ORIGINAL ARTICLE

Relationship of Body Mass Index with Pubertal Stages and Age at Menarche in Pakistani girls

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ABSTRACT

Aim: To determine the relationship of BMI, age at menarche and stages of puberty.
Study design: It is a cross-sectional analytic study.
Methods: One hundred and fifty two girls were selected from different schools in Lahore. The sample was divided into 10 groups, comprising approximately 15 girls in each age group with age range of 8.0 to 17.99 years. Their demographic data and anthropometric was collected to determine BMI. Age of menarche was obtained through a questionnaire. Stage of puberty was determined by inspection and palpation according to Tanner's staging system. Data was entered into SPSS version 16 and analyzed. Spearman correlation test were applied to observe correlation between the variables.
Results: There is strong positive correlation between BMI and pubertal stages, (rho = 0.734, and p=0.000). The mean age at menarche was 12.76±1.24 years. Pre menarche and post menarche BMI is (16.13±2.48 vs 20.22±3.53 kg/m^2). The percentages of menarcheal girls in underweight, normal weight and overweight girls were 34.62%, 49.51% and 73.91% and the mean age at menarche was 13.61±1.67, 12.88±1.06 and 11.96±1.15 years respectively (p< 0.002).
Conclusion: There is strong positive correlation between BMI, and mean pubertal stages. This study indicates that high BMI leads to earlier start of puberty and low BMI thus leads to delayed onset of puberty and menarche.
Keywords: Body mass index, BMI, Puberty, Pubertal stages, Age at menarche

INTRODUCTION

Puberty in girls is manifested by development of secondary sexual characteristics that begins almost three years prior to menarche. Onset of puberty is modestly correlated with age at menarche (AAM)[1].It has been suggested that AAM is influenced by geographical location, differs by race, age and ethnicity and may be under the influence of genetic factors.[2]Other factors such as nutritional conditions, and secular trends have been proven to influence the physiological range in age at the onset of puberty[1,2]. Several recent studies suggest that the timing of the onset of puberty in girls has become earlier over the past 30 years[1,3].

Different studies have reported a relationship between body mass index (BMI) and timing of pubertal onset in girls[4,5,6]. There are sufficient evidences that a certain degree of body fat is compulsory before pubertal development[4,5,7] and but exact causality is yet to be proved. Majority of the studies tried to examine this relationship through cross-sectional analyses[4,8,9] but some studies were carried out longitudinally[9,10]. Secular trend in breast development as early as 3 years, 5 years, and 7 years of age is reported[11,12.13] and menarche at an earlier age, as early as 8 years.[14] A growth spurt with increased BMI, 2 years prior to puberty is reported[15]. This paper will try to establish a relationship between BMI and stages of puberty and AAM in Pakistani school going girls.

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METHODOLOGY

This is a Cross sectional analytical study. One hundred and fifty two apparently healthy girls, with no pathology, age range from 8 years to 17.99 years, representing all pubertal stages (according to female Tanner staging) are recruited in the study from different schools and colleges of Lahore. All the girls were divided into 10 groups (approximately 15 girls in each group). Group 1 consisted of 8 to 8.99 years, group 2 consisted of 9 to 9.99 years, group 3 consisted of age group 10 to 10.99 years, group 4 consisted of 11 to 11.99 years, group 5 includes 12 to 12.99 years, group 6 consisted of 13 to 13.99 years, group 7 includes 14 to 14.99 years, group 8, 15 to 15.99 years, group 9, 16 to 16 .99 years, and the last group 10 includes girls of age 17 to 17.99 years. Data was obtained after getting permission from school administration. Fully informed, understood and voluntary consent was obtained from parents of girls for examination the patients, collecting data and using their data in this research. Confidentiality of the data was ensured. Questionnaire was discussed in detail and permission was taken from Ethical Committee of Post Graduate Medical Institute Lahore and Advanced Study Review Board, University of Health Sciences Lahore. Complete demographic information (name, age, address) was obtained. Date of birth was recorded and confirmed from school register. Then decimal age of each child was calculated from decimal chart.[16] The cases were examined for recording stages of puberty as per Tanner's staging.[17]Breast development was evaluated by inspection and palpation. Breast stage 1 prepubertal stage (B1) Breast stage 2 (B2) corresponds palpable glandular tissue under areola and elevation of papilla. Breast stage 3 (B3) was further enlargement of breast and areola with no separation of contour, stage 4 (B4) where areola and papilla form secondary mound, above the level of breast, and stage 5 (B5) was assigned the mature breast with only

papilla elevation. Development of pubic hair was evaluated according to photographic norms of stages of puberty by inspection as well as standardized drawing and description based on Tanner criteria[18].

