

Association between puberty and weight, height and Body Mass Index in a developing community

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Abstract

Objective: To evaluate the epidemiology of pubertal development of girls in a developing community.

Methods: The cross-sectional study was undertaken in July 2005, on 788 healthy 7-16 years old girls in Gorgan, the most populous city of Golestan province in northern Iran. Physical examination, was performed and height, weight and body mass index were noted. Pubertal stages were assessed by clinical examination according to the methods of Marshall and Tanner, while the mean menarcheal age was calculated by using the status quo method. The data was treated with analysis of variance Pearson's linear regression and SPSS version 16.0.

Results: The mean age, weight, height and BMI \pm standard deviation of the studied girls were 10.32 \pm 2.48 years, 35.07 \pm 11.30 kg, 140.11 \pm 14.62 cm, and 17.34 \pm 3.55 kg/m² respectively. Menarche had occurred with the mean menarcheal age being 12.15 \pm 1.11 years. The mean age at the onset of breast development was 10.55 \pm 1.57 years. There was no significant association between mean height, weight and BMI and the menarcheal age and pubertal stage.

Conclusion: Based on the epidemiology of pubertal development of girls in the study, there seems to be a case for creating particular guidelines for pubertal development assessment for each type of society in addition to the standard international guidelines in this regard.

Keywords: Puberty, Menarche (JPMA 62: 454; 2012).

Introduction

Puberty in girls manifested by development of secondary sexual characteristics begins almost three years prior to menarche. In fact, pubertal onset is modestly correlated with age at menarche.¹ The event is of paramount importance in the biological and physical condition of women, as early maturation has been linked to adverse health outcomes, including insulin resistance, breast cancer and cardiovascular diseases.²

It has been confirmed that age at menarche is influenced by geographical location, and differs by race and ethnicity.³ The variability involves genetic factors, as studies on heritability of menarcheal age indicate,⁴ although the molecular determinants remain unidentified. Other factors such as ethnicity, nutritional conditions, and secular trends have been proven to influence the physiological range in age at the onset of puberty.⁵ Changes at the time of puberty have implications for the treatment of individual children for diseases later in life, and for chemical testing and risk evaluation for the overall population. Children with early puberty are at a risk of accelerated skeletal maturation and short adult height, early

sexual debut, potential sexual abuse, and psychosocial difficulties.⁶ Several recent studies suggest that the timing of the onset of puberty in girls has become earlier over the past 30 years, and there is strong evidence that the increasing rate of obesity in children over the same period is a significant contributing factor.⁷

These evidences have prompted the Lawson Wilkins Paediatric Endocrine Society to review the current guidelines for the ages at which the cause of PP (precocious puberty) should be searched for, and it was recommended to lower the existing standards from 8 to 7 years for white girls and to 6 years for black girls.⁸ The suggested American guidelines would not be appropriate for the population of girls in developing nations. Therefore, we designed this study to evaluate the epidemiology of pubertal development of girls in the developing community of Iran.

Subjects and Methods

The cross-sectional study was undertaken in July 2005, on healthy girls, 7-16 years of age in Gorgan, which is the most populous city of Golestan province in northern Iran. Considering the estimated population of 40,000 girls

between the ages of 7 and 16 living in Gorgan, and taking 95% confidence level and 4% confidence interval, we calculated the sample size of 600, which was further increased to 800 to increment the power of the study.⁹ As such, 500 primary school students and 300 junior high school students were randomly selected through the clustering sampling method. Girls who were afflicted by endocrine disorders were excluded, leaving the final study population to be 788 girls.

