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Growth Pattern and Menarcheal Status in Relation to Body Size and Physique among Adolescent Rural Girls of Pinjore-Nalagarh dun Valley.

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Abstract:

The present study aims at evaluating growth pattern, menarcheal status and its relationship with body size and physique in a cross-sectional sample of 229 adolescent rural girls (11to 17 years) from Pinjore-Nalagarh dun Valley of Tehsil Kalka. In all, 17 measurements were taken on each subject, which included linear measurements, girths and skinfold thicknesses besides weight. The study demonstrated an increase in all anthropometric dimensions with the advancing age. Rural adolescent girls experienced their growth spurt in height between 12 and13 years and for weight it was observed between 13 and 14 years. Their body mass index (BMI) values showed a rapid increase from 13 to 15 years. Mean values of ponderal index revealed that the girls were most linear at 13 years and subsequently added more weight for their corresponding heights. The median age at menarche of present sample, as calculated using status quo method, was found to be 12.88 ± 1.23 years. The results indicated that girls in whom menarche had occurred were significantly taller, heavier and had greater skeletal dimensions and subcutaneous fat than the girls who had not experienced this phenomenon. Post-menarcheal girls also demonstrated higher values of body mass index and had broader body build than their pre-menarcheal peers of the same age. It is apparent from the present study that body size influences the timing of maturation and linearity of physique is associated with late maturation.

KEY WORDS: Adolescents, Menarche, Body Mass Index, Ponderal Index.

Introduction:

Human growth from infancy to maturity is an orderly process, which is characterized by significant changes in body size and appearance. Adolescence is the most critical time period in an individual's life, which witnesses the major changes in the body, marking the greatest sex differentiation and determining the characteristics of an adult. A myriad of biological changes occur during puberty including sexual maturation, increases in height and weight, completion of skeletal growth accompanied by a marked increase in skeletal mass, and changes in body composition (Stang & Story, 2005). These changes are primarily due to the effect of gonadal steroids on the tissues. Significant physiological, psychological, and behavioural changes also occur during this period. Children of the same chronological age can vary considerably in biological maturity status. The size differences among children of contrasting maturity status are most apparent during adolescence, reflecting additional variation among individuals in the timing and magnitude of the adolescent growth spurt (Malina *et al.,* 2004).

Most of the sex differences of the body size and shape as seen in adults are the result of differential growth patterns at adolescence. During adolescence, girls usually trigger these changes, on an average, two years prior to their counter sex. The most noteworthy maturity indicator in females is age at menarche, i.e., the age at first menstrual period. The average age of menarche is highly variable; menarche can occur as early as 10 years of age or as late as 17 years of age. The onset of menstruation may be delayed in females who restrict their caloric intake and body weight or who are competitive athletes. Onset of menarche is also influenced by ethnicity, social class differences, number of siblings, birth order, geographical location, body mass index, body size and physique, education, occupation, skeletal maturity, physiological variables, physical activity and secular trends (Marshall and Tanner, 1986; Danker-Hopfe, 1986; Sharma *et al.*, 1988; Gustavo & Gonzales, 1994; Bagga & Kulkarni, 2000; Berkey *et al.*, 2000; Kaplowitz *et al.*, 2001; Okasha *et al.*, 2001; Chumlea *et al.*, 2003; Talwar & Bajwa, 2005; Kaplowitz, 2006; Kaur *et al*., 2009; Zegeye *et al.*, 2009). Age at menarche is known to be regulated by factors surrounding the time of puberty, such as adiposity. A minimum body fat mass is required to achieve menarche, and an increased body fat mass is associated with earlier puberty and menarche (Blum *et al.*, 1997). Knowledge of factors regulating the age of menarche is likely to improve our understanding of female reproductive health. It is affected by genetic and environmental factors (Eveleth and Tanner, 1990; Salces *et al.*, 2001; Ayatollahi *et al*., 2002). Age at menarche varies widely and is delayed in populations with poor nutrition (Thomas *et al.*, 2001; Gluckman and Hanson, 2006). Age at menarche serves as both an indicator of ovarian function onset and a predictor of ovarian frequency (Bernstein, 2002). Fat distribution independent of fatness is also significantly related to age at menarche (de Ridder *et al.*, 1992; Brown *et al*., 1996; Laseek and Gaulin, 2007). Early menarche is a risk factor for teenage depression (Kaltiala-Heino *et al.*, 2003), insulin resistance (Bavdekar *et al.*, 1999), and breast cancer in adulthood (Maskarinec *et al.*, 2006).

