Ind. J. Phys. Anthrop & Hum. Genet. Vol. 41, No. 1, (2022) : 7-30

BODY SIZE IN RELATION TO AGE AT MENARCHE AMONG ADOLESCENT GIRLS OF DISTRICT AMBALA, HARYANA

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ABSTRACT

Age at menarche is an important maturity indicator for assessment of development status of pubertal females. It varies from population to population and is influenced by both genetic and environmental factors. The objective of the present study was to determine the age at menarche of adolescent girls of Ambala district in Haryana and examine its relationship with body size. A cross-sectional sample of 858 girls (410 rural, 448 urban) of the age-group of 10 to 19 years was taken. The data on age at menarche were collected on each subject using status quo as well as retrospective (recall) method. Four anthropometric measurements i.e. height, weight, waist circumference and hip circumference were taken using standard techniques and indices like Body Mass Index (BMI), Waist-Hip ratio (WHR), Waist-Height ratio (WHtR), Body Adiposity Index (BAI) and A body shape index(ABSI) were computed using these measurements. Student t-test was performed to study the association between body size and menstrual status of girls from 11 to 15 years of age. The median age at menarche calculated by status quo method and mean age at menarche by recall method revealed that the onset of menarche among rural girls (Median: 13.18±1.09; Mean: 13.42±1.22 years) was later than their urban counterparts (Median: 12.74±1.12; Mean: 12.58±1.18 years). Student t-test (p-value$\leq$0.05) indicated significant differences in almost all dimensions at various age-groups between pre and post-menarcheal girls. Post-menarcheal girls were found to be heavier, taller, had higher BMI scores and greater waist and hip-circumference than their pre-menarcheal peers.

Keywords: menarche, adolescent, menstrual status, BMI, circumference

INTRODUCTION

The adolescent phase is a crucial phase of human development in which accelerated body growth takes place in all dimensions and results in transformation into an adult body size and shape, with the attainment of skeletal maturity. This phase is also marked by many pubertal changes which lead to sexual or reproductive maturation. In response to rising levels of estrogens during this period, the lower half of the pelvis and hips widen and the pattern of fat

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distribution progressively contributes to the typical female body shape by the end of puberty (Tanner, 1962).Though other pubertal changes are gradual and continuous over a period of time, menarche or the first menstrual cycle is a sudden event. Age at menarche is an important maturity indicator for assessment of development status of pubertal female (Eveleth &Tanner, 1976).There is variability in the age at menarche among different ethnic groups and populations (Ikaraoha et al., 2005) and it is influenced by both genetic and environmental factors (Danker-Hopfe, 1986; Eveleth &Tanner, 1990; Ulijaszek et al., 1991; Salces et al., 2001; Ayatollahi et al., 2002). In most females, it occurs between the age of 10 and 16 years, though there may be variations (Rees, 1995; Thomas et al., 2001). A secular trend towards decreasing age at menarche has been noted among populations leading to earlier maturation of girls. Therefore, a regular monitoring of growth status along with age at menarche is imperative to assess the magnitude of change if any, in a given population.

In general, adolescents who are taller and heavier with a greater body fat mass tend to reach menarche at younger ages (Bharati & Bharati, 1998; WHO, 2003; Chowdhury et al., 2000; Gluckman & Hanson, 2006). Some studies suggest that age at menarche and age at peak height growth velocity are all associated with diet and body size much earlier in childhood (Liestol, 1982; Berky et al., 2000; Blell et al., 2008).The objective of the present study was to determine the age at menarche and examine its association with body size and composition among adolescent girls of Ambala district in Haryana.

MATERIAL AND METHODS

The cross-sectional study was conducted among 858 (410 rural, 448 urban) adolescent girls ranging in age from 10 to 19 years of District Ambala, Haryana. The date of birth of each subject was recorded from the school register. The age was calculated from the date of birth to the date of investigation, using decimal age calendar given by Tanner et al. (1966). A prior written consent was obtained from the parents and subjects after explaining the objective and methodology of the study. Four anthropometric measurements were taken on each subject using standard techniques given by Weiner & Lourie (1981). These included height, weight, waist circumference and hip circumference. The indices; Body Mass Index (BMI), Waist-Hip ratio (WHR), Waist-Height ratio (WHtR), Body Adiposity Index (BAI) and A body Shape Index (ABSI) were computed using relevant measurements. The formulae for the indices are given below:-

1. BMI = Weight (kg)/Height $(m)^2$

2. $$WHR = \left[\frac{\text{Waist circumference (cm)}}{\text{Hip circumference (cm)}} \right]$$

3. $\text{WHtR} = \dfrac{\text{Waist circumfere nce (cm)}}{\text{height (cm)}}$

4. $\text{BAI} = \dfrac{100 \times \text{hip circumfere nce in m}}{\text{height in m} \times \sqrt{\text{height}}} - 18$

5. $\text{ABSI} = \dfrac{\text{Waist circumfere nce}}{\text{BMI}^{2/3} \times \textit{height}^{1/2}}$

The data were analysed using SPSS 16.

RESULTS

The present study obtained median age at menarche using *status quo* method. The dichotomous yes-no data on the presence/absence of menarche for each girl was taken. Out of 858 adolescent girls of Ambala district, 561 (65.4%) were menstruating while 297 (34.6%) did not report the occurrence of menarche (Fig 1). Median age at menarche was calculated using probit analysis (Fisher and Yates, 1957).

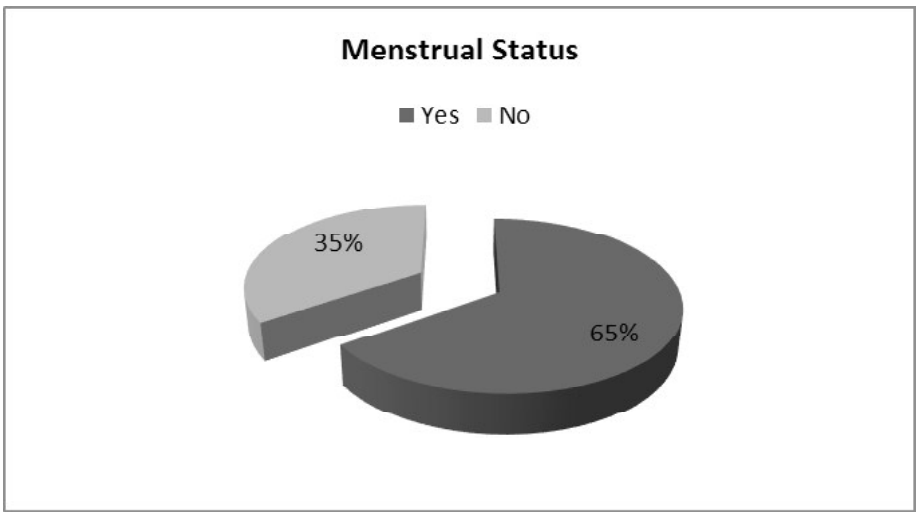

Figure. 1: Distribution of the study sample according to the menstrual status

Table 1 presents total number and percentage of rural and urban girls of Ambala district, Haryana who attained menarche in the age-groups from 10 to 17 years. In the present study, no girl had experienced menarche before the age of 11 years while all the girls of 17 years or above had experienced this event. The median age of onset of menarche of rural Ambala girls as determined by the probit analysis was found to be 13.18 ±1.09 years, whereas that of urban girls was 12.74 ±1.12 years.