In the first stage, the province was divided into four geographical regions. Then, one primary school and one junior high school were selected randomly from each of the regions. Subsequently, physical examination, height and weight measurements were carried out on the randomly selected students. At the same time, demographic data was collected through interviews. Weight was measured on a portable scale which was checked for precision daily. Height was assessed using a stadiometer to the nearest 0.1 cm, and body mass index (BMI) was calculated as weight (in kilograms) divided by height (in meters) squared. Pubertal stages was evaluated by clinical examination in accordance with methods devised by Marshall and Tanner,³ i.e., breast stages 1-5 through palpation: breast stage B2, corresponding to the breast bud stage with palpable glandular breast tissue and elevation of the papilla; stage B3, with further enlargement of the breast and areola with no separation of the contours; stage B4, where the areola and papilla form a secondary mound above the level of the breasts; and stage B5, in the case of the mature breast with projection of the papilla only. The mean menarcheal age was calculated by the status quo method (menarche yes/no).³

The study was approved by the ethical committee of the Golestan University of Medical Sciences. Thereafter, members of the community schools were approached and invited to participate. They all voluntarily agreed to take part in the study, and were included after having consent from either parents or the school administrator.

The effects of weight, height and BMI on pubertal stages were assessed using one-way analysis of variance (ANOVA) and Pearson's linear regression analysis. All quantitative data was expressed as mean \pm standard deviation (SD), and P value <0.05 was considered statistically significant. All analyses were performed using SPSS 16.0.

Results

The study population was divided into 4 groups depending on the city area. There was no significant

Table: Mean age of menarche in different populations.

Region	Mean Age at Menarche	BMI
Iran (Present Study)	12.15 \pm 1.11	17.34 \pm 3.55
Portugal ²⁶	12.4 \pm 1.8	20.4 \pm 3.5
Italy ²⁷	12.50 \pm 1.29	20.8 \pm NA*
Greece ²⁸	12.58 \pm 0.70	-
France ²⁸	12.78 \pm 0.20	-
Kenya ²⁹	14.9 \pm 1.1	15.6 \pm NA*
Turkey ³⁰	12.83 \pm 1.06	20.95 \pm 3.13
Spain ²³	11.9 \pm 0.10	-
Poland ²⁸	13.08 \pm 1.03	-
United States ¹⁷	12.9 \pm NA*	16.9 \pm 3
Tanzania ¹²	14.3 \pm 1.1	-

*Not Available.

difference in the ethnic distribution in these areas. The mean age, weight, height and BMI of the studied girls were 10.32 \pm 2.48 years, 35.07 \pm 11.30 kg, 140.11 \pm 14.62 cm, and BMI 17.34 \pm 3.55 kg/m². In the study population, menarche had occurred in 172 (21.8%) cases, with the mean menarcheal age of 12.15 \pm 1.11 years. The lowest menarcheal age was 8.75 years and the oldest girl without menarche was 15.17 years.

The mean age at the onset of breast development (B2 stage) was 10.55 \pm 1.57 years. We found a mean age at PH2 (Pubic Hair Stage 2) of 12.86 \pm 1.51. There was no significant association between mean height, weight and BMI and the menarcheal age (p values of 0.26, 0.32, and 0.18, respectively) and pubertal stage (p values of 0.31, 0.30, and 0.21, respectively).

Discussion

Comparative data (Table-1) demonstrates that despite differences of genetic, social and economic factors in different populations, the age at the onset of menarche appears nearly the same in all developed and developing communities, except for two African countries (e.g., 14.9 \pm 1.1 in Kenya and 14.3 \pm 1.1 in Tanzania), where girls experienced menarche relatively late. The data supports the hypothesis of Heger et al,¹⁰ according to whom the relation between obesity in children and earlier onset of puberty is controversial. The researchers argued that once girls had reached a standard weight for entering the maturation process, further increase in body weight does not advance the onset of puberty. However, some developing areas, such as the African countries, with its local environmental factors, are governed by specific rules.¹¹ In 2008 Nematian et al.¹² investigated the intestinal parasitic infections in children of school age in a developing community and concluded that numerous social, economic and behavioural factors had adverse effects on growth among school-age

children. We are convinced that complex local factors in developing countries influence pubertal development. In fact, different demographic parameters may have minimal overall significant influence on the age at the onset of menarche in different communities. In other words, though additional investigations are required in this regard, it is likely that the importance of demographic and socio-economic differences in the menarcheal age has been over-emphasised.

