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Trend of Menarcheal Age among Korean Girls

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The authors have no potential conflicts of
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ABSTRACT

Background: Menarcheal age has been decreasing worldwide. However, few recent studies have observed trends in menarcheal age in larger populations, and the cutoff age for early menarche remains unclear. Therefore, we aimed to analyze recent trends of menarcheal age and to determine the cutoff age of early menarche based on nationally representative data.

Methods: We conducted a cross-sectional study of 351,006 Korean girls aged 12–18 years who were born in 1988–2003 based on the data of the 2006–2015 Korea Youth Risk Behavior Survey. We identified the distribution of age at menarche using the complex sample Cox regression model. Trends in the prevalence of early menarche were determined using the complex sample linear model.

Results: Ninety-five percent of all the participants reported they had experienced menarche. The mean menarcheal age was 13.0 years (95% confidence intervals [CIs], 12.92–13.04) for girls born in 1988 and decreased to 12.6 years (95% CI, 12.54–12.61) for girls born in 2003. The cutoff age (the 3rd percentile value) for early menarche was 10.5 years during the study period. The prevalence of early menarche significantly increased from 1.8% in 2006 to 3.2% in 2015 (P -for-trend < 0.001). Downward trends of menarcheal age were noted across all body mass index groups, and this trend was most prominent in the obese group.

Conclusion: We reported an ongoing downward trend in menarcheal age in Korean girls born in 1988–2003, decreasing by 0.4 years over the 15 years.

Keywords: Menarche; Trends; Korea

INTRODUCTION

Menarcheal age is an important indicator of nutritional status, pubertal maturation, fertility and women's health.^{1,2} Many previous studies on the age at menarche (AAM) showed rapidly decreasing trends worldwide from the 19th century to the mid-20th century.³ However, from the mid-20th century to the early 21st century, the downward trends of AAM leveled off in some industrialized countries.^{4–6}

Previous adult studies have reported a continuing downward trend of mean AAM in Korea; 15.9–16.9 years for women born between 1920 and 1925, 13.1–13.8 years for those born

between 1980 and 1985.^{7,8} However, these studies on adults had some limitations to reflect the actual AAM, since the possibility of bias in reporting is likely due to the long recall interval regarding menarche.⁹ Therefore, research for girls reaching puberty is needed to estimate accurate AAM.

We recently reported a sharp increase in the incidence of central precocious puberty (CPP) in Korean girls from 2004 to 2010.¹⁰ This steep rise in Korean CPP incidence might be at least partly explained by accelerated pubertal maturation in the entire population. Therefore, it is necessary to investigate the reference age for the pubertal milestones in contemporary Korean girls, especially AAM, which is a relatively objective indicator. Also, establishing the cutoff age for early menarche is crucial for further studies to assess the health impact of AAM in the future.

In this study, we aimed to identify the reference ranges for AAM and its trend among Korean pubertal girls and to determine the cutoff age for early menarche using data from the large-scale national representative data.

METHODS

Study population

This study utilized the raw data of the Korea Youth Risk Behavior Survey (Korea YRBS) conducted from 2006–2015 that was published on the website of the Korea Center for Disease Control and Prevention (KCDC) (<https://www.cdc.go.kr/yhs/>). The Korea Ministry of Education, Health and Welfare, and KCDC have conducted the Korea YRBS every year since 2005 in order to understand the current status of health behaviors in Korean adolescents (15 areas including smoking, drinking, obesity, diet, and physical activity). The survey was done on students from the first grade of middle school to the third level of high school in Korea. The survey used stratified cluster sampling to select 800 sample schools (400 middle schools and 400 high schools) throughout Korea, and, subsequently, sample classes were chosen by the KCDC. In each sample class, students directly logged on to the website of the KCDC and completed an anonymous self-reported online survey. All students in the sample class participated in the survey, except those with long-term absences, exceptional children, and children with literacy disorders. The 1st (2005) Korea YRBS, which did not have a questionnaire on menarche, were excluded from the study. Subsequently, we included 351,006 Korean pubertal girls from 10 years of survey data from the 2nd (2006) to 11th (2015) Korea YRBS.