Table 1: Total number and percentage of adolescent girls who attained menarche

Age (years)	Rural			Urban			Probit value	
	No. of girls	No. of girls with menarche occurred	%	No. of girls	No. of girls with menarche occurred	%	Rural	Urban
11	41	5	12.19	59	8	13.55	3.83	3.90
12	40	7	17.50	45	17	37.77	4.06	4.68
13	42	15	35.71	44	26	59.09	4.61	5.23
14	40	31	77.50	47	44	93.61	5.75	6.52
15	41	35	85.36	46	44	95.65	6.05	6.70
16	40	38	95.00	40	39	97.5	6.64	6.96
17	40	40	100	46	46	100		

Age at menarche was also taken using retrospective or recall method. The mean age at menarche of urban girls (12.58±1.18 years) was found to be earlier than that of rural girls (13.42±1.22 years) using recall method. The difference in the mean values of the two was found to be statistically significant (t-value=8.291, p-value=0.000***).

An attempt has been made in the present study to correlate the menstrual status with body size among the adolescent girls of Ambala.

Menstrual status with respect to Weight (Table 2, Figure- 2)

Table 2 presents the descriptive statistics for body weight of adolescent girls of Ambala district from 11 to 15 years of age with respect to their menstrual status. The age-group of 16 years has been excluded from this comparison as the sample size of pre-menarcheal girls is too less at this age to make any meaningful inference. The mean weights of non-menstruating or pre-menarcheal rural and urban girls at 11 years of age are 27.86 kg and 34.30 kg respectively which are lower than the mean weight of post-menarcheal girls (35.10 kg and 39.56 kg) of the same age. Similarly, at all age groups 12, 13, 14 and15 years, the mean weight of rural and urban pre-menarcheal girls is lower than that of post-menarcheal girls (Fig 2). Student t-test (p-value$\leq$0.05) indicates significant differences in mean weight between pre-menarcheal and post-menarcheal rural girls at 12, 13, 14 and 15 years of age. Among urban girls, significant differences in mean weight of pre-menarcheal and post-menarcheal girls are observed at 11 and 12 years of age while in the pooled sample, it is observed at all age groups from 11 to 15 years (p-value=0.00).

Table 2: Descriptive statistics for weight among rural and urban Ambala girls with respect to their menstrual status

Age Groups (years)	Rural				Urban				Total			
	Post-Menarcheal Mean ±SD	Pre-Menarcheal Mean± SD	t-value	p-value	Post-Menarcheal Mean ±SD	Pre-Menarcheal Mean± SD	t-value	p-value	Post-Menarcheal Mean ±SD	Pre-Menarcheal Mean ±SD	t-value	p-value
11	35.10 ±7.44	27.86 ±5.67	2.09	0.09	39.56 ±3.39	34.30 ±4.67	3.85	0.00**	37.85 ±5.50	31.64 ±5.99	3.75	0.00**
12	36.85 ±2.59	30.44 ±5.22	4.80	0.00**	41.73 ±5.06	37.34 ±5.41	2.75	0.00**	40.31 ±4.97	33.61 ±6.30	5.17	0.00**
13	38.53 ±4.94	34.30 ±4.97	2.66	0.01*	46.17± 9.65	41.28 ±7.85	1.85	0.07	43.38 ±8.98	37.09 ±7.10	3.58	0.00**
14	41.35 ±4.93	35.29 ±2.42	5.07	0.00**	47.35 ±9.59	43.67 ±2.93	1.66	0.15	44.87 ±8.49	37.38 ±4.49	4.61	0.00**
15	43.27 ±3.51	35.94 ±2.46	6.62	0.00**	49.12 ±12.62	43.75 ±3.18	1.82	0.17	46.57 ±10.13	37.68 ±4.20	4.91	0.00**

*p<0.05, **p<0.01

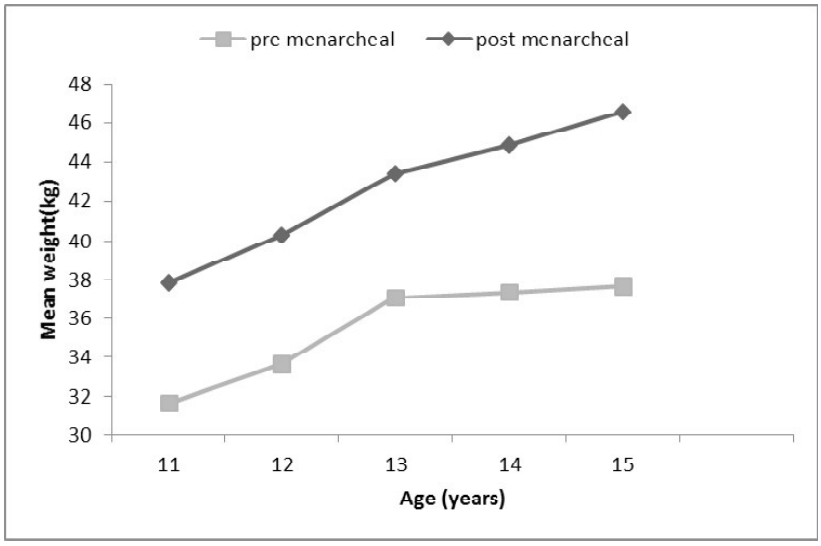

Figure- 2: Mean weight (kg) of pre-menarcheal and post-menarcheal adolescent girls (pooled sample) of Ambala district.

Menstrual status with respect to Height (Table 3, Figure- 3)

Descriptive statistics for body height of Ambala girls from 11 to 15 years of age with respect to their menstrual status has been presented in Table 3. The mean height of non-menstruating or pre-menarcheal rural girls from11 to 15 years ranges between 135.79 cm and 149.87cm, which is lower than the mean height of post-menarcheal girls of the same age (range-144.24 cm to 154.11cm). Among urban pre-menarcheal girls, from 11 years to 15 years, the mean height ranges between 140.66 cm to 153.50 cm, while it ranges between 147.09 cm to 155.75 cm for post-menarcheal girls. The distance curve of height shows an increasing trend with age irrespective of the menstrual status and clearly exhibits that mean height is higher at all age groups for post-menarcheal girls (Fig 3). Student

t-test (p-value≤0.05) shows significant difference in mean height between pre-menarcheal and post-menarcheal urban girls at 11 and 12 years. Among rural girls, significant differences were observed at 11,12 and 15 years of age while in the pooled sample, these differences were found to be significant at 11, 12, 13 and 15 years (p-value≤0.05).

