Factors Related to the Age at Menarche in Iran: A Systematic Review and Meta-Analysis

Saeideh Nasiri[1], *Mahrokh Dolatian[2], Fahimeh Ramezani Tehrani[3], Hamid Alavi Majd[4], Azam Bagheri[5], Pooneh Malekifar[6]

[1]Student Research Committee, School of Nursing and Midwifery, Shahid Beheshti University of Medical Sciences, Tehran, Iran. [2]Department of Midwifery and Reproductive Health, School of Nursing and Midwifery, Shahid Beheshti University of Medical Sciences, Tehran, Iran. [3]Reproductive Endocrinology Research Center, Research Institute for Endocrine Sciences, Shahid Beheshti University of Medical Sciences, Tehran, Iran. [4]Department of Biostatistics, School of Paramedicine, Shahid Beheshti University of Medical Sciences, Tehran, Iran. [5]Department of Midwifery, Kashan University of Medical Sciences, Kashan, Iran. [6]Department of Epidemiology & Biostatistics, School of Public Health, Tehran University of Medical Science, Tehran, Iran.

Abstract

Background
Reduced age at menarche is an important health indicator for women and may be associated with complications such as an increased risk of asthma, breast cancer, ovarian cancer, type 2 diabetes. We aimed to examine the factors related to the age at menarche in Iran.

Materials and Methods: In this systematic review and meta-analysis, an advanced search with no time restriction was conducted in online databases such as the Web of Science, Embase, Medline, Scopus, and Persian databases of SID and Magiran, as well as the Google Scholar search engine, until the end of 2019. The publication heterogeneity and bias of the extracted studies were evaluated by the Q test and Begg's test, respectively.

Results: In this study, 12 articles with a total sample size of 17672 were included. Based on the findings of these studies, the body mass index (BMI), the mother's age at menarche, physical activity, nutrition, and socioeconomic status were correlated with the age at menarche for Iranian girls. A negative correlation was found between BMI (r=-0.07), and socioeconomic status (r=-0.57) with the age at menarche (P<0.05). A positive correlation existed between the girl's age at menarche and that of the mother (r=0.42, P<0.05). Moreover, correlation was weak and positive between the age at menarche and physical activity (r=0.14, P<0.05). The quantitative results of the studies were incomplete to establish a relationship between nutrition and age at menarche.

Conclusion
Due to the effects of numerous factors on the age at menarche, it is suggested that longitudinal studies be conducted to investigate the role of all the known factors, especially environmental factors, on the age at menarche.

Key Words: Age, Girls, Menarche, Meta-analysis, Related factors.

Corresponding Author:

Dr. Mahrokh Dolatian, Department of Midwifery and Reproductive Health, School of Nursing and Midwifery, Shahid Beheshti University of Medical Sciences, Tehran, Iran

Email: mhdolatian@gmail.com

1- INTRODUCTION

Menarche is the first menstruation in girls and the last sign of their sexual maturity (1). The age at menarche differs in different societies. Currently, the mean age at menarche is about 12 years (2). However, since the 19th century (when the age at menarche was 17 years), a decreasing trend has been observed in the age at menarche (3). Although the age at menarche has remained stable in developed countries in recent years (4), evidence suggests that it is still decreasing in developing countries (5). Several studies have been conducted in Iran on the age at menarche. Based on two national studies in 1990 and 1999, the mean age at menarche was 13.86 ± 1.51 and 13.65 ± 1.47 years, respectively. The results of these studies show that one month had been reduced from the mean age at menarche of Iranian girls for every four years during the nine-year period (6). Bahrami et al. (2014) performed a meta-analysis of previous studies in Iran, and reported the age at menarche to be 12.81 years in Iranian girls (7).

Based on the studies on Asian and European populations, menstruation in younger ages is a risk factor for metabolic syndrome, increased risk of asthma, breast cancer, ovarian cancer, hypertension, type 2 diabetes, cardiovascular diseases, earlier onset of sexual intercourse and the resulting psychological and social problems (8-12). Menstruation at a younger age may increase the girls' vulnerability and have severe negative effects on their reproductive and sexual health. Thus, it is necessary to design strategies to fight its negative outcomes. Designing such strategies requires a better understanding of factors related to early menarche. Age at menarche is affected by numerous factors. Although a strong correlation has been reported between age at menarche and genetic factors, including mother's age at menarche, there are other effective factors which may influence age at menarche (3). Based on a systematic review, nutrition and BMI during childhood, psychological stress during childhood (conflicts, parents' divorce, absence of the father, and mother's mood disorder), socioeconomic status, and environmental toxins are among the factors affecting age at menarche (13). Still, there are conflicting reports about this. In low- or middle-income countries such as Iran, improved socioeconomic status, health, and nutrition have been effective in reducing age at menarche (14, 15), while in high-income countries, a younger age at menarche has been attributed to a lower socioeconomic status, family instability, and early-childhood stressful conditions (14, 16-18). Studies in the US show that age at menarche has not reduced despite the increase in BMI, and this is related to genetic factors more than any other factors (19).

