

Declining age of puberty of school girls in southern Thailand

Somchit Jaruratanasirikul, Atchariya Chanpong, Nuttaporn Tassanakijpanich, Hutcha Sriplung

Songkhla, Thailand

Background: Declines in the onset age of secondary sexual development have been reported in a number of recent studies in western and Asian countries. A study of Hat-Yai school girls in 1994 in Thailand showed that the ages at thelarche and menarche were 9.9 and 12.4 years, respectively. This study was to determine whether there was a decline in the average age of puberty in Hat-Yai school girls from 1994 to 2012.

Methods: A cross-sectional study was conducted in 2140 healthy Hat-Yai school girls, aged 6-18 years, from June 2011 to March 2012. Breast and pubic hair development was assessed by the Tanner staging method. Probit analysis was used to calculate the median ages of different stages of breast and pubic hair development, and the age of menarche.

Results: The median ages of girls having thelarche and menarche were 9.6 (95% CI, 9.4-9.8) and 12.2 (95% CI, 11.9-12.4) years, which declined from 9.9 (95% CI, 9.7-10.1) and 12.4 years (95% CI, 12.2-12.6) in the 1994 study respectively, however, without statistical significance. The youngest ages of girls who had breast stage 2 and menarche were 7.2 and 9.2 years, respectively. The final height at age 14 years in this cohort (157.3 cm) was 2.3 cm greater than that of girls in 1994 (155.0 cm).

Conclusions: From 1994 to 2012, the age at onset of thelarche and menarche of girls in Hat-Yai municipality declined by 0.2 and 0.3 years, respectively. The earlier age at onset of puberty had no effect on final adult height.

World J Pediatr 2014;10(3):256-261

Key words: growth; menarche; puberty; secular trend; thelarche

Introduction

Puberty is the normal physiological process during which children develop secondary sex characteristics, experience growth acceleration, and achieve bone maturation and reproductive competence. In girls, the tempo of puberty begins with thelarche, followed by pubarche and menarche. The mechanisms controlling the age at onset and tempo of pubertal development are complex and involve multiple interplays between genetic, metabolic, nutritional, and environmental factors.^[1,2] The ages of thelarche and menarche can serve as a normative standard of pubertal development in a population and vary from population to population. Studies of pubertal maturation in western and Asian countries have found that the onset age of secondary sex development has been declining in recent years.^[3-6] In Thailand, studies dating back 40 years have shown a steady decline in the ages of onset of puberty. The median age of thelarche in Thai girls has dropped from 10.7 years in 1980 (Bangkok),^[7] to 9.9 years in 1994 (Hat-Yai),^[8] and recently to 9.4 years in 1999 (Bangkok),^[9] and the median age of menarche from 12.7 years in 1972 (Bangkok)^[10] to 12.4 years in 1994 (Hat-Yai)^[8] and 12.1 years in 1999 (Bangkok).^[9]

Hat-Yai is the largest metropolitan area in southern Thailand and the third largest in the country. In 1994, a study on the physical growth and age at puberty of Hat-Yai school girls was undertaken,^[8,11] and the purpose of this study was to update the findings of that earlier study. The primary outcome was to evaluate any trends suggesting a declining of the age of onset of puberty in the same geographical area of Hat-Yai municipality and the secondary outcome was to examine whether nutritional status had any effect on physical growth and age of puberty.

Author Affiliations: Department of Pediatrics (Jaruratanasirikul S, Chanpong A, Tassanakijpanich N); Epidemiology Unit, Faculty of Medicine, Prince of Songkla University, Hat-Yai, Songkhla 90110, Thailand (Sriplung H)

Corresponding Author: Somchit Jaruratanasirikul, MD, Department of Pediatrics, Faculty of Medicine, Prince of Songkla University, Hat-Yai, Songkhla 90110, Thailand (Tel: 66-074-429618; Fax: 66-074-429618; Email: somchit.j@psu.ac.th)

doi: 10.1007/s12519-014-0472-2

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Methods

The protocol for this study was approved by the Institutional Review Board and the Ethics Committee of the Faculty of Medicine, Prince of Songkla University. A cross-sectional study was conducted from June 2011 to March 2012 in 9 primary and secondary schools in Hat-Yai municipality (6 private schools and 3 public schools) which were selected by probability proportional to size sampling from the 29 schools in Hat-Yai municipality (Fig. 1). Girls aged 6-18 years were asked to participate. Those with abnormal characteristics such as severe short stature or having a chronic illness were excluded. All participants were Thai nationality; 85% were Buddhist and 15% Muslim. 82% were from middle income families (20 000-50 000 Baht/month, approximately 600-1500 US dollars/month), 14% from high income families (>50 000 Baht/month), and only 4% from low income families (<20 000 Baht/month). Written informed consent and assent were obtained from all participants and their parents.

