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ORIGINAL PAPER

Age at menarche in a Korean population: secular trends and influencing factors

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Abstract This study was designed to identify the secular trend in the age at menarche and to investigate the possible factors that influence the age at menarche using representative Korean data from the 2005 Korean National Health and Nutrition Survey. Three thousand five hundred sixty-two women born between 1920 and 1985 were enrolled to identify secular trends in the age at menarche and 620 girls born between 1986 and 1995 were recruited to evaluate the factors influencing the age at onset of menarche. Mean age at menarche decreased from 16.90±1.25 years for women born between 1920 and 1925 to 13.79±1.37 years for those born between 1980 and 1985, indicating a downward trend of 0.68 years per decade (95% CI, 0.64–0.71) in age at menarche. Mean age at menarche of girls born between 1986 and 1995 was 13.10±0.06 years as estimated by the Kaplan–Meier method. Among girls born between 1986 and 1995, menarcheal girls had a larger waist circumference, a higher body mass index (BMI), and lower maternal menarcheal age and maternal age at birth than premenarcheal girls. The energy and nutrient intake of protein, sugar, fiber, ash, phosphate, natrium, thiamine, riboflavin, and niacin were greater for menarcheal girls than for premenarcheal girls. These data indicate a decreasing secular trend of age at menarche in a Korean population born between 1920 and 1995. Furthermore, maternal menarcheal age, BMI, maternal age at birth, and nutrition are important variables that appear to influence age at menarche in Korean girls.

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Introduction

Menarcheal age is a key maturity indicator of female development, and it is known to reflect population health [10]. Several studies from different countries worldwide have shown a systematic reduction in the mean age at menarche [1, 4, 6, 10, 11, 29]. Likewise, a downward trend in the mean age at menarche was reported for South Korean females based on a domestic cohort study in Ansan [9]. Age at menarche is known to be influenced by variables such as genetic factors, weight status, nutrition, geography, and socioeconomic status [3, 8, 12, 16, 21, 23, 28]. The possible factors influencing age at menarche may differ among populations, and there may be significant variation depending on the race, geography, and the time period tested. However, there are very little data on possible factors influencing the age at menarche in Korean populations.

This study was designed to identify secular trends in the age at menarche and to investigate the possible factors that influence the age at menarche using representative Korean data from the 2005 Korean National Health and Nutrition Survey (KNHANES).

Materials and methods

This study was based on the data obtained from the 2005 KNHANES performed among non-institutionalized Korean civilians. This survey was conducted by the Korean Ministry of Health and Welfare in 2005. It was a nationwide representative study that used a stratified,

multistage probability sampling design to select household units. The survey consisted of four components: the Health Interview Survey, the Health Behavior Survey, the Nutrition Survey, and the Health Examination Survey. There were approximately 246,000 primary sampling units, each of which contained approximately 60 households. Two hundred sampling frames (12,000 households) from the primary sampling units were randomly selected throughout South Korea.

Among 13,331 female participants born between the years of 1920 and 1985, 3,562 women who were asked through a questionnaire to report age at menarche were recruited. Eight women who could not remember their menarcheal age and two women who had not yet reached menarche were excluded. Consequently, 3,552 women were included in this study to evaluate the secular trend of age at menarche.

Among all 2,269 participants born between 1986 and 1995, 620 girls who reported their menarcheal status and year of their first menstrual period were included in the study to investigate the factors possible influencing age at menarche.

Data on age, age at menarche, sleep time, and hours of TV viewing or computer use were collected from girls using self-administrated questionnaires. The mothers of the participating girls were asked to provide their daughter's birth weight, maternal menarcheal age, maternal age at birth, household income, and maternal education level using self-administrated questionnaires.

A single 24-h dietary recall was collected from each girl. The dietary recalls were used to determine energy and nutrient intake of the study participants.

Maternal education level was divided into five categories: none, ≤6, 7–9, 10–12, and ≥13 years. Household income per month was divided into five categories: ≤1,000,000, 1,010,000–2,000,000, 2,010,000–3,000,000, 3,010,000–4,000,000, and >4,000,000 won. The exchange rate on January 1st, 2005 was 1,040 won to US $1.

Statistical analysis

To evaluate the secular trend in age at menarche, data of women born between 1920 and 1985 were stratified by their year of birth and presented in 5-year intervals. Mean age at menarche was evaluated by one-way ANOVA with Tukey's multiple comparison test. Changes over time in age at menarche were analyzed by a simple linear regression analysis with age at menarche as the dependent variable and year of birth as the independent covariate.

