309	<0.001
Hip circumference (cm)	(-) 0.298	<0.001
MUAC/height	(-) 0.372	<0.001
Waist circumference/height	(-) 0.345	<0.001
Hip circumference/height	(-) 0.356	<0.001
Waist/Hip	(-) 0.116	<0.05
Body fat percentage	(-) 0.538	<0.0001

Table 4 represents various physical parameters in respect to menarcheal age status. Except waist hip ratio all other parameters differ significantly between earlier and ideal menarcheal age group. Maximum significant difference was noted for BMI followed by body fat percentage.

Table 4: Anthropometric data of study subjects according to menarcheal age status

Variable	Early menarche	Mid menarche	Late menarche	t values between Early & ideal menarche	p values between Early & mid menarche
Age at menarche (month)	127.42 ± 5.22	146.42 ± 7.55	172.53 ± 13.20	20.067	<0.0001
Height (cm)	151.20 ± 1.52	152.78 ± 5.88	151.73 ± 5.11	2.401	<0.05
Weight (kg)	51.13 ± 8.89	44.62 ± 9.00	40.54 ± 7.96	6.318	<0.001
BMI (kg/m^2)	22.31 ± 3.26	19.04 ± 2.73	17.57 ± 3.15	10.304	<0.001
MUAC (cm)	24.61 ± 2.46	22.47 ± 2.73	21.41 ± 2.16	6.743	<0.001
Waist (cm)	75.66 ± 9.00	70.98 ± 8.28	66.95 ± 5.82	4.862	<0.001
Hip (cm)	88.09 ± 8.65	83.38 ± 7.76	79.82 ± 6.50	4.722	<0.001
MUAC/height	0.162 ± 0.016	0.147 ± 0.017	0.141 ± 0.015	7.590	<0.001
Waist /height	0.500 ± 0.054	0.464 ± 0.051	0.441 ± 0.038	6.072	<0.001
Hip /height	0.582 ± 0.050	0.564 ± 0.044	0.526 ± 0.041	3.519	<0.001
Waist/Hip	0.859 ± 0.063	0.851 ± 0.061	0.839 ± 0.045	1.128	>0.05
Body fat (%)	25.62 ± 4.95	20.26 ± 4.81	16.47 ± 4.50	9.586	<0.001

DISCUSSION

Menarche is a vital incidence in a female life. The downward inclination of menarcheal age has been reported in countries. The mean age of menarche in the present study was 12.2 years (144 months). Minimum age of menarche was 110 month and maximum with 192 month. In our study subjects more than 21% of girls attained menarche at early age. In order to find out the determinants of age at menarche correlation of menarcheal age with physical parameters of the subjects was studied.

A general belief among pediatricians is that girls with early menarche are shorter height than those who have a late menarche. Many evidences suggest that taller girls attain early menarche [28]. But the results of our study suggest positive correlation between height and age at menarche. Our results support previous observation of Lee *et al*. [29].

Frish and Revelle proposed critical body weight and weight gain for the onset of menarche [17]. Results of the study of John *et al*. [7] were against the "critical weight hypothesis. Our results were also against the "critical weight hypothesis".

A recent study [29] demonstrated an inverse association between menarcheal age and BMI. Our results also support significant inverse association between BMI and age at menarche. BMI of early menarcheal age group was significantly higher than ideal menarcheal age group. BMI was more than 85th percentile for early menarcheal group, in between 50th and 85th percentile for mid menarcheal group and less than 20th percentile for late menarcheal group according to WHO standard of age related BMI [30]. This observation suggests that over weight and obesity may be a cause of early onset of menarche.

The mean MUAC, triceps skin fold thickness, hip circumference and waist circumference were higher among menstruating girls in compared to non-menstruating girls [20]. Anthropometric body fat indices like waist circumference, waist height ratio, hip circumference, hip height ratio and waist hip ratio showed inverse correlation with age at menarche. Except waist hip ratio all these variables were significantly higher in early menarcheal group than ideal group. Both waist circumference and waist- height ratio were above cut of level (75th percentile) of Indian girls [31]. Thus central obesity may be a risk factor for early age at menstruation.

The mean MUAC was higher among menstruating girls in compared to non-menstruating girls [20]. Our results support previous observation. We also noted significant inverse correlation between age at menarche and mid upper arm circumference.

Body fat percentage showed significant inverse correlation with age at menarche. Body fat percentage was significantly higher in early menarcheal group than mid and late menarchel groups. Body fat percentage was above 95th percentile for early menarcheal group, in between 75th and 85th percentile for ideal menarcheal group and below 25th percentile for late menarcheal group according to reference value of body fat indices for adolescent of Bengalee ethnicity [32]. Thus body fat percentage above 85th percentile value may be risk factor for early onset of menarche.

CONCLUSION

The development of socio-economic state resulted in an early onset of puberty indicated by fall of age at menarche. Menarcheal age has significant health implication as early menarche is associated with more cardiovascular incidents, type 2 diabetes and breast cancer and let menarche is associated with osteoporosis and increased fracture risk. More than 21% of girls attained menarche at an early age. Considerable inverse relationship was noted between menarcheal age with obesity, body fat percentage and mid upper arm circumference and insignificant positive relationship between menarcheal age and height. Girls with high class BMI, waist circumference, waist-height ratio, hip circumference, hip-height ratio, body fat percentage and MUAC are prevalent to attain early menarche. It is important to control the occurrence of obesity, particularly central obesity through monitoring the change of waist circumference, hip circumference, body fat percentage, BMI and MUAC.

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