A general physical examination was performed on all participants. Standing height was measured to the

nearest 0.1 cm using a portable stadiometer. Weight was measured to the nearest 0.1 kg using a digital electronic scale. Each child was weighed without socks and shoes while wearing light clothing. Breast development and pubic hair development were assessed by a pediatric endocrinologist. The pubertal stages of breast and pubic hair development were graded from 1 to 5 according to the methods of Marshall and Tanner. In girls with breast development Tanner stage 2, the presence of breast tissue was confirmed by palpation. To obtain information about menarcheal age, the girls were asked personally whether they had menstruation with the dichotomous answer of "yes-no".

Statistical analyses

The data were collected and analyzed by the status quo method. The subjects were categorized by age at the midpoints of 6-month intervals (e.g., 7.5 years included girls aged 7.25-7.74 years). Probit analysis was used for cumulative frequency curves of girls for each Tanner stage of breast and pubic hair development and who had passed menarche. All analyses were performed using the R program.

Results

Totally 2140 healthy girls were participated in the study. The pubertal stages and proportions of girls having breast and pubic hair development at each stage are shown in Fig. 2. The details of median ages and the respective percentile values of girls attaining stages 2 to 5 for breast and pubic hair development, and who had passed menarche as calculated by probit analysis are shown in Table 1. The median ages of girls having breast stage 2, pubic hair stage 2 and menarche were 9.6 (95% CI, 9.4-9.8), 11.0 (95% CI, 10.6-11.3) and 12.2 (95% CI, 11.9-12.4) years, respectively. The median ages of thelarche and menarche of girls of our study in 1994 were 9.9 (95% CI, 9.7-10.1) and 12.4 (95% CI, 12.2-12.6) years, respectively, but there was no statistically significant difference between 1994

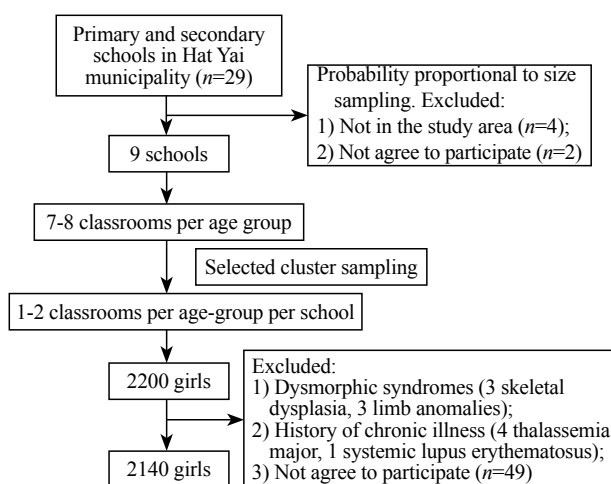


Fig. 1. Participants were selected by probability proportional to size sampling.

Table 1. Ages of attainment of different pubertal stages and menarche according to probit analysis for selected percentiles of girls

Stages and menarche	Age (y)						
	P3	P10	P25	P50 (95% CI)	P75	P90	P97
Breast stage 2	7.1	8.0	8.8	9.6 (9.4-9.8)	10.4	11.1	12.1
Breast stage 3	8.7	9.5	10.2	10.9 (10.8-11.1)	11.6	12.3	13.1
Breast stage 4	10.0	10.9	11.7	12.4 (12.1-12.7)	13.1	13.9	14.8
Breast stage 5	12.2	13.2	14.0	14.9 (14.6-15.1)	15.7	16.5	17.5
Pubic hair stage 2	10.6	10.7	10.9	11.0 (10.6-11.3)	11.2	11.3	11.5
Pubic hair stage 3	11.0	11.9	12.0	12.2 (11.3-13.0)	12.3	12.4	12.6
Pubic hair stage 4	11.7	12.0	13.1	14.1 (13.9-14.3)	15.1	16.2	17.4
Pubic hair stage 5	12.4	13.7	14.8	15.9 (15.3-16.4)	17.0	18.0	19.3
Menarche	9.8	10.5	11.7	12.2 (11.9-12.4)	12.5	13.0	14.1