Table 3: Descriptive statistics for height (cm) among rural and urban girls of Ambala with respect to their menstrual status

Age Groups (years)	Rural				Urban				Total			
	Post-Menarcheal Mean ±SD	Pre-Menarcheal Mean± SD	t-value	p-value	Post-Menarcheal Mean ±SD	Pre-Menarcheal Mean± SD	t-value	p-value	Post-Menarcheal Mean ±SD	Pre-Menarcheal Mean ±SD	t-value	p-value
11	144.24± 3.71	135.79± 6.80	4.21	0.00**	147.09±3 .37	140.66±5 .70	4.48	0.00**	145.99± 3.64	138.64± 6.60	5.96	0.00**
12	146.47± 4.07	141.94± 6.57	2.37	0.03*	152.73±5 .86	147.01±6 .14	3.12	0.00**	150.90± 6.05	144.26± 6.82	4.39	0.00**
13	149.45± 5.26	146.91± 6.21	1.40	0.17	153.67±6 .08	152.70±4 .91	0.58	0.57	152.12± 6.08	149.23± 6.35	2.16	0.03*
14	150.56± 3.42	148.59± 4.53	1.21	0.25	154.61±4 .65	152.87±6 .46	0.46	0.69	152.94± 4.62	149.66± 5.12	2.09	0.06
15	154.11± 4.94	149.87± 3.44	2.73	0.02*	155.75±4 .97	153.50±5 .51	0.57	0.67	155.03± 4.99	150.68± 3.90	3.07	0.01*

*p<0.05, **p<0.01

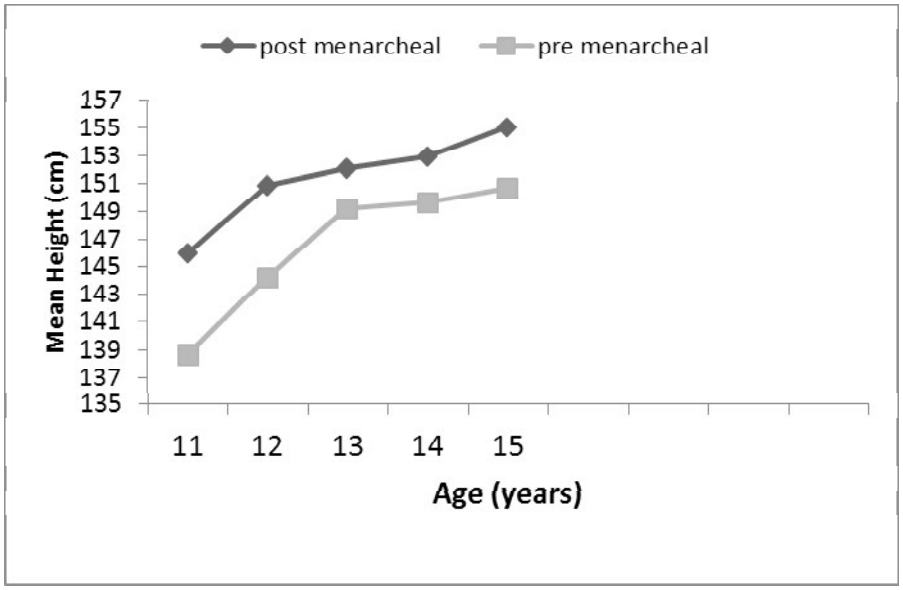

Fig 3: Mean height (cm) of pre-menarcheal and post-menarcheal adolescent girls (pooled sample) of Ambala district.

Menstrual status with respect to Waist Circumference (Table 4, Figure 4)

Table 4 presents the descriptive statistics for waist circumference of adolescent

girls of Ambala district from 11 to 15 years of age with respect to their menstrual status. The mean values of waist circumference of non-menstruating or pre-menarcheal rural and urban girls at 11 years of age are 57.64 cm and 62.45 cm respectively which are lower than the mean waist circumference of post-menarcheal girls (60.60 cm and 65.56 cm) of the same age. Similarly, at 12, 13, 14 and15 years, the mean waist circumference of rural and urban pre-menarcheal girls is lower than that of post-menarcheal girls (Fig 4).The distance curve for this circumference (pooled sample) showed an increasing trend with the advancing age for post-menarcheal girls, but a drop for pre-menarcheal girls at 14 and 15 years of age. Significant differences in mean waist circumference were noted between pre-menarcheal and post-menarcheal rural girls at 13 and 15 years of age and at 12, 13 and15 among the pooled sample (p-value$\leq$0.05). No significant differences in waist circumference of pre-menarcheal and post-menarcheal urban girls were observed.

Table 4: Descriptive statistics for waist circumference (cm) among adolescent girls of Ambala with respect to their menstrual status

Age Groups (years)	Rural				Urban				Total			
	Post-Menarcheal Mean ±SD	Pre-Menarcheal Mean± SD	t-value	p-value	Post-Menarcheal Mean ±SD	Pre-Menarcheal Mean± SD	t-value	p-value	Post-Menarcheal Mean ±SD	Pre-Menarcheal Mean ±SD	t-value	p-value
11	60.60 ±4.90	57.64 ±7.25	1.18	0.28	65.56 ±6.36	62.45 ±7.31	1.26	0.24	63.65 ±6.16	60.46 ±7.62	1.69	0.11
12	61.06 ±5.21	58.05 ±6.02	1.35	0.21	66.83 ±7.43	65.34 ±7.92	0.64	0.53	65.15 ±7.26	61.40 ±7.80	2.09	0.04*
13	61.35 ±4.14	58.33 ±3.78	2.34	0.03*	68.18 ±10.11	67.12 ±8.19	0.38	0.71	65.68 ±9.00	61.85 ±7.30	2.16	0.03*
14	63.49 ±5.05	59.06 ±7.79	1.61	0.14	68.24 ±8.79	67.17 ±14.68	0.13	0.91	66.28±7.80	61.08 ±9.84	1.74	0.10
15	63.71 ±4.33	59.07 ±2.86	3.54	0.00**	68.66 ±10.18	67.25 ±10.96	0.18	0.89	66.50 ±8.48	60.89 ±5.85	2.58	0.02*

*p<0.05, **p<0.0

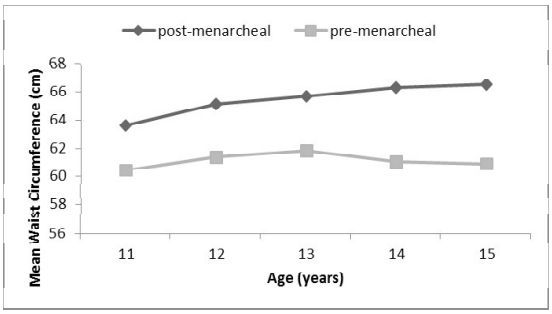

Figure- 4: Mean waist circumference (cm) of pre-menarcheal and post-menarcheal adolescent girls (pooled sample) of Ambala district.