There exist a number of studies indicating that age at menarche has declined in developed countries (Anderson *et al.*, 2003; Anderson & Must, 2005; Biro *et al.*, 2006) and as well as in developing countries (Singh & Malhotra, 1988; Bagga & Kulkarni, 2000; Hwang *et al.*, 2003; Hosny *et al.*, 2005; Goon *et al.*, 2010). Generally, these declines are significantly associated with the improvements in nutritional status and general health along with many environmental factors. The downward trend seems to have halted in some countries (Whincup *et al.*, 2001).

A review of literature reveals numerous studies on relationship between growth and menarche. These studies have indicated that girls who attain menarche are significantly heavier and taller, broader with higher BMIs than those of their pre-menarcheal peers. To understand this basic biological relationship between body size, physique and menarche and to augment data in this direction, the present study has been conducted on 229 rural adolescent Punjabi girls of Pinjore-Nalagarh dun Valley of Tehsil Kalka.

Materials and Methods:

Material:

The present study is based on a cross-sectional sample of 229 adolescent Punjabi girls ranging in age from 11 to 17 years. The data were collected from the school going girls belonging to village Karanpur, Dhamala and Basawal of the dun area of Tehsil Kalka, District Panchkula (Haryana). Care was taken to include only those subjects who were apparently healthy. Dates of births of subjects were obtained from the institutional records. The chronological age was converted into decimal age using decimal age calendar given by Tanner and Whitehouse (1966). The subjects were divided into seven

yearly groups. Each age group included individuals not more than 6 months younger or older than the age group.

Area: Panchkula District is the newly formed 17th district of Haryana state in India. It comprises two sub divisions and two Tehsils named Panchkula and Kalka. The famous towns in the district are Kalka, Panchkula, Pinjore and Raipur Rani.The dun area lies close to Pinjore,which is famous for Yadavindra gardens. The schools of Dhamala, Basawal and Karanpur, where the study was conducted are at a distance of 2.5 km, 5 km and 10 kilometers respectively from Pinjore. The area has a sub-tropical continental monsoon climate where we find seasonal rhythm; hot summer, cool winter, and great annual range of temperature. The region also receives occasional winter rains. The dun area is inhabited by people of various castes i.e. Jats, Rajputs, Lobanas, Harijans, Lohars and Gujjars. The main language spoken by them is Punjabi.

Methods:

A total of 17 anthropometric measurements were taken on each subject following the techniques given by Weiner and Lourie (1969). The anthropometric measurements taken were: weight, stature, sitting height, four diameters (biacromial, bicristal, humerus bicondylar, and femur bicondylar), five circumferences (chest, abdomen, hip, upper arm, and calf), and five skinfolds (biceps, triceps, subscapular, and medial calf). Derived indices like Ponderal index [stature (cm)/ weight (Kg) ⅓] and Body Mass index [weight (kg) / height $(m)^2$], were computed for each individual using weight and stature. Ponderal Index was used to study physique of adolescent girls. Being a cross-sectional study, the whole year mean annual increments were calculated by subtracting the mean of the preceding age group from that of the succeeding group (Tanner, 1962). Information on menarcheal status was collected by *status quo* method. Socio-economic status of the subjects was measured on the basis of educational attainment and occupation of their parents through interview schedule. Most of the fathers were either working in factories or as labourers on daily wages. Some were artisans and only few took to farming. A majority of the mothers were house wives. Most of the parents were literates. Some had education up to primary level and only few were matriculates. The subjects belonged to low socio-economic status. The staple diet of the subjects included wheat, rice, pulses and seasonal vegetables. Milk and fruits consumption was negligible among them.