In contrast to these claims, Freedman et al.¹³ explored the inter-relationships between childhood levels of BMI, menarcheal age and obesity in 1179 girls. They maintained that childhood levels of obesity were to be associated with an early menarche and "relatively fat children tended to undergo menarche earlier than did thinner children, with each standard deviation increase in pre-menarcheal BMI increasing the odds of early menarche (<12 y-o) by approximately 2-fold."¹³ In the same way, DiVall et al.¹⁴ also assumed the recent trend toward obesity might play a significant role in the cause of early puberty in girls.¹⁴ Based on their investigations on the prevalence of pubertal stages in overweight children of Macedonian and Albanian healthy girls, Krstevska-Konstantinova et al.¹⁵ arrived at similar conclusions. Other studies stated that increasing rates of obesity in the United States may cause an earlier average age of onset of puberty for US girls.¹⁶ According to a research performed in the United States, children with precocious puberty were considerably higher and heavier than normal population.¹⁷ Another American study¹⁸ showed that 6-9 year-old white girls who had only pubic hair had higher BMI and z-scores than pre-pubertal girls without pubarche, unlike the African-American girls.

The prevalence of overweight and obesity is increasing worldwide at an alarming rate in both developing and developed countries. Though theoretically hyper-insulinaemia and hyper-androgenaemia take place in obese girls at pre-puberty, it is uncertain whether these factors have a significant role in the early onset of puberty in obese girls.¹ Zehr et al.¹⁹ explored the impact of body weight on regulating pubertal development in outdoor-housed female rhesus monkeys. They found that females ovulating at early age had higher pubertal body weights and BMI. They concluded that better nutritional conditions or positive energy balance have an effect on pubertal development. In 1985, Baker²⁰ also stated that the body's fat content in association with a variety of variables — such as environmental and psychosocial factors - are responsible for the development of female reproductive functions.

Our survey findings do not fall in line with all the

findings of the above-mentioned studies. In fact, our findings demonstrated no significant relationship between menarcheal age and height on the one hand, and weight and BMI, on the other. Our results were confirmed across the same population universe by Delavar et al. and Gharravi et al.^{21,22} Also, another study performed in the Netherlands demonstrated that there was no association between menarche and BMI.²³ Other European studies have found that there is no significant increased BMI in girls with a history of premature pubarche at ages 6-18 years (although increased central fat was noted).²⁴

Based on previous observations, different hypotheses are considered to explain difference in various societies. Some possible factors affecting menarche include nutrition,¹⁶ socioeconomic factors and GDP (domestic product per capita).^{11,22} The first physical finding in sexual maturation of girls is breast budding, for which the mean age in the north of Iran was found to be $11.86 \pm 1/95$. According to a recent European survey,²³ earlier breast development is detected among girls more recently born, and the mean estimated age at the attainment of breast budding (Tanner breast stage 2+), occurred significantly earlier in the 2006 cohort than the one that was studied in 1991 (estimated mean age: 9.86 years in 2006 vs. 10.88 years in 1991). Previous studies on this subject demonstrated that genetic influence, nutrition, drinking high-carbohydrate drinks, height of the father and mother, weight of the mother at the start of pregnancy, history of mononucleosis, origin and education of the parents and physical activity have their own effect on breast development and menarche.²⁵ Rabbani et al. assessed normal pubertal development in Iranian girls.²⁶ They reported that the mean age at breast bud stage (B2), pubic hair stage (PH2) and menarche was 10.12, 10.48 and 14.54 years, correspondingly. Our results are compatible with available literature. Although the pattern of occurrence of menarche in our community is similar with the other developed countries, but breast development is detected later among the Iranian population. It seems that in pubertal development process in different societies, other factors need to be pinpointed in further studies. The population in our study, however, was too small to demonstrate the relationship between the investigated parameters.

Conclusion

Several environmental and man-made factors play key roles in the pubertal development of girls. There is a strong evidence that the inter-relation among genetic, social, economic, and environmental variables affect puberty. Further research is needed in order to

identify and describe these particular factors. Based on epidemiology of pubertal development of girls, there is a case in favour of creating particular guidelines for pubertal development assessment for each type of society in addition to the standard international guidelines.

Acknowledgment

This study was carried out with the sponsorship of Golestan University of Medical Sciences, Iran.

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