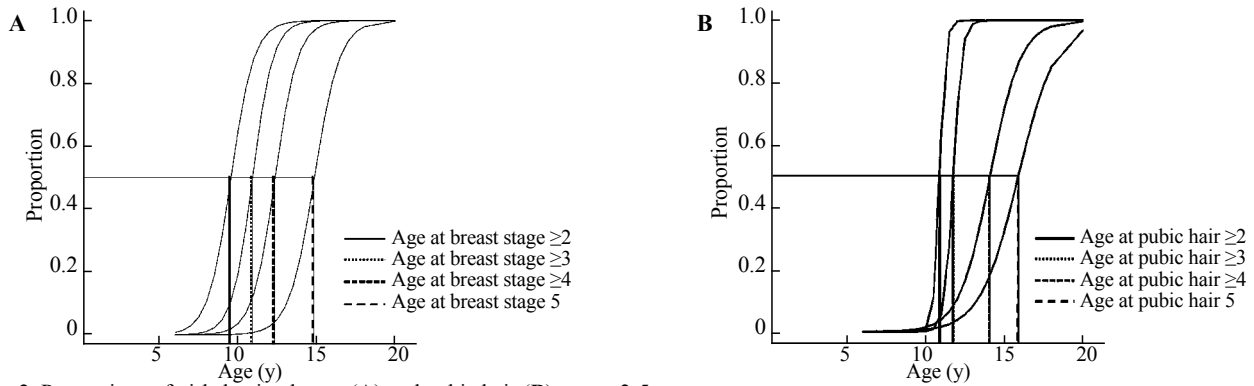


Fig. 2. Proportions of girls having breast (A) and pubic hair (B) stages 2-5.

and 2012 due to the overlapping of 95% CIs in the 2 studies ($P=0.28$ and 0.30 , respectively). It was also noted in this study that the youngest ages of girls who had breast stage 2 and menarche were 7.2 and 9.2 years, respectively. At age 7.5 years, 3.6% of girls (3 of 84) had breast development stage 2 and this proportion increased to 10.5% at age 8 years (17 of 162). There were 1.9% of girls (3 of 155) who had passed menarche at age 9.0 years, which had increased to 10.6% at the age of 10 years (17 of 160). The percentage of girls having breast development stage 2 at the age of 8 years and menarche at the age of 10 years was significantly greater than that in 1994, in which none of the 345 school girls had breast stage 2 at the age of 8 years ($P<0.001$), and only 1.5% (5 of 326) had passed menarche at the age of 10 years ($P<0.001$), respectively.

In this study, we found that the median weight and height of girls in all age groups were 2.5-3.5 kg and 1.5-2.5 cm greater than growth of girls aged 9-18 years in 1994, respectively. The near-final-height (as defined by a median height difference per 1-year age range of less than 0.5 cm of the participants) was 157.3 cm (range: 150.5-168.0 cm) ($n=771$), 2.3 cm greater than the near-final-height of girls in 1994 (155.0 cm; range: 148.5-164.5 cm) ($n=932$), and was attained at the age of 14 years, with 1 year earlier than the age of 15 years in the study of 1994.

To determine the effect of weight on the age of pubertal onset, we divided the girls into 3 groups: over the 75th percentile ($n=512$), 25th-75th percentile ($n=1132$), and below the 25th percentile for age ($n=496$). We found that the median age at breast stage 2 in girls with weight over the 75th percentile was 8.7 years (95% CI, 8.4-9.2 years) which was significantly younger than that of the 25th-75th percentile of 9.6 years (95% CI, 9.4-9.8) and below the 25th percentile of 11.7 years (95% CI, 11.4-12.1 years) ($P=0.002$). The median age at menarche in girls with a weight over the 75th percentile was 11.5 years (95% CI, 11.2-11.8 years), which was significantly younger than that of