Statistical analysis:

The data so generated were statistically analysed to obtain measures of central tendencies and dispersion. Median age of menarche was calculated by probit analysis. The t-values have been used to compare the body size and menarcheal status of pre-menarcheal and post-menarcheal girls.

RESULTS:

Table 1 presents descriptive statistics of various anthropometric measurements and indices of rural Punjabi adolescent girls of Pinjore-Nalagarh dun Valley. A general trend of increase in the mean values of anthropometric measurements was witnessed from 11 to 17 years. During this period these girls gain 15.51% in stature, 57% in weight and 14.53% in sitting height. The sample girls experienced their first marked spurt in height between 11 to 12 years (5.28cm) followed by the peak height velocity (6.84cm) between 12 to 13 years. They also added weight with a greater pace from 12 to 14 years

Table - 1 Means and standard deviation of anthropometric measurements and indices of rural adolescent Punjabi girls of Pinjore-Nalagarh dun Valley.

VARIABLES	11 (32)	12 (30)	13 (46)	14 (32)	15 (30)	16 (30)	17 (29)
	Mean± S.D.	Mean± S.D.	Mean± S.D.	Mean± S.D.	Mean± S.D.	Mean± S.D.	Mean± S.D.
Weight (kg)	26.19±5.13	28.69±4.73	32.11±5.53	35.83±7.29	39.52±6.18	40.24±5.15	41.14±4.23
Stature (cm)	132.19±5.3	137.47±4.4	144.31±4.9	148.14±4.4	150.54±4.1	151.34±4.0	152.70±3.3
Sitting Height (cm)	68.82±3.39	71.16±3.14	73.84±3.82	76.49±4.40	77.92±3.40	79.03±2.56	78.82±2.61
Diameters (cm)							
Biacromial	28.41±1.78	29.38±1.54	30.49±1.79	31.68±1.82	32.55±1.66	33.35±1.65	33.15±1.12
Bicristale	20.59±1.36	21.36±1.52	22.31±1.76	23.52±2.09	24.54±1.86	24.69±1.45	25.25±1.09
Humerus Bicondylar	5.12±0.36	5.31±0.31	5.53±0.43	5.56±0.37	5.58±0.33	5.63±0.29	5.72±0.33
Femur Bicondylar	7.43±0.37	7.58±0.66	7.71±0.48	7.87±0.37	7.89±0.36	8.00±0.34	8.04±0.45
Circumferences (cm)							
Chest	59.72±5.57	61.50±5.12	64.81±5.05	68.89±7.43	73.11±6.59	74.24±6.38	75.73±3.80
Abdomen	55.00±5.34	57.16±3.95	58.57±5.07	61.64±5.76	63.04±5.23	62.36±5.57	62.74±4.68
Hip	63.04±4.84	66.24±5.30	69.60±4.97	74.03±8.12	77.07±6.61	77.75±5.17	79.28±4.23
Upper Arm	16.19±1.66	17.03±1.51	17.76±1.76	18.73±2.17	20.00±2.22	20.04±2.44	21.09±2.26
Calf	23.16±1.93	23.93±2.02	24.79±1.99	25.88±2.72	27.17±2.46	27.54±1.73	27.87±1.67
Skinfold Thickness (mm)							
Biceps	4.09±1.62	4.20±1.53	4.39±1.97	5.12±1.91	6.16±1.79	5.86±1.94	6.31±1.91
Triceps	7.19±2.51	7.21±2.11	7.44±2.78	8.28±2.87	9.48±1.54	9.79±3.38	9.79±2.32
Subscapular	6.12±2.10	6.34±1.97	7.22±2.47	8.56±3.59	9.62±3.08	9.83±4.69	10.55±2.57
Supra-iliac	5.66±2.82	5.76±2.09	6.51±2.82	7.50±3.42	9.62±3.21	9.34±3.07	9.55±3.07
Calf	6.47±2.32	6.48±1.92	7.24±2.47	7.84±2.45	9.45±2.79	9.52±3.37	9.45±3.07
Body Mass Index	14.86±2.01	15.22±1.82	15.31±1.54	16.12±2.37	17.31±2.02	17.56±2.01	17.62±1.39
Ponderal Index	44.80±1.80	45.10±1.90	45.50±1.30	45.30±1.70	44.40±1.60	44.30±1.72	44.30±1.20