Self reported age of onset of menarche was recorded. Most of the girls claimed that they remember their exact year and month of first bleeding. The age was cross checked from elders. Age of menarche was also calculated in decimals[18,19]. Their body weight (up to 0.1 Kg) was recorded by aportable standardweighing scale in kilograms in normal school clothes without shoes. Their height was measured in meters (up to 0.1cm) without shoes with mandible plan parallel to floor with portable manual height board[19]. BMI was calculated by dividing weight in Kg by square height in meters.

RESULTS

The data of the groups in relation to mean age, and mean BMI with standard deviations is shown in table 1. Data of pubertal development is shown in tables 2. Majority of our subjects were still going through the puberty (58%). Second major bulk (25.7%) of the girls, were still at pre-pubertal stage (Tanner stage 1), and 15.8% were at stage 5 (post pubertal stage).

Out of these 152 girls, 77 girls (50.70%) had passed the milestone of menarche. The youngest AAM was 10.32 years, and maximum AAM was 16.9 years. The mean AAM was 12.76±1.24 years, and median was 12.68 years. Mean pubertal stage II started at the age of 11.36±1.84 years, while breast development (B2) started at the age of 11.36±1.8 years. Table 2 shows relationship of the BMI (kg/m^2) to different mean pubertal stages. The BMI differs significantly in different pubertal stages. The Spearman's correlation test was applied to see the relationship between BMI and mean pubertal stages. Highly significant positive correlation was observed showing that BMI increases with increase in mean pubertal stage, (Spearman's correlation coefficient rho = 0.734, and p <0.000). Seventy seven girls had menarche having mean body mass index of 20.21±3.54 kg/m2 and 75 girls had not menarche, having mean body mass index of 16.13±2.55 kg/m2 revealing a significant difference of BMI of menarcheal and non menarcheal girls.

Pearson's correlation test was applied to see relationship between BMI and AAM. Figure 2 showed significant negative correlation between BMI and AAM it was observed that as BMI increased the AAM decreased (r = -0.334, and P <0.003).

Out of total 152 girls, 26 (17.10%) girls were under weight, (BMI less than 5th percentile, group 1), 103 (67.80%) girls were of normal weight, BMI (between 5th to 85 percentile, group 2) and 23 (15.10%) girls were overweight (BMI more than 85th percentile, group 3). The effect of BMI on AAM was shown in table 3. This table shows that percentage of menarcheal girls were significantly higher in normal weight girls than under weight, and in over weight girls than normal weight girls. The AAM significantly decreased with increase in BMI especially in over weight girls. This table also indicated that overweight girls were in later pubertal stages. A strong positive correlation was seen between BMI groups and mean pubertal stage, rho = 0.734, P < 0.000. A significant negative correlation was seen between AAM and BMI group, indicating AAM decreases as BMI group advances, r =-.391, P<.000 (table 3).

Table 1: Anthropometric measurement with BMI of the subjects.

Group	N	Age Range (Mean Age) (Years)	BMI Kg/m^2 Mean ±S.D
Group 1	15	8-8.99 (8.40)	15.62±1.50
Group 2	16	9-9.99 (9.37)	15.81±2.45
Group 3	17	10-10.99(10.57)	16.66±2.96
Group 4	15	11-11.99 (11.40)	17.01±3.45
Group 5	15	12-12.99 (12.60)	17.11±2.92
Group 6	15	13-13.99 (13.57)	18.44±2.50
Group 7	15	14-14.99 (14.44)	18.91±2.78
Group 8	16	15-15.99 (15.40)	19.63±4.08
Group 9	13	16-16.99 (16.54)	22.82±4.34
Group10	15	17-17.99 (17.45)	20.84±3.28
Mean	152	12.89	18.20±3.70