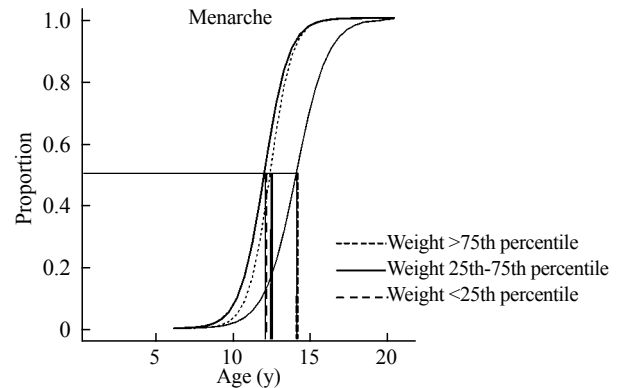


Fig. 3. Proportions having menarche of girls whose weight >75th percentile, 25th-75th percentile, and <25th percentile.

the 25th-75th percentile of 12.1 years (95% CI, 11.9-12.4) and below the 25th percentile of 13.7 years (95% CI, 13.2-14.0 years) ($P<0.001$) (Fig. 3). The mean near-final-heights of girls with weight over the 75th percentile, the 25th-75th percentile and below the 25th percentile were 156.8 cm, 157.3 cm and 157.0 cm respectively, without statistically significant difference among the groups ($P=0.28$).

Discussion

Three findings of our study confirmed the existence of a secular trend towards an earlier onset of puberty in Hat-Yai school girls in 2012 compared to the study in 1994. First, the median age at the onset of puberty occurred 0.2-0.3 years or 3-4 months earlier (age at thelarche varied from 9.9 years in 1994 to 9.6 years in 2012, and age at menarche from 12.4 to 12.2 years). Although the differences of the median ages of thelarche and menarche between 1994 and 2012 were not statistically significant, which were due to the overlapping of the 95% CIs of the median ages of these two studies, the earlier ages of the onset of puberty found in our present study were of some clinical significance.

Second, the youngest age of girls having breast stage 2 and menarche had declined to 7.2 and 9.2 years in our study, both notably reduced from 8.5 and 9.8 years respectively in the 1994 study.^[8] And finally, about 10% of the Hat-Yai school girls in our study had breast stage 2 at the age of 8 years, and about 10% of girls had passed menarche by the age of 10 years, whereas in the study of 1994, none of the school girls had breast stage 2 at the age of 8 years and only 1.5% had passed menarche by the age of 10 years.^[8] These findings confirm the secular trend towards an earlier age for pubertal maturation in Hat-Yai school girls, as has been reported in other Asian^[6,12-15] and western^[3-5] populations. Our study also demonstrated a secular trend towards an increase in physical growth measurements of girls in all age groups, and an increase in weight and near-final-height at age of 15 years from, respectively, 47.5 kg and 155.2 cm in 1994 to 50.2 kg and 157.3 cm in 2012.^[8,11] These results indicated that the 3-4 months earlier age at thelarche and menarche had no effect on somatic growth since the near-final-height of girls was 2.3 cm greater than the near-final-height of girls in 1994.^[11] The near-final-height of girls of 157.3 cm in our study was similar with that of girls (156.9 cm) found by the national survey in 1997^[16] and Bangkok girls (158.0 cm) in the 1999 study.^[9]

The secular trend towards increased physical growth accompanying with the earlier age of onset of puberty may be explained by or related to socioeconomic growth, improvements in sanitation, and better living standards. Improved nutritional status in Thailand has been shown by national data concerning the decreased prevalence of underweight children and malnutrition, and the increased prevalence of overweight children and obesity.^[17] Our study also found that the ages of thelarche and menarche in girls who were overweight for age were significantly lower than those of normal and underweight-for-age girls. During the last decade, many studies have

shown a positive association between body fat and the earlier age of onset of puberty.^[18-20] The mechanisms underlying this association are still unclear in terms of whether the increased body fat may be the cause or the result of pubertal changes. Endocrine disruptors, a class of chemicals that interfere with steroid hormone production and activity by a variety of actions and disruptions at different times of exposure during intrauterine or early childhood period, have been identified as a major factor responsible for the earlier timing of pubertal onset.^[21-24] Nutritional status, either over or under recommended levels, in early childhood has been considered as one of the potential endocrine disruptors associated with the timing of pubertal development. To test this hypothesis, well-designed longitudinal studies with data collection of genetics, life style and environmental exposure factors are needed to identify factors related to the secular trend of somatic growth and the timing of puberty in young girls, which are very difficult to determine at the population level.