registering maximum gain from 13 to 14 years (3.72 Kg). The circumferential measurements also showed progressive increase in the mean values from 11 to 17 years. The maximum annual increment for chest, hip, upper arm and calf circumference was observed between 14 and 15 years and for abdomen circumference between 13 and 14 years, as for body weight. Mean values for trunk as well as extremity skinfold thickness also witnessed an increasing trend with age. However, the magnitude of increase was more after 13 years. The maximum annual increment in biceps, triceps, suprailiac, and calf skinfold was noticed between 14 and 15 years and for subscapular skinfold between 13 and 14 years. Mean body mass index increased throughout the growth period under consideration. However, a rapid increase in the values as seen from 13 to 15 years clearly speaks of a better overall growth associated with menarcheal age during this period. Sample girls registered the minimum value for ponderal index as 44.3 at 17 years and the maximum value for this index (45.5) at 13 years, after which a gradual decrease in the mean values till 17 years was observed.

Table 2 compares the anthropometric measurements and indices of pre-menarcheal and post-menarcheal rural adolescent Punjabi girls from 12 to 16 years. As expected, post menarcheal girls exhibited significantly greater mean values for almost all the anthropometric measurements and indices from 12 to 16 years. They were significantly taller, heavier, broader, and had greater amount of muscle and subcutaneous fat than their pre-menarcheal peers. Their mean values for body mass index were also significantly higher from 13 to 15 years, than their counter parts. Higher ponderal index indicates a linear body build, i.e., less weight for height. Post-menarcheal girls showed lower mean values for ponderal index than pre-menarcheal girls, and possessed lateral body build.

In the present study, no girl experienced menarche before the age of 12 years and all the girls of 16 and above had experienced this event. Using probit analysis the median age at menarche was calculated to be 12.88 ± 1.23 years.

DISCUSSION:

To assess the growth status of any population it is necessary to investigate the growth patterns in various bodily dimensions and make a cross-comparison with the existing international and national standards to ascertain the magnitude and factors responsible for differences in the growth patterns in different populations. WHO (2007) has published 'Growth Reference data for 5-19 years' for both the sexes. Studies on affluent Indian children have also been carried out to provide growth norms (Aggarwal *et al.,* 1992, 2001; Khadilkar *et al.,* 2009).The present sample could not be compared with WHO reference data because of lack of weight percentiles beyond 10 years provided by these data. Therefore, it has been compared with NCHS reference data. To study the population differences, heights and weights of the sample girls have been compared with NCHS percentiles, well-nourished Indian Children (Aggarwal *et al.,* 1992; Khadilkar *et al.,* 2009), Punjabi girls from low and high socio-economic status (Talwar *et al.,* 1994); and all India average sample (ICMR, 1989).

As compared to NCHS reference data, weight curve of sample girls lied between 3rd and 5th percentiles up till 15 years, where after it runs below the 3rd percentile. Whereas, the height curve of these girls lied along the 3rd percentile till the age of 14, there after it joined the 5th percentile of the NCHS curve. WHO (1983a) recommended cut off point of -2SD (< 3rd centile) for undernourished children. On the basis of the above, sample girls can be described as suffering from stunted growth and wasting when they entered adolescence. The adolescent girls of the present study were considerably shorter and lighter when compared with affluent Indian children (Aggarwal *et al.,* 1992; Khadilkar *et al.,* 2009) as demonstrated in tables 3 and 4. It is also evident from the statistically highly significant t-

Table – 2: Means, standard deviations and t-values of anthropometric measurements and indices of rural adolescent Pre and Post-menarcheal Punjabi girls of Pinjore – Nalagarh dun Valley.

