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Original Article

The association between age at menarche and anthropometric factors

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Abstract

Background and aims: The purpose of this study was to investigate the association between age at menarche (AAM) and anthropometric parameters in young female students in Shahrekord, southwest Iran.

Methods: A cross-sectional study was conducted in elementary and senior girls' schools in Shahrekord in 2018. The sampling method was multistage cluster sampling. The 633 students were studied out of 4868 students selected before the commencement of the study. The statistical analysis was done with a one-way analysis of variance, Spearman's correlation coefficient, and the Kaplan-Meier estimate. The checklist was used to collect the participants' information. All analyses were conducted using SPSS version 24 (IBM Corp, Armonk, NY, USA).

Results: The average AAM of our participants was 13.34±0.95 years. Only 8.5% of the 633 participants had reached menarche before the age of 12. In this study, the association between AAM and height ($P<0.001$) and weight ($P=0.007$) were significant, while there was no relationship between AAM and body mass index ($P=0.91$).

Conclusion: This study found that the average AAM was like that found in other studies in Iran and other regions of the world. Furthermore, efficient puberty health education is required for female students, especially those aged 12 years.

Keywords: Menarche age, Anthropometric, Body mass index, Weight, Height

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Introduction

Menarche is a significant moment in a girl's life that has a significant impact on her physical and sexual health (1). The first menstrual bleeding, known as menarche, is a watershed moment in a woman's reproductive life (2). The typical age at first menopause has reduced in recent years, averaging between 12 and 13 years worldwide (3,4). In the United States, it is 12.8 years, 12.9 years in Europe (5,6) and 11.8-12.9 years in Iran (7,8). The global trend of menarche at a younger age is most likely due to increased nutrition, fewer infectious diseases, chemical exposure, and environmental variables (7,9). Body mass index (BMI), type 2 diabetes mellitus, metabolic syndrome, cardiovascular disease, dyslipidemia, nonalcoholic fatty liver disease, breast cancer and uterine cancer have all been associated with age at menarche (AAM) (10-14). AAM is also associated with psychological issues like depression, smoking, and alcohol consumption (15). Much research has looked at the influence of anthropometric parameters on AAM, such as height, weight, and body structure, but the results have been mixed (7,16,17). In the study conducted in Sanandaj, west Iran, the likelihood of early menarche in children with higher BMI was 3.57 times higher than others (18). In the study in Indonesia, AAM was inversely correlated to BMI and weight but was not associated with height (19). In the other study in Mexico, it was observed that the girls with early AAM had a risk of a 4.09 cm lower height and 1.37 kg/m^2 higher BMI (20). In the study, in Bangladesh, the menarcheal girls were taller and heavier (21). However, in a study in Iraq, the relationship between AAM and BMI was not significant (22). It is argued that children with higher BMI are more likely to have earlier menarche and subsequently higher BMI, and therefore, high BMI is a risk factor for noncommunicable disease in adulthood (23). This study aims to investigate the relationship between AAM and anthropometric parameters among female students in Shahrekord, southwest Iran because this variable is an indicator of a society's health growth and helps the government deal with this problem.

Materials and Methods

Study population

A cross-sectional study was done in elementary and

senior girls' schools in Shahrekord in 2018. The study included 633 female students aged 9-16 years who had experienced their first menarche within six months before the commencement of the study. These samples were drawn from 4868 students at Shahrekord's primary and senior schools. An average population was also included as a comparison group in this investigation. The average population was considered to be the students whose AAM was not investigated, including both the students who had experienced the menarche and the students who had yet to experience menarche.

Sampling method

A multistage cluster sampling strategy was used in the current investigation. All of Shahrekord's girls' schools were initially assigned into two clusters. Then, based on simple random sampling, 11 schools were selected from each cluster (4868 students). Afterwards, all students in each school were surveyed, and those who had experienced their first menopause six months before the commencement of the study were enrolled in the study.

Inclusion criteria

Volunteering to participate in the study, being a student, experiencing their first menarche within six months before the commencement of the study, and age over 9 years and less than 16 years.