Menstrual status with respect to Hip Circumference (Table 5, Figure- 5)

Descriptive statistics for hip circumference of adolescent girls of Ambala district from 11 to 15 years of age with respect to their menstrual status has been presented in Table 5. The mean hip circumference of non-menstruating or pre-menarcheal rural girls from11 to 15 years ranged between 71.43 cm and 78.96 cm, which were lower than the mean hip circumference of post-menarcheal girls of the same age group (range- 78.50 cm to 84.84 cm). Among urban pre-menarcheal girls, from11 years to 15 years, the mean hip circumference ranged between 78.53 cm to 87.25 cm, while for post-menarcheal girls, it ranged from 84.29 cm to 89.18 cm. The distance curve of hip circumference (pooled sample) showed an increasing trend with age except for a drop at 14 years for pre-menarcheal girls. It clearly exhibited that mean hip circumference was higher at all age groups for post-menarcheal girls (Fig 5). Student t-test (p-value$\leq$0.05) showed significant difference in mean hip circumference between pre-menarcheal and post-menarcheal girls from 11 to 15 years among the rural and pooled sample and only at 11 years among the urban girls (p-value$\leq$0.05).

Table 5: Descriptive statistics for hip circumference (cm) among adolescent girls of Ambala district with respect to their menstrual status

Age Groups (years)	Rural				Urban				Total			
	Post-Menarcheal	Pre-Menarcheal	t-value	p-value	Post-Menarcheal	Pre-Menarcheal	t-value	p-value	Post-Menarcheal	Pre-Menarcheal	t-value	p-value
	Mean ±SD	Mean± SD			Mean ±SD	Mean± SD			Mean ±SD	Mean ±SD		
11	78.50 ±2.29	71.43 ±5.32	5.22	0.00*	84.29 ±5.94	78.53 ±7.90	2.43	0.03*	82.06 ±5.56	75.59 ±7.76	3.69	0.00*
12	79.54 ±6.19	73.18 ±6.06	2.48	0.03*	85.39 ±6.18	82.78 ±6.71	1.33	0.19	83.68 ±6.63	77.58 ± 7.95	3.60	0.00**
13	80.40 ±4.19	76.80 ±6.14	2.25	0.03*	85.93 ±8.64	84.38 ±7.54	0.63	0.53	83.91 ±7.75	79.83 ±7.64	2.45	0.02*
14	83.30 ±5.57	76.91 ±4.42	3.58	0.00*	87.30 ±8.65	85.33 ±11.86	0.28	0.80	85.64 ±7.74	79.02 ±7.37	-2.87	0.01*
15	84.84 ±3.78	78.96 ±1.79	6.27	0.00*	89.18±1 0.22	87.25 ±3.89	0.61	0.60	87.29 ±8.32	80.80 ±4.20	-3.84	0.00*

*p<0.05, **p<0.01

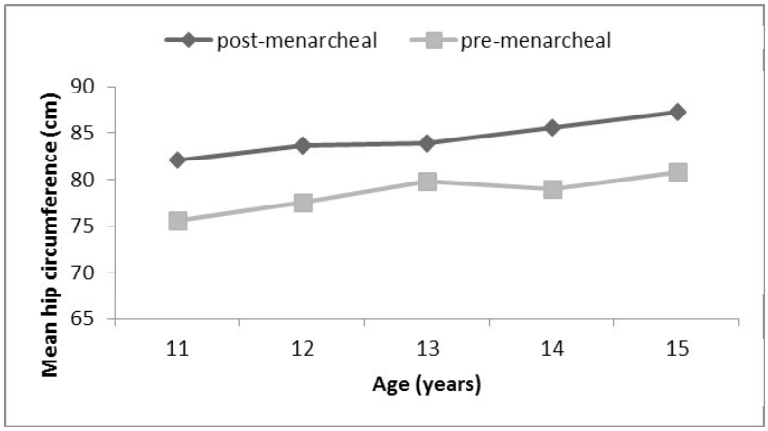

Figure- 5: Mean hip circumference (cm) of pre-menarcheal and post-menarcheal adolescent girls (pooled sample) of Ambala district.

Menstrual status with respect to BMI (Table 6, Figure- 6)

Table 6 presents the statistical summary for BMI of adolescent girls of Ambala district from 11 to 15 years of age with respect to their menstrual status. Mean BMI values of non-menstruating or pre-menarcheal rural and urban girls at 11 years of age are 14.97 kg/m^2 and 17.27 kg/m^2 respectively which are lower than the mean BMI of post-menarcheal girls (16.76 kg/m^2 and18.26 kg/m^2) of the same age. Similarly, at 12, 13, 14 and 15 years, the mean BMI of rural and urban pre-menarcheal girls is lower than that of post-menarcheal girls (Fig 6). The distance curve for this index showed an increasing trend with the advancing age for menstruating girls but a fluctuating trend for non-menstruating girls. Significant difference in mean BMI is noted between pre-menarcheal and post-menarcheal rural girls from 12 to 15 years, among urban girls at 11 and 15 years and at all ages among the pooled sample (p-value$\leq$0.05).

Table 6: Descriptive statistics for BMI (kg/m²) among rural and urban adolescent girls of Ambala district with respect to their menstrual status

Age Groups (years)	Rural				Urban				Total			
	Post-Menarcheal Mean ±SD	Pre-Menarcheal Mean± SD	t-value	p-value	Post-Menarcheal Mean ±SD	Pre-Menarcheal Mean± SD	t-value	p-value	Post-Menarcheal Mean ±SD	Pre-Menarcheal Mean ±SD	t-value	p-value
11	16.76 ±2.87	14.97 ±1.85	1.36	0.24	18.26 ±1.00	17.27 ±1.53	2.39	0.03*	17.68 ±1.98	16.32 ±2.01	2.32	0.03*
12	17.16 ±0.58	15.04 ±1.81	5.56	0.00**	17.89 ±1.96	17.21 ±1.67	1.19	0.24	17.68 ±1.69	16.03 ±2.04	3.79	0.00**
13	17.19 ±1.31	15.82 ±1.55	3.03	0.00**	19.49 ±3.57	17.67 ±3.00	1.83	0.08	18.65 ±3.13	16.56 ±2.40	3.44	0.00**
14	18.25±2 .16	16.05 ±1.80	3.07	0.00**	19.75 ±3.64	18.68 ±0.38	1.81	0.08	19.13 ±3.19	16.71 ±1.95	3.59	0.00**
15	18.25±1 .69	16.00 ±0.97	4.83	0.00**	20.15 ±4.49	18.55 ±0.02	2.36	0.02*	19.32 ±3.66	16.57 ±1.40	4.41	0.00**

*p<0.05, **p<0.01

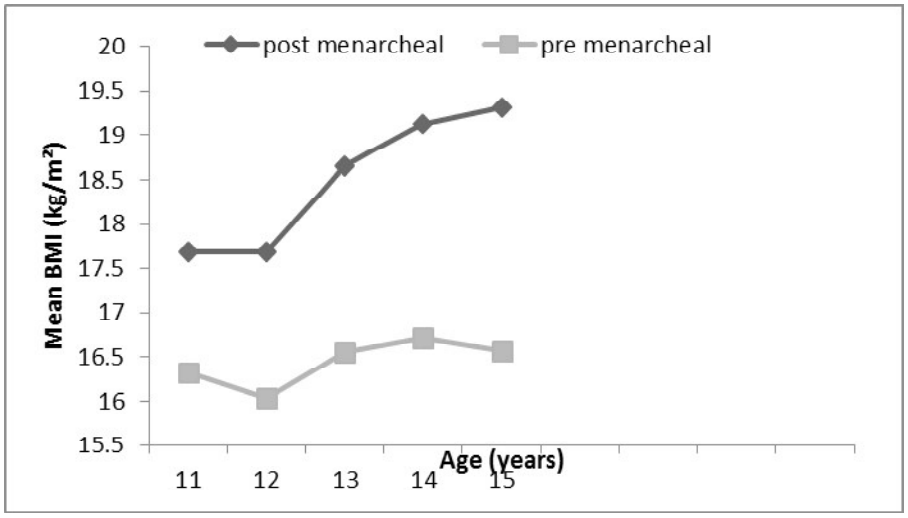

Figure- 6: Mean Body Mass Index (BMI) (kg/m²) among pre-menarcheal and post-menarcheal adolescent girls (pooled sample) of Ambala district.