Demographic factors and assessment of the AAM

The Korea YRBS included a questionnaire on the menstrual experience and the AAM. Since the AAM was surveyed based on school grade, we converted the school grade into the year-age based on the birth year, year of survey, and the school grade at the time of the survey were used. The household economic status was classified into five classes based on the perception of the participants: high, upper-middle, middle, lower-middle, and low. Residential areas were divided into urban areas (includes major cities such as Seoul, Busan, Daegu, Incheon, Gwangju, Daejeon, Ulsan, Sejong, and parts of Gyeonggi-do), suburban areas (small and medium-sized cities), and rural areas. Body mass index (BMI) values (kg/m^2) were calculated according to the formula body weight (kg) divided by the square of the height (m^2), based on the height (cm) and weight (kg) provided by the study subjects in the Korea YRBS. We

classified the BMI status according to age- and sex-specific BMI percentiles based on the 2017 Korean National Growth Charts for children and adolescents: underweight (< 5th percentile), normal (\geq 5th percentile and < 85th percentile), overweight (\geq 85th percentile and < 95th percentile), and obesity (\geq 95th percentile).¹¹

Statistical analysis

Statistical analysis was carried out using SPSS software version 25.0 for Windows (IBM Co., Armonk, NY, USA). Data analysis was performed using the complex sample design method, based on the investigation characteristics of the Korea YRBS, using stratified cluster sampling. The complex sample generalized linear model was used to estimate the mean and standard error/standard deviation, of the scale variables, and the complex sample crosstab procedure was used for categorical or ordinal variables. The distribution of the AAM was determined using the complex sample Cox regression model. Trends in the prevalence of early menarche were determined using the complex sample linear model. All analyses were considered statistically significant when the *P* value was < 0.05.

Ethics statement

The Korea YRBS was reviewed by the Institutional Review Board (IRB) of the KCDC (approval No. 117058, 2014-06EXP-02-P-A). All subjects received informed consent prior to the investigation. Additionally, this study was approved by the IRB of the Inje University Sanggye Paik Hospital (approval No. SGPAIK 2019-09-012).

RESULTS

The general characteristics of the study population are summarized in **Table 1**. The age distribution of the study population was 12–18 years. Approximately 95.2% of all the participants reported they had experienced menarche. Mean ages (95% confidence intervals [CIs]) of menarche stratified by birth year are shown in **Fig. 1**. The mean AAM was significantly lower among pubertal girls born in 2003 (12.6 years, 95% CI, 12.54–12.61) than in pubertal girls born in 1988 (13.0 years, 95% CI, 12.92–13.04) ($P < 0.001$). The AAM of study subjects showed a steadily decreasing trend, except for the girls born in 1988 who showed an earlier

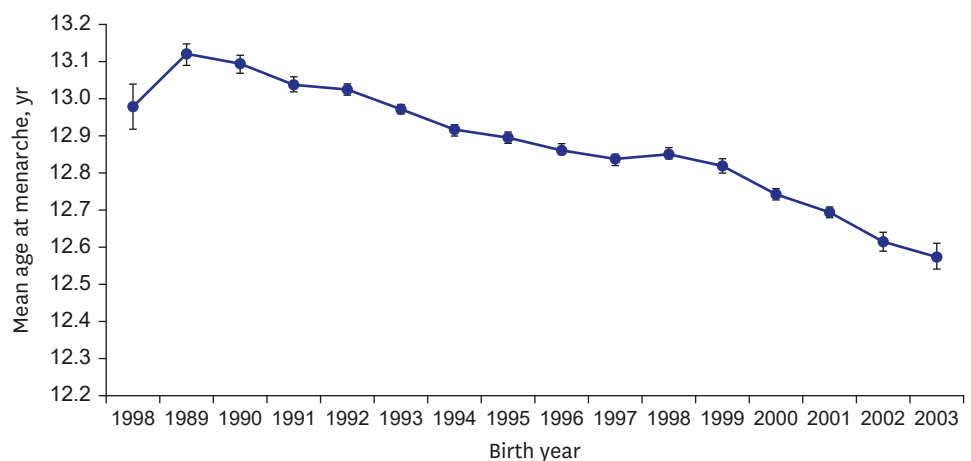


Fig. 1. Trends in the age of menarche stratified by birth year in Korean girls. The graph shows the mean ages of menarche (95% confidence intervals) by birth year.

Table 1. General characteristics of the study population (n = 351,006)

Characteristics	Values
Age, yr	15.50 ± 0.01
Age group, yr	
12	26,280 (7.3)
13	59,193 (16.7)
14	59,939 (17.2)
15	59,491 (17.4)
16	59,008 (16.8)
17	59,159 (16.7)
18	27,936 (7.9)
Menarche	
Yes	333,827 (95.2)
No	17,179 (4.8)
Perceived household economic status	
High	17,263 (5.1)
Upper-middle	76,784 (22.8)
Middle	175,368 (49.7)
Lower-middle	64,021 (17.6)
Low	17,597 (4.7)
Residential area	
Urban	164,402 (47.0)
Suburban	145,063 (46.9)
Rural	41,541 (6.1)
BMI, kg/m ²	20.20 ± 0.01
BMI status	
Underweight	29,274 (8.7)
Normal	270,720 (79.3)
Overweight	25,968 (7.3)
Obese	16,707 (4.6)

Data are presented as mean ± standard error or number (%).