VARIABLES		12 (30)		13 (46)		14 (32)		15 (30)		16 (30)	
Absolute Measurements		O (13)	NO (17)	O (24)	NO (22)	O (19)	NO (12)	O (25)	NO (5)	O (24)	NO (6)
Weight (kg)	Mean	33.23*	25.53	35.67*	28.18	39.55*	29.42	41.20*	30.60	41.58*	34.33
	S.D.	3.47	2.23	5.19	2.42	6.06	4.19	4.71	4.32	4.68	1.80
Stature (cm)	Mean	141.37	134.42	149.07	139.06	151.78	141.98	152.44	141.28	152.55	145.55
	S.D.	6.13*	3.62	4.97*	4.83	3.75*	5.50	4.19*	5.77	5.64*	3.73
Sitting Height (cm)	Mean	73.52*	69.36	76.05*	71.45	78.53*	73.27	78.92*	72.94	79.46	77.32
	S.D.	2.49	2.29	2.93	3.18	3.42	3.83	2.51	2.90	2.59	1.53
Diameters (cm)											
Biacromial	Mean	30.41*	28.60	31.72*	29.16	32.57*	30.29	33.11*	29.78	33.80*	31.55
	S.D.	1.32	1.22	1.53	0.86	1.47	1.42	1.14	0.90	1.49	0.82
Bicristale	Mean	22.58*	20.44	23.36*	21.18	24.61*	21.81	25.13*	21.60	25.05*	23.27
	S.D.	1.28	0.93	1.77	0.80	1.48	1.74	1.31	1.39	1.33	1.01
Humerus Bicondylar	Mean	5.53*	5.16	5.75*	5.34	5.73*	5.32	5.68*	5.48	5.66	5.48
	S.D.	0.25	0.26	0.50	0.21	0.35	0.26	0.27	0.20	0.30	0.25
Femur Bicondylar	Mean	7.88*	7.39	7.85	7.58	8.09*	7.52	7.98*	7.44	8.08§	7.75
	S.D.	0.27	0.29	0.58	0.30	0.23	0.26	0.32	0.10	0.35	0.21
Circumferences (cm)											
Chest	Mean	65.44	58.50	67.51*	61.87	72.28*	63.54	74.88*	64.28	75.60#	68.78
	S.D.	4.44	3.23	5.07	2.99	7.10	4.01	5.59	3.30	6.34	2.44
Abdomen	Mean	59.39*	55.46	60.93*	56.00	64.47*	57.18	64.09#	57.80	63.40§	58.22
	S.D.	4.23	2.68	5.36	3.12	5.46	2.47	4.66	4.80	5.18	5.18
Hip	Mean	70.44*	63.04	72.78*	66.15	78.58*	66.83	78.84*	68.24	78.69§	74.03
	S.D.	4.38	3.37	4.24	3.04	5.91	5.52	5.42	4.68	5.31	1.92
Upper Arm	Mean	18.30*	16.21	18.62*	16.74	19.72*	16.99	20.44*	17.58	20.43	18.30
	S.D.	1.16	1.15	1.75	1.09	1.95	1.33	2.00	1.40	2.49	0.88
Calf	Mean	25.77*	22.67	25.69*	23.70	27.07*	23.84	27.75*	24.40	27.84§	26.27
	S.D.	1.30	1.39	1.94	1.49	2.18	2.36	2.19	1.50	1.73	0.57
Skinfolds (cm)											
Biceps	Mean	4.62	3.88	4.83	3.91	5.79#	4.08	6.36	5.20	6.08	5.00
	S.D.	1.78	1.23	2.36	1.28	1.99	1.19	1.81	1.33	2.06	1.00
Triceps	Mean	8.23§	6.59	8.29§	6.50	9.68*	6.88	9.72	8.60	10.08	8.67
	S.D.	2.36	1.75	3.32	1.56	2.77	1.38	1.54	1.02	3.64	1.25
Subscapular	Mean	7.54*	5.59	8.00#	6.27	10.00*	5.75	9.88	8.40	10.38	7.67
	S.D.	2.10	1.42	2.96	1.29	3.42	1.16	3.15	2.15	4.98	1.25
Supra-iliac	Mean	6.62§	5.06	7.12	5.68	8.84*	5.92	9.72	7.80	9.75	7.50
	S.D.	2.40	1.43	3.46	1.55	3.51	1.26	3.29	1.94	4.74	1.98
Calf	Mean	7.54#	5.82	7.96	6.55	8.53#	6.50	9.60	8.60	9.75	8.17
	S.D.	2.06	1.46	2.88	2.23	2.11	1.94	2.86	1.74	3.36	1.34
Body mass index (kg/m^2)	Mean	16.62	14.10	15.90*	14.50	17.10*	14.50	17.70*	15.20	17.20	16.20
	S.D.	1.48	1.23	1.62	1.03	2.37	1.23	1.90	1.17	3.87	1.51
Ponderal Index	Mean	44.42	45.70	45.40	45.80	44.70#	46.10	44.20	45.20	44.20	44.70
	S.D.	2.06	1.50	1.20	1.30	1.90	0.90	1.80	0.60	1.70	1.70