Menstrual status with respect to Waist-Hip Ratio (WHR) (Table 7, Figure- 7)

Descriptive statistics for Waist-Hip Ratio of adolescent girls of Ambala district from 11 to 15 years of age with respect to their menstrual status has been summarized in Table 7. The mean WHR of pre and post-menarcheal rural girls of 11 to 15 years of age ranged between 0.81 and 0.75.The mean values of WHR for rural girls were lower for post-menarcheal girls than pre-menarcheal

girls at 11, 12 and 14 years whereas these were same for girls at 13 and 15 years of age, irrespective of their menstrual status. Significant difference was noted only at 12 years as shown by the p-value (0.02). Among urban pre-menarcheal girls, the mean value of WHR ranged from 0.79 at 11 years to 0.77 at 15 years and from 0.78 at 11 years to 0.77 at 15 years in post-menarcheal girls. At 11, 12 and 13 years, post-menarcheal urban girls showed lower mean values of WHR than pre-menarcheal girls but the differences were not significant. Lower values were also seen for post-menarcheal girls at 11and 12 years among the pooled sample, but the difference is significant only at 12 years. The distance curve of Waist-Hip Ratio (pooled sample) showed an overall decreasing trend with age in both pre and post-menarcheal girls (Fig 7).

Table 7: Descriptive statistics for Waist-Hip Ratio (WHR) among adolescent girls of Ambala district with respect to their menstrual status

Age Groups (years)	Rural				Urban				Total			
	Post-Menarcheal Mean ±SD	Pre-Menarcheal Mean± SD	t-value	p-value	Post-Menarcheal Mean ±SD	Pre-Menarcheal Mean± SD	t-value	p-value	Post-Menarcheal Mean ±SD	Pre-Menarcheal Mean ±SD	t-value	p-value
11	0.77±0.07	0.81 ±0.07	-0.98	0.37	0.78 ±0.04	0.79 ±0.03	-1.27	0.23	0.78 ±0.05	0.80 ±0.05	-1.60	0.13
12	0.77±0.02	0.79 ±0.04	-2.52	0.02*	0.78 ±0.04	0.79 ±0.04	-0.47	0.64	0.78 ±0.04	0.79 ±0.04	-1.39	0.02*
13	0.76 ±0.03	0.76 ±0.04	0.14	0.89	0.79 ±0.05	0.80 ±0.06	-0.27	0.79	0.78 ±0.04	0.77 ±0.05	0.55	0.58
14	0.76 ±0.03	0.77 ±0.07	-0.14	0.89	0.78 ±0.03	0.78 ±0.06	0.21	0.85	0.77 ±0.03	0.77 ±0.06	0.32	0.76
15	0.75 ±0.03	0.75 ±0.02	-0.30	0.77	0.77 ±0.05	0.77 ±0.09	0.00	1.00	0.76 ±0.05	0.75 ±0.04	-0.62	0.55

*p<0.05, **p<0.01

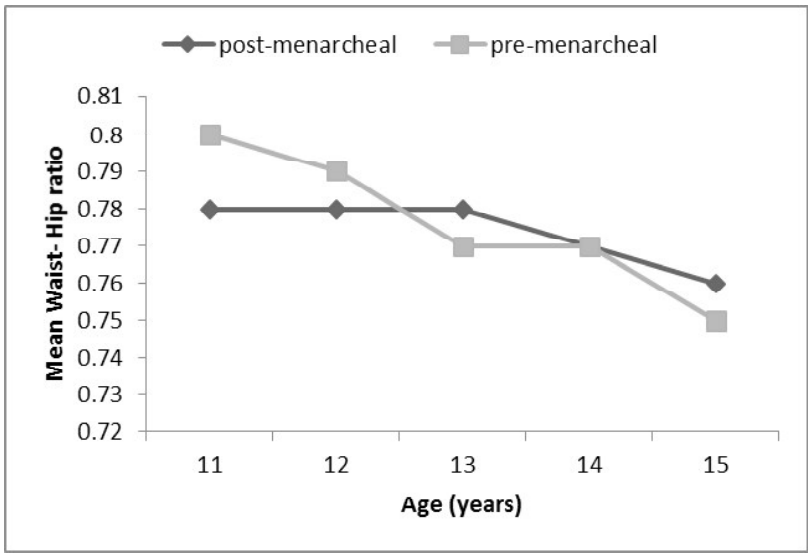

Figure-7: Mean Waist-Hip Ratio (WHR) among pre-menarcheal and post-menarcheal adolescent girls (pooled sample) of Ambala district.

Menstrual status with respect to Waist-Height Ratio (WHtR) (Table 8, Figure- 8)

Table 8 presents the statistical summary for Waist-Height Ratio (WHtR) of adolescent girls of Ambala district from 11 to 15 years of age with respect to their menstrual status. The mean WHtR of pre-menarcheal rural girls ranged from 0.42 at 11 years to 0.39 at 15 years while for post-menarcheal girls, it was 0.42 at 11, 12 and 14 years and 0.41 at 13 and 15 years. Among urban girls the mean waist-height ratio of pre-menarcheal girls was 0.44 at all ages while for post-menarcheal girls, it was 0.44 at all ages except at 11 years (0.45). The distance curve for WHtR showed a decreasing trend with the advancing age for pre-menarcheal girls and lower values than post-menarcheal girls at all ages, except at 11 years (Fig 8). However, it remained same (0.43) for post-menarcheal girls at all age groups except at 11 years (0.44). Only significant difference in mean waist-height ratio was noted between pre and post-menarcheal rural girls at 15 years (p-value$\leq$0.05).