The finding of a secular trend towards earlier timing of pubertal maturation in many Asian countries (Table 2)^[6,12-15] and our study may have significant influences on public health policies in various ways. For example, concerning the decision to lower the cut-off age criteria for diagnosis and investigation of girls with early normal pubertal development, and thus decreasing the overtreatment of girls in this group. In 2002, the Lawson-Wilkins Pediatric Endocrine Society recommended a lowering of the age limit for evaluation of precocious puberty in girls to 7 years in Caucasian girls.^[25] Based on our study, if the cut-off age of the diagnosis of precocious puberty remains at 8.0 years, then about 8%-10% of Thai girls with a normal variant of puberty will continue to be diagnosed as precocious puberty and will be unnecessarily treated. Another phenomenon related to the secular trend of declining age of puberty has been an increased number of girls referred for investigation of precocious puberty.^[26-28] In our two studies, we found the percentage of girls in the

Table 2. Median age of pubertal development of girls in various Asian populations

Countries	Year(s) data collected	Type of study	n	Median age at		
				Thelarche	Pubarche	Menarche
China ^[6]	2003-2005 (9 cities)	C-S	20 654	9.20	11.16	12.27
Hong Kong ^[12]	1993	C-S	3 749	9.78	11.64	12.38
Japan ^[13]	1990-2000 (Tokyo)	L	832	9.74	ND	12.24
India ^[14]	1988-1991	C-S	9 951	ND	ND	12.50
Korea ^[15]	1993-1995 (Ansan)	C-S	4 237	ND	ND	12.50
Thailand	1980-1984 (Bangkok) ^[7]	C-S	4 443	10.70	12.40	12.70
	1993-1994 (Hat-Yai) ^[8]	C-S	3 029	9.90	ND	12.40
	1997-1999 (Bangkok) ^[9]	C-S	300	9.40	11.10	12.10
	2011-2012 (Hat-Yai)	C-S	2 140	9.60	11.00	12.20

C-S: cross-sectional study; L: longitudinal study; ND: no data.

7-9 years age group (25.4%) presenting with thelarche was higher than that of the girls with true precocious puberty (23.8%).^[29] The majority of girls with early normal puberty were overweight for age and they reached a final height of 1-2 cm above their midparental height, which indicates that early normal puberty had no effect on the final adult height of these girls.^[30]

The current study had some limitations. It was a cross-sectional study carried out in only one city in southern Thailand, and one might be concerned it, thus, does not represent the overall Thai population. However, since we divided the girls into 3 groups according to the weight status of relatively overweight (weight over the 75th percentile), normal weight (weight between the 25th-75th percentile), and relatively underweight (weight below the 25th percentile), the results of our study could be interpreted as representing a cross-section of all Thai children in both urban areas where there is a relatively high prevalence of overweight children, and rural areas where there is a relatively high prevalence of underweight children. Using the normal weight girls as a reference, the overweight girls would develop thelarche about 1 year earlier and menarche 6-8 months earlier than normal weight girls, whereas the underweight girls would develop thelarche 1 year later and menarche 1.5 years later than the normal weight girls. The strength of this study is that it is the second such study of physical growth of Thai children carried out from the same center, with almost two decades between them, and thus the data can be directly compared to look for secular trends concerning physical growth and the age at onset of puberty in the same geographical area; and second, the sample size was large enough, with over 150 subjects in each age group, with participants selected by a well-prepared sampling method, to minimize any selection bias.

In summary, we confirmed the existence of a secular trend towards an earlier age of onset of pubertal development of Hat-Yai school girls, and found that this earlier age of pubertal maturation had no effect of near-final-height. Based on the results of this study, we suggest that the cut-off age for the criteria for diagnosis of precocious puberty in Thai girls should be lowered to 7.5 years to prevent the overtreatment of girls with early normal puberty.

Funding: The study was supported by a grant from the Faculty of Medicine, Prince of Songkla University.

Ethical approval: This study was approved by the Ethics Committee of the Faculty of Medicine, Prince of Songkla University.

Competing interest: None.

Contributors: JS proposed the project and wrote the paper.

CA and TN collected the data. SH analysed the data. JS is the guarantor.

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Received June 16, 2013

Accepted September 30, 2013