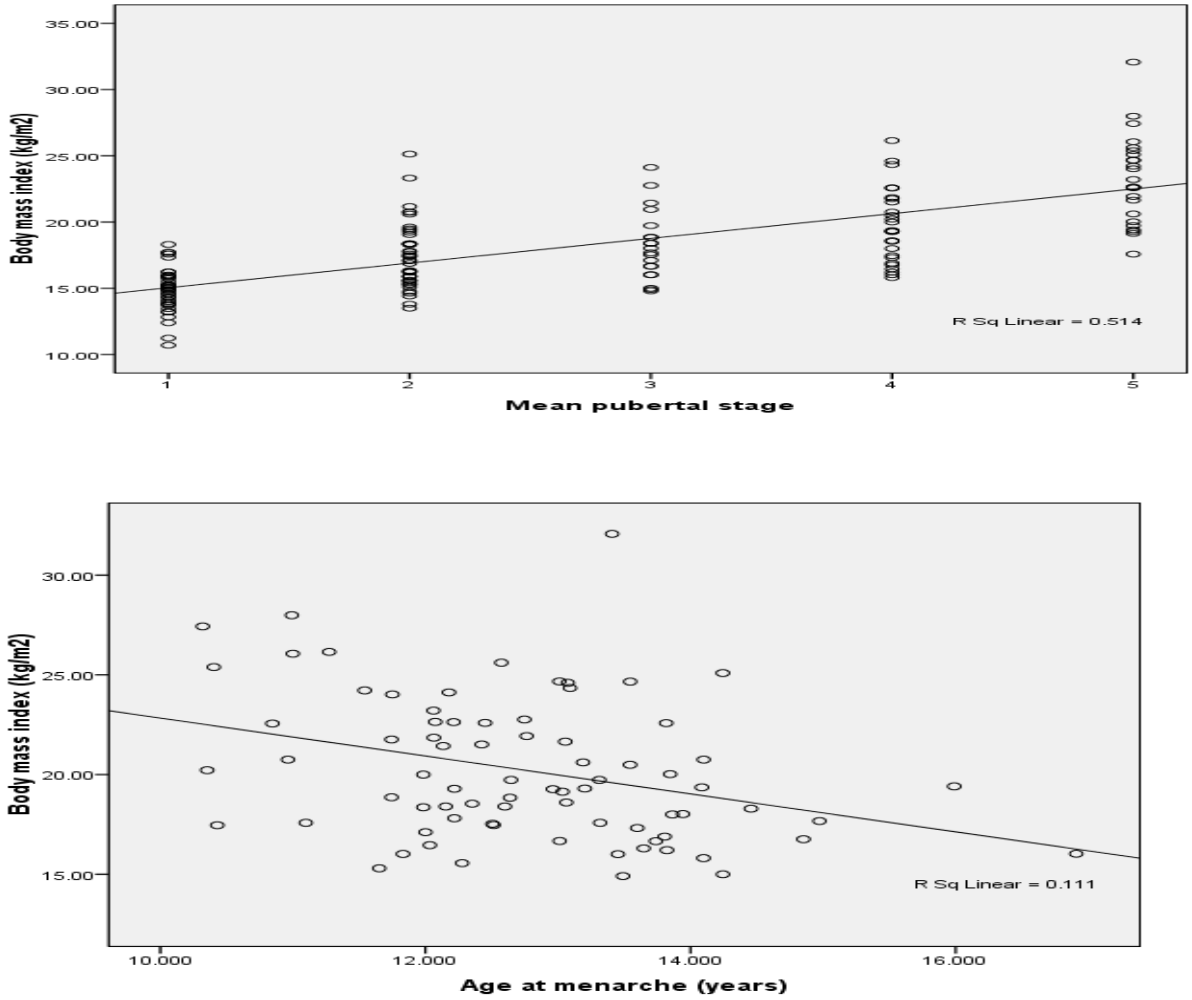
Table 2: Data of pubertal development (Mean pubertal stages).

Pubertal stage	Frequency	%age	Age Range(Mean Age) (Years)	BMI Kg/m^{2}Mean ±S.D
Mean pubertal stage 1	39	25.7	10.13±1.67	14.90±1.66
Mean pubertal stage 2	43	28.3	11.36±1.84	17.44±2.47
Mean pubertal stage 3	20	13.2	14.53±1.45	18.20±2.57
Mean pubertal stage 4	26	17.1	15.32±1.85	19.72±2.85
Mean pubertal stage 5	24	15.8	16.11±1.30	23.23±3.36

Table 3: Menarche and mean pubertal stages in BMI group (n=152)

BMI Groups According to Percentile	n	BMI Kg/m^2 (Mean ±SD)	No of menarcheal girls in each group	% of menarcheal girls in groups	AAM (Mean±SD)	Mean pubertal stage in each group
Group 1:Under weight <5th percentile	26	14.35±1.63	9	34.62%	13.61±1.67	1.92±1.13
Group 2: Normal weight: 5th to 85th percentile	103	17.85±2.45	51	49.51%	12.88±1.06	2.64±1.38
Group 3: Overweight >85th percentile	23	24.08±2.98	17	73.91%	11.96±1.15	3.78±1.31