BMI = body mass index.

AAM compared to girls born in 1988–1991. The proportion of girls who experienced menarche, mean (median) AAM, and specific percentile values of AAM are presented in **Table 2**. The mean (median) AAM was 12.9 (12.8) years for pubertal girls aged 12–18 years. The 3rd percentile value of AAM of pubertal girls aged 12–18 years was 10.5 years. Based on the results of our study, early menarche was defined as menarcheal age less than 10.5 years.

Table 2. Distributions of AAM in Korean pubertal girls

Variables	Value
Age, yr	12–18
No. of total responders	351,006
Girls who experienced menarche	333,827 (95.2)
AAM, yr	
Mean ± SD	12.90 ± 1.18
Median	12.8
AAM by percentile, yr	
3rd	10.5
5th	11.0
25th	12.0
50th	12.8
75th	13.7
95th	14.9
97th	15.4

Data are presented as number (%).

AAM = age at menarche, SD = standard deviation.

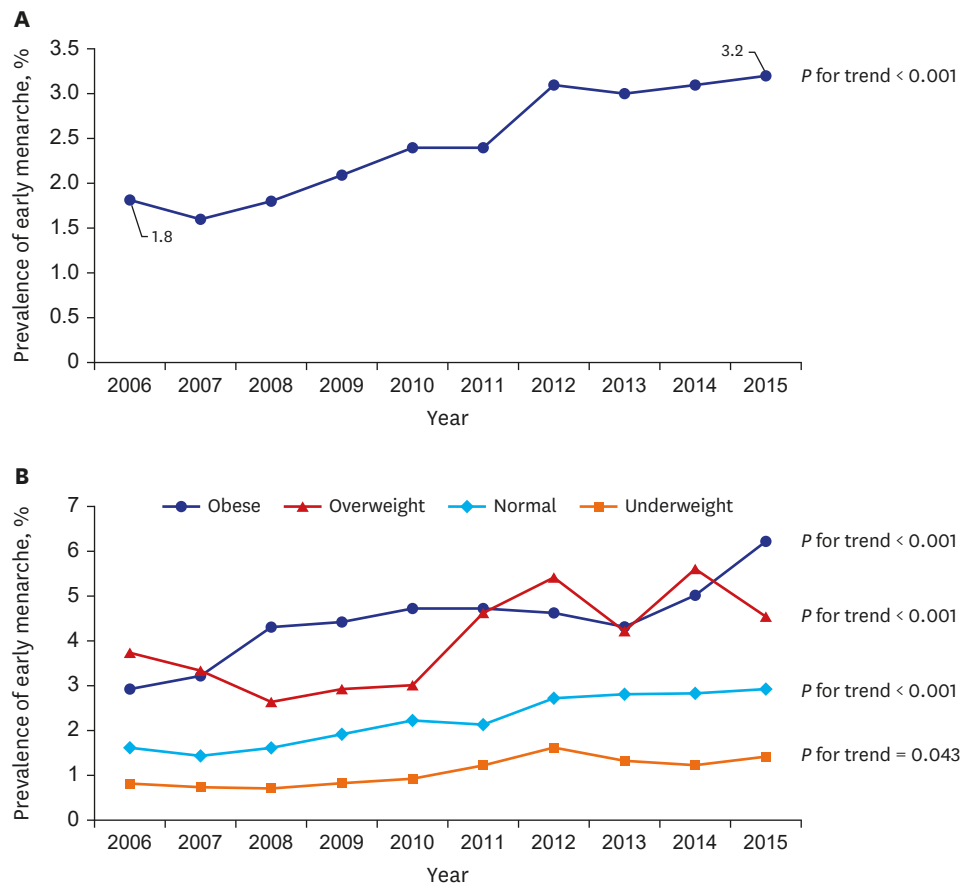


Fig. 2. Trends in prevalence of early menarche. (A) The graphs show annual trends in the prevalence of early menarche and (B) the trend of prevalence of early menarche stratified by body mass index status (B) in Korean pubertal girls.

The 10-year trend of the prevalence of early menarche is summarized in **Fig. 2A**. The prevalence of early menarche determined by AAM of less than 10.5 years significantly increased from 1.8% in 2006 to 3.2% in 2015 (*P*-for-trend < 0.001). The 10-year trend of the prevalence of early menarche stratified by BMI status is presented in **Fig. 2B**. The obese group demonstrated the highest prevalence of early menarche, followed by the overweight, normal-weight, and underweight groups, respectively. The prevalence of early menarche showed a significant increasing trend, regardless of BMI status. During the study period from 2006 to 2015, the greatest increase in the prevalence of early menarche occurred among pubertal girls in the obese group (from 2.9% to 6.2%, *P*-for-trend < 0.001), followed by normal-weight (from 1.6% to 2.9%), underweight (from 0.8% to 1.4%), and overweight groups (from 3.7% to 4.5%).