Data collection instruments

In the present study, demographic variables including birth date, father's age, mother's age and data registration date were collected. Moreover, the anthropometric factors, including waist circumference, arm circumference, leg length, triceps skinfold thickness, weight (kg), and height (cm), were all measured and recorded in a checklist. BMI was calculated by dividing the weight (kg) by the height (m) squared. After normal expiration, the waist circumference was measured using a non-stretchable flexible tape in a horizontal posture at a location halfway between the lower border of the ribs and the highest point of the iliac crest, with the individual standing erect and looking straight forward. The tape was stretched around their arm at the mid-point between their shoulder and elbow to measure arm circumference in the contraction position. The participants were in a sitting position when the leg length was measured, and the flexible tape was placed between the knee and the sole. The subject's arm was in a relaxed position when the triceps skinfold was measured with a Lange caliper, and the skinfold was selected based on the thumb and index fingers near the midway of the arm. A minimum of 0.1 kg of clothing, but no shoes or heavy accessories, was necessary for accurate weight measurement. Every day, a portable scale (JUPITER, Iran) was calibrated against a standard scale. A plastic measuring tape was mounted to the wall and used to measure the participants' height. The study's participants were instructed to maintain their legs straight, their arms at their sides, and their knees, shoulders, and back heads all pointing in the same direction. The ruler was kept in contact with the tops of their heads, and the measurement was conducted to the nearest 0.5 cm. Their parents reported AAM for elementary school students and by themselves for secondary school students.

Data analysis

For numerical measurements, data were presented as means ± standard deviation (SD) and for categorical measurements as numbers (percentage). The association between quantitative variables and age groups was investigated using a one-way analysis of variance. The association between AAM and quantitative characteristics was then determined using Spearman's correlation. The Kaplan-Meier estimate was used to forecast the onset of menarche. The P value < 0.05 was considered a significance level. All analyses were conducted using SPSS version 24 (IBM Corp, Armonk, NY, USA).

Results

Only 633 students out of 4868 had menarche in the six months leading up to the commencement of the study (Table 1). In our participants, menarche occurred at a median age of 13.32 years and a mean age of 13.34 ± 0.95 years. Table 2 shows how the students were assigned to three age groups. The age group of 12-14 years had the earliest start of menarche (67.5%). Furthermore, the study's participants had an AAM of 9.90-16.09 years (Figure 1).

Factors affecting AAM

In this study, there was a significant and positive relationship between AAM and weight (P = 0.007, rs = 0.094), height (P < 0.001, rs = 0.194), father's age (P < 0.001, rs = 0.238), and mother's age (P < 0.001, rs = 0.016). Therefore, the girls who experienced menarche sooner were taller and heavier, and their mothers and fathers were younger. In the present study, there was no significant relationship between AAM and BMI, waist circumference, arm circumference, leg length, or triceps skinfold thickness (P > 0.05, Tables 3 and 4).

Comparison with normal population

The average BMI in the age group of less than 12 years was higher than the average population (20.04 ± 3.98) with respect to the comparison between BMI, weight, and height in the average population and the examined samples. However, it was lower among those aged over 14 years (20.20 ± 4.20). For both weight and height, the outcomes were the same (Table 5).

In Figures 2-4, the comparison of BMI percentile in the studied samples and average population for age groups under 12, 12-14 and over 14 years is illustrated.

Discussion

In this study, the average AAM was 13.34 ± 0.95 years.

Table 1. The frequency of menarche over the past six months

Grade	The number (%) of participants in studied grades	The frequency (%) of menarche
4th Grade	647 (13.3)	2 (0.3)
5th Grade	701 (14.4)	24 (3.8)
6th Grade	672 (13.8)	88(13.9)
7th Grade	967 (19.9)	291(46)
8th Grade	919 (18.9)	172 (27.2)
9th Grade	847 (17.4)	56(8.8)
10th Grade	847 (17.4)	0
Total	4868 (100)	633 (100)

Table 2. The distribution of age groups of participants

Age group (y)	The number (%) of participants in studied age groups	Mean age (y)	Standard deviation	Median age (y)
<12	54 (8.5%)	11.50	0.44	11.64
12-14	427 (67.5%)	13.13	0.48	13.15
>14	152 (24%)	14.60	0.48	14.41
Total	633	13.34	0.95	13.32