Next, we evaluated mean and median age at menarche in girls born between the years 1986 and 1995 using the Kaplan–Meier survival analysis [2]. Age at menarche in girls who had reached menarche was calculated using the recall method. The menarcheal ages of the mothers and their daughters were compared by Pearson's correlation. To understand the possible influencing age at menarche, the clinical and biochemical differences between premenarcheal and menarcheal girls were examined using analysis of covariance (ANCOVA; after controlling for age) and the chi-square test when the variables were continuous and categorical, respectively.

Values are expressed as mean ± SD. A two-sided p value of <0.05 was considered statistically significant. Statistical analyses were performed using the SPSS software, version 12.0 (SPSS Inc., Chicago, IL, USA).

Results

Table 1 shows age at menarche in different age groups. Mean age at menarche decreased over time, from 16.90±1.25 years for women born between 1920 and 1925 to 13.79±1.37 years for those born between 1980 and 1985 (Fig. 1). Regression analysis showed a negative association between the year of birth and the age at menarche, indicating a downward trend of 0.68 years per decade (95% CI, 0.64–0.71) in age at menarche.

In girls (n=620) born between 1986 and 1995, 69.8% (n=433) of the girls had already experienced menarche, while 30.2% (n=187) of the girls had not reached menarche. Age differed significantly between premenarcheal girls and menarcheal girls (11.06±1.26 vs. 15.13±2.31, p=0.001). Mean age at menarche of menarcheal girls was 12.90±1.28 years by the recall age method. There was a

Table 1 Mean age at menarche for women born between 1920 and 1985 by year of birth

Year of birth	Number (n)	Age at menarche (years)
1920–1924	31	16.90±1.25[a]
1925–1929	101	16.71±1.79[a,b]
1930–1934	169	16.65±1.71[a,b]
1935–1939	219	16.94±1.83[a]
1940–1944	244	16.74±1.88[a,b]
1945–1949	232	16.31±1.98[b]
1950–1954	287	16.18±1.90[b]
1955–1959	348	15.47±1.81[c]
1960–1964	458	15.13±1.77[c]
1965–1969	404	14.39±1.41[d]
1970–1974	430	14.16±1.48[d,e]
1975–1979	312	14.16±1.48[d,e]
1980–1985	317	13.79±1.37[e]

The same superscript letters indicate non-significant differences between the means of groups based on Tukey's multiple comparison test

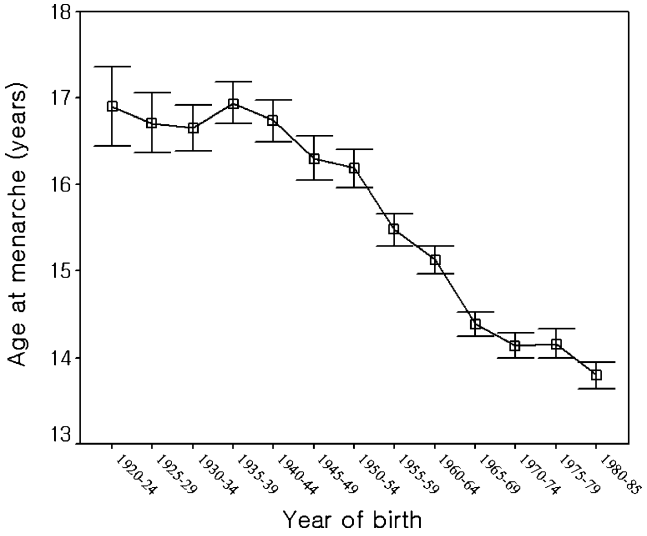

Fig. 1 Secular trend of mean age at menarche for women born between 1920 and 1985

significant correlation between age at menarche of menarcheal girls and their maternal menarcheal age (r=0.219, p< 0.001). The mean and median ages at menarche of girls aged 10–19 years were 13.10±0.06 and 13.00±0.07 years, respectively, based on the Kaplan–Meier analysis.

Table 2 shows the general characteristics of the girls according to their menarcheal status. Waist circumference and body mass index (BMI) were significantly higher among menarcheal girls compared with premenarcheal girls. However, no significant differences in birth weight, sleep time, and hours of TV viewing or computer use were observed between premenarcheal and menarcheal girls. Menarcheal girls had lower maternal menarcheal age and maternal age at birth than premenarcheal girls. Household income was not different between the two groups. The distribution patterns of maternal education level between premenarcheal and menarcheal girls were similar.