Fig. 1: Relationship of BMI (kg/m^2) to different mean pubertal stages. rho = 0.734, and p <0.000



DISCUSSION

Puberty is a process, that evolves slowly and actually begins many years before the first physical signs or biochemical changes are observed. Sufficient evidences suggest that a certain degree of body fat is compulsory before sexual maturation may proceed[4,5,7]. The main etiological factors leading to early onset of puberty are obesity and environmental chemicals[3,10,20]**.** The changing level of calories in the body, intake of food, ratio of lean mass to fat mass, or amount of fat stores may affect the hormonal secretion from hypothalamus. All these factors may be exerting a permissive action in initiation of puberty[5].

BMI is an indicator of total body fat of the person[21] . Body fat is not measured by BMI directly but BMI correlates to actual measurement of body fat. BMI can be easily calculated and is non expensive method. So it is substitute for direct measures of body fat[21]. Many studies strongly support the hypothesis, that higher childhood BMI is responsible for early occurrence of puberty [3,5,19,22,23,24]**.**

The above theory is supported by the findings that if a women loses 10 to 15% of weight, or one third of body fat, it leads to amenorrhea [7,25]. The reproductive capability of an adult female directly depends upon suitable percentage of body fat (23-29%). Calorie required for pregnancy is 50,000 kilocalories above normal and for lactation is almost half of above calories per month. Puberty can advance only when the women contains adequate amount of adipose tissue[7]. The reasonable amount of fat mass or body composition in humans may be also a triggering signal for the onset of puberty, or it may act as a permissive factor that will complete the sexual growth and maturation. The above findings are supported by two studies which noted that body fat in pre- pubertal girls was 16%, and at puberty it was 23.9% to 24.6% of body weight. Moreover body weight at menarche was 48 to 50.6 kg and the ratio of lean mass to body fat was 3[23].

In our study, mean pubertal stage II and B II started at the age of 11.36±1.84 years. This data suggested that pubertal stages in girls of normal weight had also declined significantly in Pakistan, although Pakistani girls did not have optimal nutritional and health status compared with USA [26,27]. Comparing our results with that of eastern Turkish girls, our result generally corresponds them in early stages as in that study, B2 through B5, 11.48, 13.45, 14.64, and 14.78 year[28]. The results of another study revealed early B2 started at 9.65 years, while rest stages are at age

10.10, 11.75, and 14.17 years[29]. In later stages, the development of our girls was much delayed. Contrary to our study, development of B 2 stage was much earlier in a study done in Copenhagen, which compared the results of cohort of 2006 with that of 1991, revealing B2 stage was much earlier in 2006 [20]. The results of a study carried in USA in 1997, also revealed earlier B2 development as early as 7 to 8 years especially in African American than white American girls [4] .

In our study the mean BMI differs significantly in different pubertal stages. The Spearman's correlation test revealed a highly significant positive correlation (rho = 0.734, (P<0.000) between BMI and mean pubertal stages, The results of our study correlates well with Blum et al who reported that progressive BMI increases from stage 1 to 5, having BMI of 16.30 ±2.10, 16.94±1.59, 18.11±2.23, 18.45±1.63 and 21.20±2.39 kg/m2 respectively[30].

Burrow et al., 2004 conducted a study to see the relationship between BMI and pubertal stages with chronological age in school attending subjects. The study disclosed that the age of onset of puberty (Tanner Stages B2) varied greatly, from 8 to 14 years in females. Mean BMI in a specific stage of pubertal development did not show significant differences. However, there were significant difference (p<0.05) in mean BMI when comparing children of the same chronological age but differ in Tanner stages. Per each stage of Tanner development, increase of BMI 1.0 point or more among females was seen. So he concluded that during puberty, BMI increases with advancement of pubertal stages and is associated to biological and not chronological age[31] .Bini et al also supported the findings by reporting that BMI values depend on pubertal development especially in girls and stated that BMI varied according to age and pubertal stage. In this study, girls of similar age demonstrated a significant differences of BMI values at different pubertal stages in 11□□□□14 year old females (*P*<0.001). BMI values were significantly higher in post-menarche girls as compared to pre-menarche girls similar in age (*P*<0.001) [2] .Kaplowitz et al reported the BMI-ZS were markedly higher in pubertal versus prepubertal, 6- to 9-year-old girls; although the difference was less marked in black girls. This study by multivariate analysis, confirms that obesity (as measured by BMI) is significantly associated with early puberty [4]. Rosenfield et al (2009) reported that girls with excessive BMI had a significantly higher prevalence of breast appearance from ages 8.0 through 9.6 years and pubarche from ages 8.0 through 10.2 years than those with normal BMI. Menarche was also significantly more likely to occur in preteen girls with an elevated BMI [6,8].