DISCUSSION

In this study, we analyzed the distribution of menarcheal age and its trend over 15 years using the latest, large-scale national data on menarcheal age among Korean pubertal girls. We found that the menarcheal age continued to decline, and the rate of decline was slowing down compared to the past. Early menarche, defined as a menarcheal age under 10.5 years

of age, showed a steady increasing trend during the study period. This increase was the most prominent among the obese group compared to other BMI groups.

Previous epidemiologic studies suggest that mean AAM has declined from 17 years of age in the 19th century to 12.5–13 years of age in the 20th century for most ethnicities.^{3,12-14} During the recent 3–5 decades, AAM has stabilized in several countries, including the US, UK, Greece, Italy, and Belgium.^{5,15-18} In contrast, recent studies from Denmark, the Netherlands, Colombia, and China demonstrated continuous downward trends of mean AAM, but its rate was much slower.¹⁹⁻²² Previous studies found that the AAM of Korean women born between 1904 and 1994 decreased by 0.7 years per decade.^{7,8,23} However, these studies with elderly women may have recall bias in reporting AAM. In this study, the AAM of Korean girls born in 1988–2003 decreased by 0.4 years over the 15 years. Therefore, the AAM of modern Korean pubertal girls is still decreasing, although the rate of decrease appears to have slowed in recent years.

We demonstrated that the 3rd percentile of AAM for contemporary Korean girls is 10.5 years old, and therefore defined this age as the cutoff for early menarche. Based on our cutoff age for early menarche, the prevalence of early menarche increased significantly from 1.8% in 2006 to 3.2% in 2015. While many studies have focused on the worldwide secular trends of AAM, studies focusing on the age cutoff of early menarche have been extremely scarce. For this reason, the age cutoff for early menarche has not yet been established, and definitions of early menarche differ even among classical textbooks, ranging from 9.5 years to 12.5 years.^{24,25} These age limits do not reflect the real-world distribution of AAM in recent years. Of note, previous Korean studies describing the health effects of AAM had established the age criteria for early menarche before 12 years.²⁶⁻²⁸ This age corresponds to about the 3rd to 6th percentile of AAM for Korean women born before the 1980s; however, currently, it corresponds to the 24th percentile for contemporary Korean pubertal girls.¹⁴ Therefore, it is necessary to study the health effects of early menarche using the new early menarche (< 10.5 years) criterion based on the results of this study, rather than the past.

In this study, early menarche was the most prevalent among obese girls, and the increasing rate of early menarche was also the highest in obese girls. Many studies had shown a positive association between adiposity and early menarche in girls.²⁹⁻³² Previous cross-sectional studies demonstrated that a downward trend in the mean AAM had been accompanied by an increase in BMI in the pediatric populations from the US and China.^{22,33} A possible mechanism for this association is the direct and indirect stimulation of the gonadotropin-releasing hormone-gonadotropin axis by leptin produced from adipose tissue.^{29,34} Notably, the increasing trend of early menarche in Korea was not limited to pubertal girls with high BMI, but also noted among normal and underweight pubertal girls. This result is consistent with our previous study showing the secular trend of an earlier pubertal growth spurt in Copenhagen children in all BMI categories, which was the most prominent among children in the obese category.³⁵ These results suggest that while increasing obesity is a crucial factor for advancing puberty in recent decades, other environmental factors such as nutritional components and endocrine-disrupting chemicals also might play a role.^{36,37}

Our study had some limitations. First, since the Korea YRBS data were based on a self-reported survey, there is a possibility of recall bias in this study. Second, the Korea YRBS questionnaire did not include extensive surveys of other factors, including birth weight, early life soy intake, and exposure to endocrine-disrupting chemicals, that may affect pubertal

timing and tempo.^{32,38,39} Nevertheless, the strengths of this study are as follows. First, we have minimized the probability of recall bias by utilizing the largest and most recent data on the menarcheal age. Second, we proposed the cutoff age for early menarche based on the previous studies and our up-to-date large-scale national data. Lastly, we presented trends in the prevalence of early menarche according to the different BMI statuses.

In conclusion, this study demonstrated an ongoing downward trend of AAM in Korean pubertal girls born in recent 15 years. Notably, we provided an updated age cutoff for early menarche (< 10.5 years). These findings will provide an important cornerstone for future studies on the trend and possible health effects of a change in menarcheal age in Korea.

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