Table 8: Descriptive statistics for Waist-Height Ratio (WHtR) among adolescent girls of Ambala district with respect to their menstrual status

Age Groups (years)	Rural				Urban				Total			
	Post-Menarcheal Mean ±SD	Pre-Menarcheal Mean± SD	t-value	p-value	Post-Menarcheal Mean ±SD	Pre-Menarcheal Mean± SD	t-value	p-value	Post-Menarcheal Mean ±SD	Pre-Menarcheal Mean ±SD	t-value	p-value
11	0.42 ±0.04	0.42 ±0.04	-0.21	0.84	0.45 ±0.04	0.44 ±0.05	0.11	0.91	0.44 ±0.04	0.44 ±0.05	0.02	0.99
12	0.42±0.03	0.41±0.04	0.63	0.54	0.44 ±0.05	0.44 ±0.05	-0.44	0.67	0.43 ±0.04	0.42 ±0.05	-0.60	0.55
13	0.41 ±0.02	0.40 ±0.02	1.74	0.09	0.44 ±0.06	0.44 ±0.06	0.18	0.86	0.43 ±0.05	0.41 ±0.05	1.61	0.11
14	0.42 ±0.03	0.40 ±0.06	1.11	0.29	0.44 ±0.05	0.44 ±0.08	0.09	0.94	0.43 ±0.05	0.41 ±0.06	1.31	0.21
15	0.41 ±0.03	0.39 ±0.02	2.13	0.05*	0.44 ±0.06	0.44 ±0.06	0.09	0.94	0.43 ±0.05	0.40 ±0.03	2.06	0.06

*p<0.05, **p<0.01

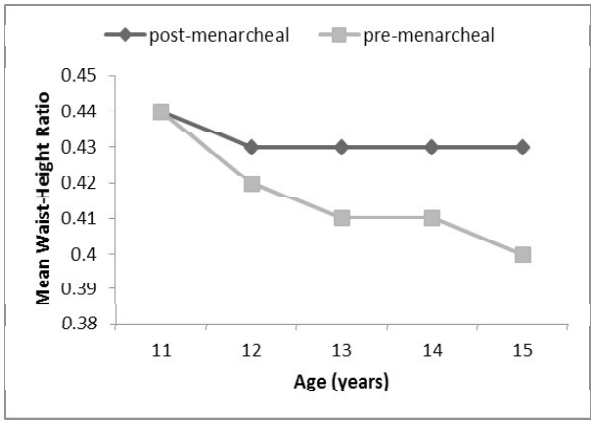

Figure- 8: Mean Waist-Height Ratio (WHtR) among pre-menarcheal and post-menarcheal adolescent girls (pooled sample) of Ambala district.

Menstrual status with respect to Body Adiposity Index (Table 9, Figure- 9)

Descriptive statistics for Body Adiposity Index (BAI) of adolescent girls of Ambala district from 11 to 15 years of age with respect to their menstrual status has been presented in Table 9. The mean BAI for menstruating or post-menarcheal rural girls from 11 to 15 years ranged from 27.39% to 26.44% and for pre-menarcheal girls, from 21.17% to 25.07%. Among urban post-menarcheal girls, mean value of BAI ranged between 29.21% to 27.88% and 29.07% to 27.88 % in pre-menarcheal girls. Among the pooled sample, higher values for mean BAI in post-menarcheal girls were seen at all age- groups. The distance curve of mean BAI showed a decreasing trend with age till 13 years for post-menarcheal girls and for pre-menarcheal girls till 14 years (Fig 9). No significant difference in mean BAI between pre-menarcheal and post-menarcheal girls was observed among the rural, urban and pooled sample.

Table 9: Descriptive statistics for BAI among rural and urban adolescent girls of Ambala district with respect to their menstrual status

Age Groups (years)	Rural				Urban				Total			
	Post-Menarcheal Mean ±SD	Pre-Menarcheal Mean± SD	t-value	p-value	Post-Menarcheal Mean ±SD	Pre-Menarcheal Mean± SD	t-value	p-value	Post-Menarcheal Mean ±SD	Pre-Menarcheal Mean ±SD	t-value	p-value
11	27.39 ±3.0	21.17± 2.47	0.16	0.88	29.21 ±2.35	29.07 ±4.07	0.14	0.89	28.51 ±2.66	28.28 ±3.61	-0.28	0.78
12	26.82 ±2.21	25.29 ±2.87	1.57	0.15	27.28 ±3.13	28.46 ±3.24	-1.21	0.23	27.14 ±2.85	26.75 ±3.41	0.55	0.59
13	26.01 ±1.53	25.11 ±2.28	1.54	0.13	27.11 ±3.92	26.75 ±4.08	0.29	0.77	26.71 ±3.27	25.77 ±3.19	-1.35	0.18
14	27.10±2 .98	24.58 ±3.74	1.86	0.09	27.41 ±4.14	26.99 ±3.33	0.21	0.86	27.28 ±3.68	25.18 ±3.66	-1.84	0.09
15	26.44 ±3.09	25.07 ±1.67	1.67	0.11	27.88 ±4.78	27.88 ±0.43	0.00	1.00	27.25 ±4.17	25.69 ±1.91	-1.97	0.06

$p<0.05$, $^{**}p<0.01$

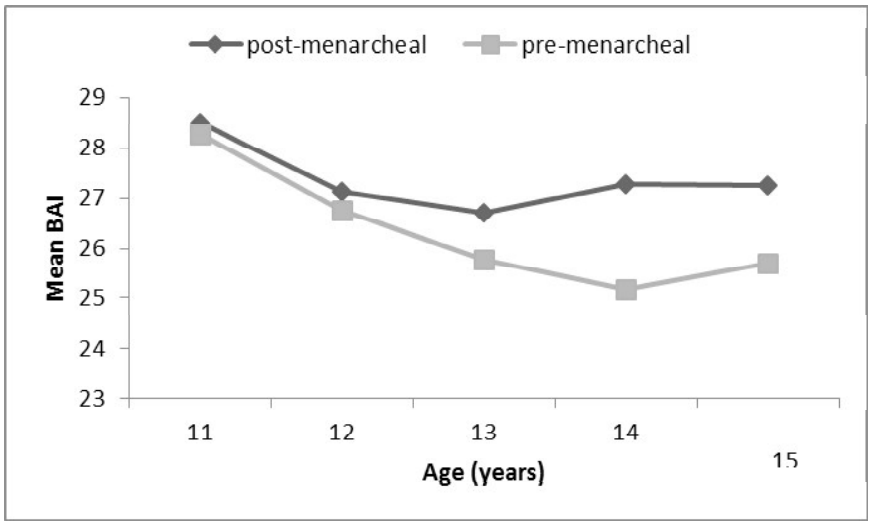

Figure- 9: Mean BAI among pre-menarcheal and post-menarcheal adolescent girls (pooled sample) of Ambala district.

Menstrual status with respect to A Body Shape Index (ABSI) (Table 10, Figure- 10)

Table 10 presents the statistical summary for A Body Shape Index (ABSI) of adolescent girls of Ambala district from 11 to 15 years of age with respect to their menstrual status. The mean ABSI of pre-menarcheal rural girls ranged from 0.81 at 11 years to 0.76 at 15 years while for post-menarcheal girls, it was 0.78 at 11 years to 0.74 at 15 years. Among urban girls, the mean ABSI of pre-menarcheal girls was 0.79 at 11 years and 0.77 at 15 years while for post-menarcheal girls; it was 0.78 and 0.75 at the corresponding ages. The distance curve for this ratio showed a decreasing trend with the advancing age for both pre and post-menarcheal girls, except for an increase seen at 12 years for post-menarcheal girls. Post-menarcheal girls reported lower values than pre-menarcheal girls at all ages (Fig 10). Significant difference in mean ABSI was noted between pre and post-menarcheal rural girls at 12 years and among pre and post-menarcheal urban girls and the pooled sample at 13 years (p-value$\leq$0.05).