Contrary to above findings Bazraafshan et al disagreed and stated that on set of breast development started at 10.55±1.11 years, and stressed that there is no association between mean height, weight and BMI and pubertal stages and menarcheal age[1]. Aksglaede et al (2009) reported that onset of puberty, (Tanner breast stage 2+), occurred significantly earlier in the 2006 cohort (estimated mean age: 9.86 years) when compared with the 1991 cohort (estimated mean age: 10.88 years) but the difference remained significant after adjustment for BMI. So concluded that BMI did not explain these marked changes, which suggests that other factors may be involved[20].

Continuous decrease in menarche age was also observed throughout world. The mean AAM in our study is 12.76±1.24 years, while in another study, the reported AAM in Indo-Pakistani girls was 13.06±0.20[32]. The results of Ulijaszek et al. (1991) correspond with results of Marie Stopes, in which reported AAM was13.6 years[33]. This is also supported by a recently carried out study from Karachi Pakistan, which reported AAM 11.73±1.2 years[34]. The reported average AAM in African American girls is 12.16 years, white Americans 12.88 years [4,19], and Irani girls, is 12.5±1.1 years[35].

Comparing BMI in premenarche and postmenarche girls in our study, BMI was lower in pre menarche girls; and significantly higher in post- menarche age (16.13±2.55 vs 20.21±3.54 kg/m^2) (figure 2). The National Survey of Indonesia also supported our finding demonstrating the average age at first menarche was 12.96 years with mean BMI at menarche 19.17 kg/m^2. They also showed that premenarche was associated with lower BMI, and postmenarche girls had higher BMI supporting our finding[36.]

Another study carried in Sabzevar Iran, the average age at first menarcheal period was 12.5±1.4 years and mean BMI in menstruating and non menstruating girls was 21.3± 4.2 kg/m^2 and 18.43± 3.6 kg/m^2 respectively[37]. Maisonet et al. (2010) in their study showed that higher BMI and gain of weight during early infancy also lead to an early puberty attainment [36]. In our study only 34.62% of girls were menarcheal among under weight (<5th percentile), 49.51% among normal weight (between 5th to 85th) and 73.91% of girls among overweight girls (>85th percentile). Our findings correlate well Mounir et al which stated that 7.5%, 37.8%, and 65.6% of the girls were menarcheal among underweight, normal weight, and overweight girls[39]. AAM in our study in underweight, normal weight and obese girls was 13.61±1.67, 12.88±1.06, and 11.96±1.15 years respectively. This correlate well with finding of Bau et al, who reported 13.7, 12.9, and 12.5 years at age menarche in underweight, normal weight and obese girls[40]. Al-Awadhi et al also stated 12.61 years AAM in normal weight and 12.00 years in overweight girls[41].

As our study was cross sectional in nature we had information about BMI of girls at the specific time of puberty at which the reading was recorded and not that particular time when they became menarcheal, but still, it was demonstrated that menarcheal girls were having higher BMI than non menarcheal girls.

Majority of the cross sectional studies, that have disclosed the relationship of early onset of pubertal development and increased weight in girls have not answered the query of whether increase in body fat subjected the girls to earlier pubertal development or earlier pubertal development of girls had lead them to an estrogen generated rise in body fat. However, there are evidences from longitudinal studies showing rise in weight gain precedes the initiation of early pubertal development in girls[24]. Another longitudinal study, examined the subjects as children, adolescence and adult. This study reported that fatty children underwent menarche earlier than did thinner children and adult adiposity was strongly associated with childhood adiposity and early AAM[22]. Indirectly our study also supported this finding.

CONCLUSION

BMI values vary in relations to level of sexual maturation. A statistically significant positive trend was seen for pubertal development in relation to BMI increase in our series. Age at menarche was inversely related to BMI values. In this series, a statistically significant BMI difference was seen between premenopausal and postmenopausal girls.

Limitation of study: These findings should be considered under the light of our study limitations. The main limitation of this study is that it is a cross-sectional in nature. Longitudinal study may be more beneficial to establish the exact relationship between BMI and pubertal stages

Conflict of interest: Nothing.

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