§ $p<0.05$ (significant) ; # $p<0.01$ (highly significant) ; * $p<0.001$ (very highly significant)

TABLE 3. Comparison of stature (cm) of the Present study with the stature of Affluent Indians and Punjabi Girls.

STATURE	11 yr	12 yr	13 yr	14 yr	15 yr	16 yr	17 yr
Present Study							
N	32	30	46	32	30	30	29
Mean	132.96	137.47	144.31	148.14	150.54	151.34	152.70
S.D.	7.09	6.06	7.08	6.52	6.22	6.01	5.02
Affluent Indians (Agarwal et al., 1992)							
N	503	435	455	391	291	176	116
Mean	141.3	146.7	151.4	153.6	155.0	155.1	157.1
S.D.	7.168	6.66	5.96	5.73	5.62	5.03	5.91
Affluent Indians (Khalidkar et al., 2009)							
Mean	143.2	149.1	153.0	155.2	156.3	156.8	156.9
Punjabi Girls (LSES)							
N	30	30	30	30	30	28	
Mean	134.49	142.33	147.75	148.64	151.98	152.03	---
S.D.	6.59	5.87	5.20	5.68	5.31	4.05	
Punjabi Girls (HSES)							
N	33	32	36	30	30	35	
Mean	141.37	149.11	152.46	155.66	156.35	159.64	---
S.D.	7.58	6.41	6.25	5.04	6.61	6.09	
Comparison of means							
t-test values:	17.07***	18.96***	18.56***	12.32***	9.73***	8.31***	8.80***
PS vs AI (1992)	2.26**	7.58***	5.75***	0.78	2.28**	1.15	---
PS vs LSES	12.33***	18.04***	13.97***	12.08***	8.72***	13.35***	---
PS vs HSES							

PS= Present Study; AI= Affluent Indians;
HSES= High Socioeconomic Status;
LSES= Low Socioeconomic Status
* $p<0.05$ (significant) ** $p<0.01$ (highly significant) *** $p<0.001$ (very highly significant)

TABLE 4. Comparison of weight (kg) of the Present study with the weight of Affluent Indians and Punjabi Girls.