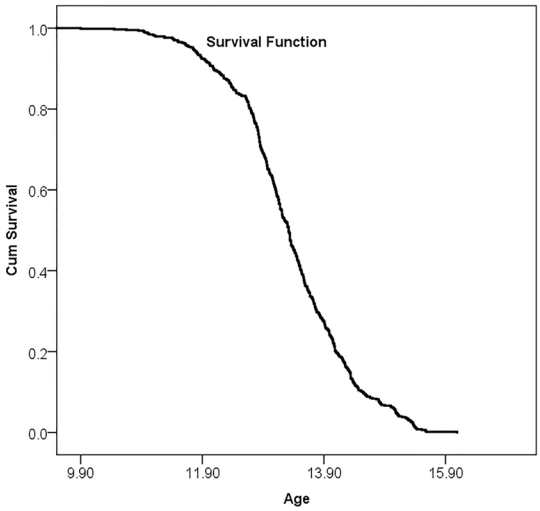

Figure 1. The survival function curve based on the Kaplan-Meier estimate for the onset of menarche

Table 3. The relationship between age at menarche and quantitative variables in studied age groups

Variable	Age < 12 y (mean ± SD)	Age 12-14 y (mean ± SD)	Age > 14 y (mean ± SD)	*P* value
Weight (kg)	47.35 ± 11.25	51.31 ± 10.41	52.83 ± 12.05	0.007
Height (cm)	153.43 ± 9.32	160.42 ± 5.81	161.45 ± 6.17	<0.001
BMI (kg/m^2)	20.04 ± 3.98	19.9 ± 3.69	20.22 ± 4.19	0.91
Waist circumference (cm)	66.39 ± 8.24	67.73 ± 8.33	68.42 ± 9.15	0.38
Arm circumference (cm)	23.94 ± 2.98	24.31 ± 2.91	24.36 ± 3.25	0.67
Leg length (cm)	34.31 ± 2.88	35.24 ± 2.87	35.14 ± 2.91	0.053
Triceps skinfold thickness (cm)	11.91 ± 3.83	12.78 ± 4.56	13.12 ± 4.95	0.26
Father's age (y)	41.28 ± 4.31	44.15 ± 5.08	46.11 ± 5.74	<0.001
Mother's age (y)	37.27 ± 4.52	39.3 ± 4.75	40.64 ± 5.13	<0.001

BMI, Body mass index.

Table 4. Spearman's correlation coefficients between age at menarche and quantitative variables

Variable	Spearman's correlation coefficient	*P* value
Weight (kg)	0.094	0.01
Height (cm)	0.194	<0.001
BMI* (kg/m2)	0.017	0.66
Waist circumference (cm)	0.012	0.76
Arm circumference (cm)	0.017	0.67
Leg length (cm)	0.042	0.29
Triceps skinfold thickness (cm)	0.052	0.19
Father's age (y)	0.238	<0.001
Mother's age (y)	0.0166	<0.001

BMI, Body mass index.

Also, the relationship between AAM and height, weight, father's age and mother's age were significant. Moreover, the average weight in the age group < 12 years was higher than that in the average population, which indicates that the girls who had a higher weight experienced menarche earlier. However, the relationship between AAM and anthropometric factors, including BMI, waist circumference, arm circumference, triceps skinfold thickness, and leg length, was not statistically significant.

The results of studies undertaken in various regions of the world were inconsistent, but they all have revealed that the average AAM drops over time (13,24). In the study of Ather et al in Pakistan, the average AAM was 12.76 ± 1.24 years (25). In the other study conducted by Bratke et al in Norway, the average AAM was 13.3 ± .9 years (26). In the study of Dashtabi et al in Shiraz, southwest Iran, the mean AAM was 12.27 ± 0.73 years (12). In the study of Khoshnevisasl et al in Zanjan, northwest Iran, the average AAM was 12.6 ± 1.6 years (27). In the study of Dharmarha and Konda in India, the average AAM age was 12.23 ± 1.09 years (28). In another study by Idris et al in Eritrea, the mean AAM was 13.8 ± 1.2 (24). In the study of Jung et al in Korea, the mean AAM was 14.9 ± 1.9 (29). The difference in AAM in various regions of the world can be due to racial, genetic, and geographical variations (27).