Table 3 shows the energy and nutrient intake of the girls according to their menarcheal status. The energy intake for menarcheal girls was higher than premenarcheal girls (p= 0.017). Moreover, nutrient intake of protein, sugar, fiber, ash, phosphate, natrium, thiamine, riboflavin, and niacin was greater for menarcheal girls than for premenarcheal girls. However, the intake of other nutrients was not significantly different between premenarcheal and menarcheal girls.

Discussion

Many countries found the downward trends in age at menarche, indicating values of 0.12 years per decade in Dutch women between 1955 and1997 [4], 0.35 years per decade in Israeli girls [1], 0.50 years per decade in South African black girls between 1956 and 2004 [10], 0.27 years per decade in North American women born between 1920 and 1940 [29], 0.7 years per decade in Chinese women over an approximately 40-year period [6], and 0.12 years per decade in Brazilian women born between 1920 and 1979 [11]. Similarly, this study showed a decreasing secular trend in age at menarche in Korean populations using representative data. The downward trend was 0.68 years per decade, consistent with the previous report on the Ansan cohort study in Korea [9]. However, age at menarche in girls born between 1980 and 1985 was higher compared to the results

Table 2 General characteristics of girls aged 10–19 years of age according to menarcheal status

	Premenarcheal girls (n=187)	Menarcheal girls (n=433)	p value
Waist circumference (cm)	63.93±0.73	67.86±0.48	<0.001
BMI (kg/m^2)	18.37±0.24	19.84±0.15	<0.001
Birth weight (kg)	3.25±0.39	3.20±0.24	0.328
Sleep time (hours/day)	7.21±0.20	6.85±0.06	0.093
TV viewing (hours/day)	2.14±0.14	2.46±0.089	0.078
Computer use (hours/day)	1.49±0.12	1.56±0.08	0.661
Maternal menarcheal age (years)	14.96±0.16	14.53±0.95	0.036
Maternal age at birth (years)	27.35±4.42	26.69±3.83	0.035
Household income (10,000 won/month)	248.83±15.67	282.11±9.08	0.088
Maternal education level (%)			0.189
≤6 years	2.3	5.6	
7–9 years	9.4	11.8	
10–12 years	61.4	54.8	
≥13 years	26.9	27.8	

Values are expressed as means with standard deviation (SD) or percent. p value calculated by ANCOVA after controlling for age (continuous data) or chi-square test (categorical data)

Table 3 Energy and nutrient intake per day of girls aged 10–19 years according to menarcheal status

	Premenarcheal girls (n=187)	Menarcheal girls (n=433)	p value
Energy (kcal/day)	1,802.83±65.75	2,005.70±38.34	0.017
Protein (g/day)	62.51±2.84	73.16±1.66	0.004
Water (g/day)	685.75±31.26	723.96±18.23	0.343
Fat (g/day)	48.22±2.87	55.00±1.68	0.067
Sugar (g/day)	270.59±9.72	299.30±5.67	0.022
Fiber (mg/day)	4.80±0.28	5.58±0.16	0.027
Ash (mg/day)	16.30±0.75	18.61±0.44	0.017
Calcium (mg/day)	495.26±26.29	511.55±15.33	0.630
Phosphate (mg/day)	1,053.24±42.18	1,173.47±24.60	0.027
Iron (mg/day)	10.74±0.76	11.69±0.44	0.330
Natrium (mg/day)	3,904.58±214.58	4,594.76±125.12	0.013
Potassium (mg/day)	2,201.193±92.85	2,423.41±54.15	0.063
Vitamin A (μg RE)	607.21±48.34	664.35±28.19	0.359
Carotene (mg/day)	2,747.85±267.23	2,958.83±155.84	0.540
Retinol (mg/day)	103.16±10.09	118.66±5.88	0.233
Thiamine (mg/day)	1.11±0.06	1.34±0.04	0.004
Riboflavin (mg/day)	1.05±0.05	1.21±0.03	0.024
Niacin (mg/day)	12.66±0.74	15.58±0.43	0.002
Vitamin C (mg/day)	83.55±7.40	89.16±4.32	0.556

p value was calculated by ANCOVA after controlling for age

RE retinol equivalents

from the Ansan cohort study. An investigation in China found that urban girls were starting menstruation significantly earlier than girls in rural areas [8]. Ansan is a major city on the west coast of the peninsula of Korea with population of about 720,000. Ansan province is an industrialized and urbanized region. The higher age at menarche found in this study for girls born between 1980 and 1985 may be due to the facts that a higher proportion of girls from rural areas were included and that a larger number of girls in this birth year group were evaluated compared to the Ansan study.