WEIGHT	11 yr	12 yr	13 yr	14 yr	15 yr	16 yr	17 yr
Present Study							
N	32	30	46	32	30	30	29
Mean	26.19	28.69	32.11	35.83	39.52	40.24	41.14
S.D.	5.13	4.73	5.53	7.29	6.18	5.15	4.23
Affluent Indians (Agarwal et al., 1992)							
N	503	435	455	391	291	176	116
Mean	34.3	38.7	42.6	45.7	48.0	49.2	49.0
S.D.	8.06	8.54	8.52	8.88	9.19	9.12	7.74
Affluent Indians (Khadilkar et al., 2009)							
Mean	36.3	41.1	44.9	47.7	49.4	50.3	51.1
Punjabi Girls (LSES)							
N	30	30	30	30	30	28	
Mean	28.30	32.56	38.55	38.83	42.53	44.00	---
S.D.	5.47	4.54	7.23	6.83	6.47	6.23	
Punjabi Girls (HSES)							
N	33	32	36	30	30	35	
Mean	31.95	37.45	42.75	44.52	47.60	47.88	---
S.D.	6.67	7.01	5.63	6.32	6.64	4.62	
Comparison of means							
t-test values:							
PS vs AI (1992)	15.83***	18.42***	23.55***	18.07***	14.79***	15.43***	14.18***
PS vs LSES	3.55***	6.84***	10.89***	4.37***	4.55***	2.42**	---
PS vs HSES	9.4***	13.96***	19.99***	12.91***	12.12***	13.71***	---

PS=Present Study; AI=Affluent Indians; HSES= High Socio-economic Status;
LSES=Low socio-economic Status
* $p<0.05$ (significant) ** $p<0.01$ (highly significant) *** $p<0.001$ (very highly significant)

values observed between affluent Indians (Aggarwal *et al.,* 1992) and present sample. When compared with Punjabi girls of high socio-economic status, they are found to be shorter and lighter at all age groups, as is revealed from highly significant t-values. As compared to Punjabi girls of low socio-economic group they were also found to be lighter and shorter at all age groups and statistically significant values for weight were observed at all age groups but for stature from 11 to 13 and at 14 years only. However, their growth curves for weight and height are comparable with similar curves of ICMR (1989). The poor growth performance of rural adolescent Punjabi girls may be attributed to poverty, poor diet, and poor living conditions that points towards nutritional inadequacies.

Peak height velocity and menarche are major events of adolescence. Both landmarks of adolescence occur when a major percentage of adult height has been attained. The growth in height that remains after these events is called final phase of growth (Roche, 1989). In the present study, median age at menarche of rural adolescent girls using probit analysis was found to be 12.88 ± 1.08 years. Age at menarche is well correlated with age at peak (Tanner and Whitehouse, 1976). In our study median age at menarche coincided with peak height velocity (PHV). PHV and gain in body fat influenced menarcheal age prominently. Under nutrition only delays onset of adolescent events in terms of chronological ages but neither the sequence of events nor the time between two consecutive events namely, age at PHV and age at menarche (Rao *et al.,* 1998). Age at menarche has been reported in several parts of the world and the most extensive summary of reported age at menarche in populations around the world based on status quo method and probit analysis is provided by Eveleth and Tanner (1990). About 60% of the median ages at menarche range between 12.50 and 13.49 years.