In the current study, the association between weight and AAM was significant that is consistent with the results of studies by Dashtabi et al in Shiraz (12), Malitha et al in Bangladesh (21) and Petersohn et al in Mexico (30) while in the studies of Lee et al in Korea (31) and Tiyuri et al in Qaen, northeast Iran, the association was not significant

Table 5. The comparison between weight, height, and body mass index between studied samples and the average population

Age group (y)	Sample size		Weight (kg) (mean ± SD)		Height (cm) (mean ± SD)		BMI (mean ± SD)	
	Studied samples	Normal population	Studied samples	Normal population	Studied samples	Normal population	Studied samples	Normal population
Age < 12	54	106	47.3 ± 25.1	40.5 ± 10.8	153.4 ± 9.3	146.2 ± 0.08	20.04 ± 3.9	18.6 ± 3.5
Age 12-14	427	383	51.2 ± 10.4	50.9 ± 8.5	160.4 ± 5.8	158.2 ± 0.06	19.8 ± 3.6	20.2 ± 2.5
Age > 14	151	143	52.8 ± 12	58.4 ± 10.9	161.4 ± 6.1	164.2 ± 0.05	20.2 ± 4.2	21.6 ± 3.8
Total	633	632	51.3 ± 10.9	50.8 ± 11	160 ± 6.5	157.5 ± 0.08	20 ± 3.8	20.9 ± 3.1

BMI, Body mass index.

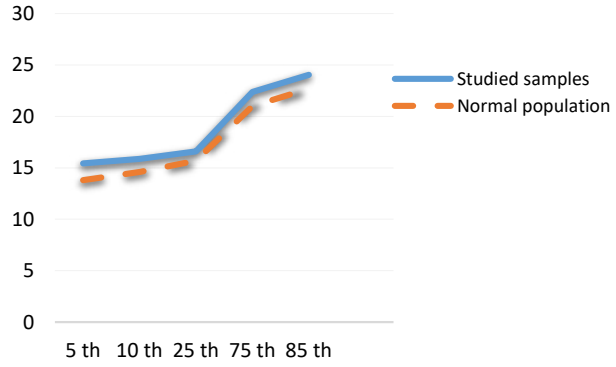

Figure 2. Comparison of body mass index percentile in participants and average population for age group < 12 years

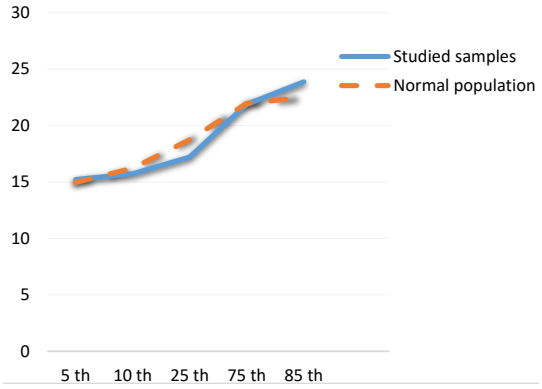

Figure 3. Comparison of body mass index percentile in participants and average population for age group 12-14 years

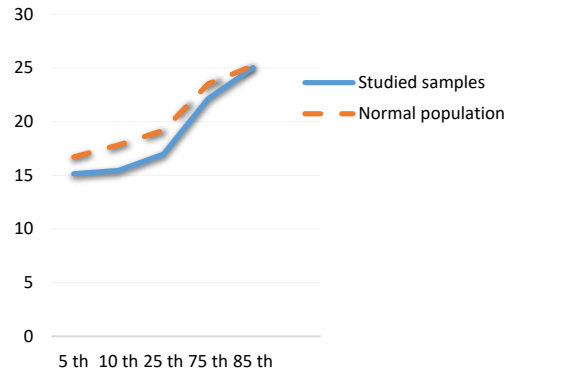

Figure 4. Comparison of body mass index percentile in participants and average population for age group > 14 years

(32). Although the mechanisms involved in the negative association between obesity and AAM are not well recognized, it is suggested that many endocrine factors are alleged to affect the speed of sexual puberty and fat accumulation in the body (7). Some experts believe that to start menarche, girls need to reach a minimum weight of 47.8 kg, and their body fat should amount to 23.7%. The findings of our study confirm this theory, as weight is inversely correlated to AAM. Therefore, girls who are overweight experience menarche comparably earlier (17).