Table 10: Descriptive statistics for ABSI among rural and urban adolescent girls of Ambala district with respect to their menstrual status

Age Groups (years)	Rural				Urban				Total			
	Post-Menarcheal Mean ±SD	Pre-Menarcheal Mean± SD	t-value	p-value	Post-Menarcheal Mean ±SD	Pre-Menarcheal Mean± SD	t-value	p-value	Post-Menarcheal Mean ±SD	Pre-Menarcheal Mean ±SD	t-value	p-value
11	0.78 ±0.12	0.81 ±0.04	-0.60	0.58	0.78 ±0.06	0.79 ±0.06	-0.42	0.68	0.77 ±0.08	0.80 ±0.06	-1.02	0.32
12	0.76 ±0.05	0.80 ±0.05	-2.24	0.05*	0.79 ±0.06	0.81 ±0.06	-0.88	0.38	0.78 ±0.06	0.80 ±0.05	-1.67	0.10
13	0.75 ±0.04	0.77 ±0.04	0.89	0.38	0.76 ±0.05	0.80 ±0.07	-2.27	0.03*	0.76 ±0.04	0.78 ±0.06	-2.03	0.05*
14	0.75 ±0.04	0.76 ±0.07	-0.47	0.65	0.75 ±0.04	0.77 ±0.16	-0.18	0.88	0.75 ±0.04	0.76 ±0.09	0.41	0.69
15	0.74 ±0.04	0.76 ±0.01	-1.98	0.06	0.75 ±0.04	0.77 ±0.11	-0.33	0.80	0.75 ±0.04	0.76 ±0.04	-1.21	0.25

*p<0.05, **p<0.01

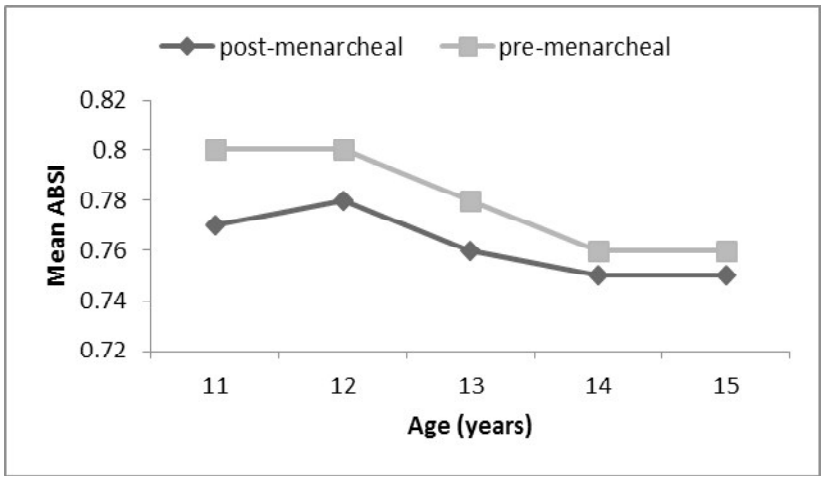

Figure- 10: Mean ABSI among pre-menarcheal and post-menarcheal adolescent girls (pooled sample) of Ambala district.

To identify the nature of relationship between mean age at menarche and height and derived anthropometric indices like BMI, Waist-Hip ratio, BAI and ABSI, correlation coefficient (r) was calculated.

	Height	BMI	WHR	BAI	ABSI
Mean Age atMenarche	0.173***	-0.246***	-0.226***	-0.246***	-0.055

A significant negative correlation between mean age at menarche and BMI (r=-0.246, p-value=0.000***) as well as BAI (r=-0.246, p-value=0.000***) was found in the present study. There was also a significant correlation between mean age at menarche and height (r=0.173, p-value=0.000***). The mean age at menarche was also strongly associated with Waist-hip ratio (r=-0.266, p-

value=0.000***), in a negative correlation. No significant correlation between mean age at menarche and ABSI was found.

DISCUSSION

Adolescence heralds the transition to adulthood. It marks the onset of puberty which is associated with growth acceleration and appearance of secondary sexual characteristics. It is the formative stage towards attainment of sexual and reproductive maturity. Among girls the most prominent developmental milestone associated with adolescent years is menarche or the first menstrual bleeding. The age at which menarche occurs is the most commonly reported variable and an excellent marker of adolescent maturation.

In the present study among rural and urban girls of District Ambala, Haryana, all girls attained menarche between the ages of 11years and 16 years. Using probit analysis, the median age of menarche of rural adolescent girls was found to be 13.18±1.09 years whereas that of urban girls was 12.74±1.12 years. Similarly, the mean age at menarche calculated by recall method revealed that the onset of menarche among rural girls (13.42±1.22 years) was later than their urban counterparts (12.58±1.18 years). This finding is consistent with many such studies conducted in India (Deo & Gattarji, 2004; Mokha & Kaur, 2006; Rokade & Mane, 2008; Ray et al., 2010; Thakre et al., 2011 ; Dambhare et al., 2012; Pathak et al., 2014; Ambade & Sagdeo , 2017), China (Lin et al., 1992; Wang et al., 2016), Morocco (Montero et al.,1999), Nigeria (Ikaraoha et al., 2005), Iran (Delavar & Hajian-Tilaki, 2008) and Ghana (Ameade & Garti, 2016).

The relationship between menarche and body size has been examined in the present study. Comparisons between pre-menarcheal and post- menarcheal rural and urban girls for weight, height, waist circumference and hip circumference and indices like BMI, waist-hip ratio, Waist- height ratio, BAI and ABSI were made.

The results indicated that menstruating girls were heavier and taller than their pre-menarcheal peers (Table 2, 3; Fig 2, 3). These findings are in accordance with the results of earlier studies (Ghai,1977; Zacharias & Rand, 1983; Sharma et al., 1988; Talwar & Singh, 1994; Singh et al., 1998; Koprowski et al., 1999; Bagga & Kulkarni, 2000; Hesketh et al., 2002; Janssens et al., 2003; Biro et al., 2006; Ghosh et al., 2005; Talwar & Bajwa, 2005; Sloboda et al., 2007; Kaur et al., 2009; Goon et al., 2010; Kim et al., 2010; Talwar et al., 2012). It was also noted that rural girls were lighter, shorter than their urban counterparts irrespective of their menstrual status, reflecting their nutritional inadequacies.

Different hypotheses have been postulated to explain the relationship of physical growth to menarcheal age. According to Frisch's well-known "critical weight (fat)" hypothesis, a certain amount or percentage of body fat is needed for the onset of menarche, i.e. heavier girls mature earlier (Frisch & Revelle, 1970). Frisch (1984) stated that subcutaneous fat tissue acts as a secondary

hormonal gland and produces 'leptin' which stimulates the hypothalamus to increase secretion of gonadotropin releasing hormone (GnRh) (Wilson et al., 2003).The increased activity of GnRH neurons triggers the hormonal changes that are necessary to begin reproductive period of life.