When compared with other Indian studies, sample girls report similar median age at menarche as that of Bania girls (12.88 years) of Mandi Gobindgarh, Punjab (Talwar and Kaur, 1999). They showed an early median age at menarche as compared to Punjabi girls of Chandigarh from lower socio-economic status (13.18 years) studied by Kaul *et al.* (1997); Meitei girls of Manipur (13.34 years) reported by Talwar & Singh (1994); Punjabi twins (13.03 years) reported by Sharma (1982); Solan Rajput girls (13.00 years) studied by Talwar & Bajwa (2005); rural (13.62 years) and urban (13.31 years) Jat Sikh girls studied by Mokha *et al.*(2006); Scheduled caste girls from Naraingarh (13.40 years) reported by Sharma and Shandilya (2005) and Rajput girls of Theog (13.7 years) studied by Talwar *et al.* (2010), but later median age at menarche than Punjabi girls (12.54 years) from higher socio-economic status (Kaul *et al.*, (1997); Punjabi urban (12.06 years) and rural girls (12.74 years) reported by Sharma & Sharma (2005); Bengali girls (12.03 years) from Kolkata (Ghosh *et al*., 2005) and rural girls from Puruila, West Bengal (12.60 years) reported by Banik, (2011). Singh and Malhotra (1988) studied secular shift in median age at menarche of Patiala girls between 1974 and 1986 and concluded that median age at menarche of higher social class was 12.90 years in 1974 and 12.54 years in 1986 and of lower social class girls 14.40 years in 1974 and 13.65 years in 1986. The study supported that social class differences during this period had decreased. It is well documented that an individual's menarcheal age depends on genetic potential and health status which in turn is governed by various environmental factors. The growth studies also reveal that growth during adolescence is less affected by environmental factors than growth during the previous stages and is said to be more under genetic control. A trend towards increased age at menarche with an increase in altitude has been observed by many researchers (Kapoor & Kapoor, 1986; Gustavo & Gonzales, 1994). In girls low birth weight followed by catch up growth has been associated with earlier menarche (Ibanez *et al*., 2000; Ibanez & de Zegher, 2006). Furthermore, it has been suggested that girls need to reach a critical weight for height for menarche to occur and changes in dietary habits as observed in children may have caused this critical weight to be reached at an earlier age (Maclure *et al.,* 1991; Baanders and de Waard, 1992; Hauspie *et al.,* 1997; Stoll, 1998). It is still unclear whether energy intake or specific nutritional components play role or whether nutrition affects menarche through its affect on

accumulation of adipose tissues (Kissinger and Sanchez, 1987; Moisan *et al.,* 1990; Merzenich *et al.,* 1993).

Early maturing children have on average greater body weights as young adults and have greater weight for height (BMI) than average maturing and late maturing children. The differences in body weight and the BMI persist into adulthood. The trends suggest physique and body composition differences among children who differ in maturity status. They have relatively broader hips relative to shoulders and leg length accounts or a greater percentage of stature in late maturers. They also have more subcutaneous adipose tissue at all ages but the differences are more marked during adolescence (Malina *et al.,* 2004).

Table 2 clearly demonstrated that the post-menarcheal girls were significantly taller. heavier, broader, had greater muscle and fat mass as compared to pre-menarcheal girls of the same age groups from 12 to 16 years. They also showed significantly greater mean values for body mass index than their pre-menarcheal peers from 13 to 16 years. Rural adolescent Punjabi girls with high ponderal index had a later menarche than those with low ponderal index values. Comparison of body size and ponderal index suggests that linearity of physique is associated with late maturation. These findings are in accordance with the earlier studies (Ghai, 1977; Zacharias and Rand, 1983; Sharma *et al*., 1988; St. George *et al*., 1994; Talwar and Singh, 1994; Singh *et al.,* 1998; Koprowski *et al*., 1999; Hesketh *et al.,* 2002; Biro *et al.,* 2003; Janssens *et al.,* 2003; Ghosh *et al.,* 2005; Talwar and Bajwa, 2005; Sloboda *et al.,* 2007; Kaur *et al.,* 2009; Goon *et al.,* 2010). Dietz *et al.* (2005) also found an inverse association between increasing weight and earlier age at menarche. A gain in overall fatness and subcutaneous adipose tissue appears to occur during the transition from the pre-menarcheal state to post-menarcheal state. The gain in body fat may be one of the key signals, possibly through secretion of the fat derived protein leptin, for stimulating the hypothalamus to increase secretion of gonadotropin releasing hormone (GnRh) (Wilson *et al.,* 2003), which in turn stimulates the pituitary ovarian axis and initiates the pubertal stage. Many previous studies support the general belief 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 relation 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). It is apparent from the present study that body size influences the timings of sexual maturation and linearity of physique is associated with late maturation.

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