In the present study, the girls who had experienced menarche at the age of under 12 years were taller in the studied sample than the average population, which was similar to the results of Kaplowitz (33) and Kim et al in Korea (34). These findings are inconsistent with those reported by Asrullah et al in Indonesia (19) and Banik in Mexico (20). The association has been explained by the earlier closure of epiphyseal growth disks because of the increase in ovarian estrogen, which is responsible for the elongation of the bones (19). In this study, the average weight, height, and BMI in the age group > 14 years in the studied samples were less than the average population, which was the same as the results of Pejhan et al (7), Kim et al (34) and showed that the girls who had lower weight, height and BMI experience the menarche later.

In the present study, the correlation between AAM and BMI was not significant, which is parallel with the study of Noipayak et al in Thailand (9) but in two studies conducted by Hozoori et al in Qom, central Iran (8) and Wang et al in China, the association between BMI and menarche was significant (4). The reasons for these inconsistencies may be related to the economic, social, and geographical conditions and lifestyles of individuals (2,35). In addition, in the present study, the relationship between menarche and arm circumference was not significant, which is not consistent with studies conducted by Yusofi and Rajaie in Mashhad, northeast Iran (36) and Pramanik et al in Bangladesh (37), which is probably due to the relationship between arm circumference and weight as the participants of this study had weight and BMI of a normal range. Moreover, the association between menarche and waist circumference was not significant, which is consistent with the study conducted by Chen et al in the United States (38). However, in the study of Kim et al in Korea, there was a significant relationship between waist circumference and AAM (34). In the current study, the relationship between triceps skinfold thickness and AAM was not significant, which is in agreement with the study of Bratke et al in Norway (26), but in the study of Pramanik et al in Bangladesh, the association was

significant (37). In this study, the relationship between the father's age and the mother's age with AAM was significant. However, in similar studies, less attention was paid to this variable. In a study conducted by Noipayak et al in Thailand, the relationship between the father's age and the mother's age at birth and AAM was not significant (9). The reasons for these inconsistencies may be related to racial and ethnic diversity (39).

Limitations

One of the limitations of the present study was the need for more study on genetic factors, diet, and physical activity. In addition, in the present study, the data were collected based on the answers that girls gave to the questionnaires during the study. Another limitation was related to the (cross-sectional) study design, which requires conducting longitudinal studies on the causal relationship between AAM and anthropometric variables.

Strengths

Despite the limitations mentioned above, this study has some strengths. One of the strengths of the present study was determining the incidence of menarche in students under 12 years; their mothers were also questioned to reduce the likelihood of recall bias. Another strength was the inclusion of 4868 female students who were selected from all girls' schools in the studied city.

Conclusion

The results of this study are significant in terms of public health. Based on this study, there is a need to educate puberty health in schools to female students aged 9.9-16 years, especially in the age group of 12-14 years because they experience menarche most frequently. This study can also be used as a basis for other studies in the future. On the other hand, due to the strong relationship between the mean AAM and noncommunicable diseases such as cardiovascular disease, diabetes mellitus, metabolic syndrome, breast cancer, and cervical cancer, the need for noncommunicable disease screening at lower age is essential.

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Authors' Contribution

Conceptualization: Saleh Jafarian Dehkordi, Masoud Amiri.
Data curation: Soleiman Kheiri, Masoud Amiri, Saleh Jafarian Dehkordi.
Formal analysis: Soleiman Kheiri, Saleh Jafarian Dehkordi.
Funding acquisition: Saleh Jafarian Dehkordi.
Investigation: Saleh Jafarian Dehkordi.
Methodology: Soleiman Kheiri, Masoud Amiri, Masoud Lotfizadeh.
Project administration: Saleh Jafarian Dehkordi, Masoud Amiri.
Resources: Masoud Amiri.
Software: Saleh Jafarian Dehkordi.
Supervision: Masoud Amiri.
Validation: Soleiman Kheiri, Masoud Amiri.
Visualization: Masoud Amiri.
Writing–original draft: Saleh Jafarian Dehkordi, Masoud Amiri.
Writing–review & editing: Masoud Amiri, Saleh Jafarian Dehkordi .

Competing Interests

The authors declare no conflict of interest related to this study.

Ethical Approval

Shahrekord University of Medical Sciences Ethical Committee approved the study protocol (Code: IR.SKUMS.REC.1397.052). In addition, all the participants signed a consent form. Each girl was given a printed consent to take home and was instructed to obtain parental consent as well.

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