Recent data from some countries including Denmark [7], Greece [21], Belgium [25], and the UK [27] showed that age at menarche was static over recent decades while an increase in the age at menarche was seen in Croatia [22]. However, in our study, the mean age at menarche of girls born between 1986 and 1995 calculated by the Kaplan–Meier survival and recall age method was 13.10±0.06 and 12.90±1.28 years, respectively, which was lower than the 13.78±1.40 years in girls born between 1981 and 1985, suggesting that the decrease in age at menarche is still occurring. This trend may be due to certain social changes that occurred in Korea during this period such as the Seoul Asian Games in 1986. Soon after the Seoul Asian Games, South Koreans rapidly accepted aspects of Western culture that have markedly altered the lifestyles and diets of South Koreans [9].

In line with the results from other population studies [3, 21], there was a positive association between age at menarche and maternal menarcheal age in our study, suggesting the influence of genetic factors on menarche [21]. Towne et al. [24] reported that half of the variance in menarcheal age was due to genetic factors. However, age at menarche of North Korean refugees who stayed at a North Korean female refugee camp and shared the same genetic backgrounds as South Korean women was 16.0±2.1 years. In particular, refugees who were young and had not had sufficient nutrition showed a later age of onset of menarche than others [15]. This finding suggests that other factors including nutrition and socioeconomic conditions may have a greater effect on age at menarche than genetic factors.

Frisch and Revelle [5] reported that the degree of body fatness acts as a trigger of menarche by neuroendocrine events. Previous studies have demonstrated a positive association between early menarcheal age and body weight or BMI [3, 8, 16, 23]. Similarly, menarcheal girls had higher BMI than premenarcheal girls in our study.

Nutrition is an important determinant of age at menarche. In particular, a higher dietary energy intake is associated with an earlier age at menarche [12, 19]. In contrast, age at menarche and the start of puberty were delayed in malnourished people [16, 23]. Maclure et al. [17] reported that nutritional factors influence age at menarche mainly through their effects on accumulation of adipose tissue. In our study, menarcheal girls consumed more dietary energy than premenarcheal girls after adjustment for age. Moreover, the amount of intake of certain

nutrients including protein, sugar, fiber, ash, phosphate, natrium, thiamine, riboflavin, and niacin was also higher in menarcheal girls than premenarcheal girls. The mechanism by which each nutrient intake affects age at menarche is not clear in this study. Whether the difference found in our study is only a chance finding accompanied by high energy intake or has an underlying biologic basis will need to be evaluated by future studies.

Interestingly, menarcheal girls had a lower maternal age at birth than premenarcheal girls. The mechanism underlying this association is still unclear. It has been reported that earlier maternal age at first birth is associated with a graded increase in body weight [13, 26]. Various factors including dietary and lifestyle alterations may contribute to sustained postpartum weight gain. Hence, these factors which result in weight gain may also influence their daughters and, in turn, may be related to factors which affect age at menarche.

Ku et al. [15] reported that sleep time was significantly and negatively correlated with age at menarche. Although the mean sleep duration in menarcheal girls was shorter than premenarcheal girls (6.82±1.31 vs. 7.47±1.18, p= 0.001) based on a t test, the difference was not significant in ANCOVA when age was controlled. Taken together, the facts that age is the most important determinant of menarcheal status and sleep time decreases with increasing age due to increased participation in activities including school work in Korea, the association between sleep time and age at menarche may be mediated by age.

It has been shown that prolonged TV viewing time is associated with increased consumption of high-fat and high-sugar foods resulting in increased daily energy intake [18]. However, TV viewing or computer use time was not different between premenarcheal and menarcheal girls in this study.

Socioeconomic status evaluated by measuring features such as household income, maternal education level, housing type, and home ownership was also similar between premenarcheal and menarcheal girls, in contrast with other studies [12, 28].

Several limitations should be kept in mind when interpreting the findings of this study. First, this study used a cross-sectional design so that causality could not be determined. Recall bias may be another limitation of this study. However, results from other studies have reported that the recall method of age at menarche is reliable and valid [14, 20].

These data indicate that the trend for age at menarche to decrease is continuing and can be seen in girls born between 1986 and 1995. Furthermore, maternal menarcheal age, BMI, maternal age at birth, and nutrition are important variables that influence age at menarche in Korean girls.

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