On the other hand, the critical weight hypothesis has been questioned and criticized by many with accumulating contradictory evidence (Billewicz et al., 1976; Cameron, 1976; Trussell & Frisch, 1978; Ellison, 1981; Scott & Johnston, 1982; Sherar et al., 2007; John et al., 2014).The criticism is mainly concerned with the validity of estimating fatness and also the fact that there is variance of fat patterning at menarche which differs from individual to individual.

Another hypothesis postulates that the pre-menarcheal girl is growing towards an appropriate structural status to prepare for reproduction (Ellison, 1982). It suggests a close correlation between rate of skeletal maturation and menarcheal age (Shuttleworth, 1937; Simmons & Greulich, 1943; Marshall, 1974). Age at menarche is well correlated with age at peak height velocity (Tanner et al., 1976; Kaczmarek, 2002). In our study a significant and positive correlation with height and age at menarche was found (r= 0.173, p-value= 0.000***).

Many previous studies support the hypothesis that girls who reach menarche at a later age will eventually grow taller compared with girls who reach their menarche at an earlier age. This may be explained by the earlier closure of epiphyseal growth disks because of the increase in ovarian estrogens (Helm et al., 1995; Georgiadis et al., 1997). A delay in menarche allows more growth of long bones before the epiphysis unite and results in taller adult height. Therefore, the menarcheal age probably has its main effect on height in the long bones (Onland-Moret et al., 2005).

There are conflicting reports in the literature on the relationship between adult stature and menarcheal age. Frisch and Revelle (1970) suggested that age at menarche might be related to attainment of appropriate weight for reproduction rather than appropriate skeletal status. The whole range of Western longitudinal growth studies indicate that early and late maturing children on average attain the same adult height (Tanner & Davies, 1985; Marshall & Tanner, 1986).

It is apparent from the present study that linearity of physique may be associated with late maturation as all the pre-menarcheal girls were shorter and slimmer. The results presented herein confirm that post-menarcheal girls had higher BMI scores (Table 6, Fig 6). The difference between the average BMI scores in the pre-menarche and post-menarche groups was found to be statistically significant. A significant inverse association (r=-0.246, p-value=0.000***) between BMI and age at menarche was also revealed, in line with results of the study conducted by Lee et al. (2013). Kapiro et al. (1995) found a linear association between BMI and menarche age in twin girls. On the contrary, Erosy et al. (2004) reported decrease in attainment of menarche with

increase in BMI whereas Demerath et al. (2004) reported that onset of menarche and changes in body mass index were independent. In separate studies, Garcia et al (2010) found no correlation between age at menarche and BMI while Khadgawat et al. (2016) reported earlier pubertal onset in overweight and obese Delhi school girls.

It is seen in the present study that the post-menarcheal girls had greater waist circumference and hip-circumference than pre-menarcheal girls (Table 4, 5; Fig 4, 5), the difference being more significant in rural girls. The mean age at menarche was also strongly associated with Waist-hip ratio (r=-0.266, p-value=0.000***) in a negative correlation. However, there were no significant differences in WHR or WHtR of pre and post-menarcheal girls (Table 7, 8), which may point to similar fat distribution in girls before and after menarche. Similar findings have been reported by Maron (2015) in Tanzanian girls and Kim et al. (2010) in Korean girls.

Lassek and Gaulin (2007) hypothesized that instead of total fat amount, distribution of fat and the ratio of fat stores in lower vs. upper body part is related to the age of menarche. This hypothesis was based on the findings that odds of menarche increases with increasing amounts of fat in the hips and buttocks and declines with increasing waist circumference and triceps skinfolds. This was supported by studies in which increasing hip circumference and declining waist-to-hip ratio in adolescents during the time of menarche were observed (Fredriks et al., 2005; Forbes, 1992).

Ziomkiewicz and Koziel (2015) through a longitudinal study demonstrated parallel changes in skeletal growth of the pelvis and in lower body fat deposition that were equally predictive for menarche occurrence in young girls. They confirmed that skeletal maturation of pelvis precede deposition of gluteofemoral fat tissue. It was proposed that hips circumference to pelvis breadth ratio should be used as a reliable predictor of onset of menarche due to its specific pattern of change in the period around menarche.

BMI alone does not reflect actual body fat mass but only indicates relative overweight. Adiposity can also be estimated by BAI and ABSI. Table 9, 10 and Figure- 9, 10 clearly indicate that there exist higher adiposity levels among post-menarcheal girls compared to pre-menarcheal girls; though difference is not statistically significant. This result is supported by many such studies (Bhadra et al., 2013; De, 2017). Several earlier studies have indicated that differences exist in body fat between pre and post-pubertal females. A significant negative correlation between mean age at menarche and BAI (r=-0.246, p-value=0.000***) was found. This can be explained on the basis of a known hypothesis that menarcheal age is significantly associated with increased body fat (Garn et al., 1986, Frisancho & Flegel, 1982). No significant correlation between mean age at menarche and ABSI was found in the present study.

The present study suggests that living in an urban vs. rural environment

has a considerable effect on the age of onset of menarche as the urban girls reported an earlier age of menarche than their rural peers. This may be due to the disparity between incomes and nutritional status in urban and rural households. Results of studies conducted in other undeveloped countries also indicate that girls who have reached menarche are significantly taller, heavier and have higher BMIs than pre-menstrual girls in the same age group (Goon et al., 2010**).** Saar et al. (1988) suggested that energy drain may have a modulator effect on the hypothalamic–pituitary set point at puberty, which in combination with low body weight, may delay the menarcheal age by prolonging puberty.

Many studies show that numerous factors such as genetic predisposition, diet, nutritional status, socioeconomic conditions, exercise, general health and climate act and interact synergistically to influence sexual maturity (Belsky et al., 1991; Rees, 1993; John et al., 2014). It is possible that some of these factors are the common causes of early onset of sexual maturity and obesity.

In general, the lower the anthropometric measurements, the less would be the possibility of the onset of menarche at an early age.

SUMMARY & CONCLUSION

The median age at menarche calculated by *status quo* method and mean age at menarche by recall method revealed that the onset of menarche among rural girls (Median: 13.18±1.09; Mean: 13.42±1.22 years) was later than their urban counterparts (Median: 12.74±1.12; Mean: 12.58±1.18 years). The results indicated that post-menarcheal girls were heavier, taller and had higher BMI scores than their pre-menarcheal peers. They also had greater waist circumference and hip-circumference than pre-menarcheal girls. Student t-test (p-value$\leq$0.05) indicated significant differences in almost all dimensions at various age-groups between pre and post- menarcheal girls among rural and urban areas. BAI and ABSI indicated higher adiposity levels among post-menarcheal girls compared to pre-menarcheal girls.

The study supports the association between body composition and age at menarche. But its cross-sectional design does not have the scope to establish the temporal sequence of events surrounding the age at menarche. Further longitudinal investigation is required to better understand the determinants of age at menarche. Early sexual maturation, its consequences and other factors like diet and lifestyle that may predispose to early menarche should be studied in-depth as a part of the strategy to address the health of adolescent girls.

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