However, based on other studies, mother's age at menarche in non-obese girls is a predictor of girl's age at menarche (13, 20). Results of a meta-analysis on the correlation between obesity and girl's age at menarche showed that obesity can affect age of onset of puberty, i.e. breast development, but the relationship between obesity and age at menarche was not significant (21). Given the decreasing trend of age at menarche in different countries, including Iran, a comprehensive understanding of the factors affecting age at menarche is essential for proposing strategies to fight the negative outcomes of early puberty; still, there is no systematic review or meta-analysis to provide a complete picture of the factors examined in Iran. Thus, the present meta-analysis was conducted to determine the factors related to age at menarche in Iran.

2- MATERIALS AND METHODS

The present systematic review and meta-analysis were conducted based on the

Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) system (22) on observational (cross-sectional and correlational) studies published in Persian and English until the end of 2019.

2-1. Eligibility criteria

The inclusion and exclusion criteria were designed based on PICO.

Participants: adolescent girls with the onset of the first menstrual bleeding

Intervention: Not Applicable

Comparators: factors related to age at menarche

Outcome: age at menarche

2-2. The exclusion criteria

The exclusion criteria for the articles were: 1. Research designs such as reviews, clinical trials, cohort studies, case reports, letters to the editor, animal studies, or laboratory studies; 2. Studies examining age at menarche without determining the factors related to it; 3. Studies related to boy's puberty.

2-3. Search strategy

Before starting the review, a protocol was developed for directing the process of systematic review. Searches were conducted by two researchers independently in English databases such as PubMed, Web of Science, Embase, Scopus, and Persian databases of SID and Magiran, as well as the Google Scholar search engine. The following is an example of the advanced search in PubMed by using AND/OR operators and the relevant keywords. **Table.1** presents the search query for Medline database. To search the Persian databases, the Persian equivalents of the following MeSH terms were used. Two researchers independently screened the titles and abstracts of the articles. Then, each researcher examined the full text of the relevant articles to ensure that the article met all the inclusion

criteria. Moreover, the references cited in the retrieved articles were examined so that potential eligible data would not be missed. Disagreements between the researchers were resolved upon discussion and reaching a consensus or by a third reviewer (PhD Reproductive Health). Studies with ordinal or continuous variables of the factors related to menarche and reporting the risk estimates (relative risk, odds ratio, or risk ratio) with the confidence interval (CI) of 95% with sufficient data for estimation were examined for the meta-analysis. Articles which lacked sufficient data, as well as meta-analyses and systematic reviews were excluded.

Table-1: Search query in Medline (via PubMed).

Database	Query
	(((((((((("Menarche"[Mesh]) OR "age at menarche"[Mesh])) AND "adolescent"[Mesh])) OR ("student" [Mesh])) AND ("Diet"[Mesh] AND "nutrition" [Mesh] OR "nutritional status" [Mesh] OR "food"[Mesh])) OR ("energy intake"[Mesh] OR "body mass index"[Mesh] OR "body weight"[Mesh] OR "obesity" [Mesh])) OR ("genetic"[Mesh] OR "mother's age at menarche" [Mesh])) OR ("exercise"[Mesh] OR "physical activity"[Mesh])) OR)"stress"[Mesh] OR "anxiety"[Mesh] OR "depression" [Mesh])) OR ("cigarette" [Mesh])) OR ("violence"[Mesh] OR "domestic violence"[Mesh])) OR ("social support" [Mesh])) OR ("media" [Mesh]) OR ("internet"[Mesh])) OR ("breastfeeding"[Mesh])) OR ("adoption" [Mesh])) OR ("parent-child relationship" [Mesh]) OR ("abuse" [Mesh])) OR ("rape" [Mesh]))))))))).

2-4. Quality assessment and data extraction

Two researchers used Modified Newcastle - Ottawa scale to independently assess the quality of the methodology of each article (23). In this checklist, three sub-categories of sample selection (scores 0-4), comparability (scores 0-2), and outcome (scores 0-3) are examined (23). In the present study, all the articles included in the meta-analysis achieved a minimum

score of 2 in selection, 1 in comparability, and 2 in outcome. **Table. 2** presents the quality of the evaluated articles in the systematic review section. The main data of the articles were summarized in special data collection forms. The following data were extracted from each article: First author's name, year of publication, location, research design, sample size, mean or range of age, and factors affecting the adolescent girls' age at menarche.

2-5. Statistical Analysis

The sample size of the articles and the correlation coefficient between girl's age at menarche and BMI, mother's age at menarche, physical activity, and socioeconomic status were extracted from the articles. Then, standard error and 95% CI were calculated. The *metan* command was used to merge the results of the articles and obtain a pooled estimate. The final results are presented as a forest plot. Q test was used at the confidence level of 0.05 to assess heterogeneity, shown with I2 statistic. When a heterogeneous effect was found (P < 0.05 or I2 > 20%), the random effects model was used. Meta-regression was performed for examining the source of heterogeneity. The funnel plot and Begg's test were employed to assess the publication bias. P-value <0.05 was set as the significance level. The data were analyzed in STATA software version 14.0 (College Station, Texas).

Table-2: General Characteristics and quality assessment of the studies extracted based on the factors related to age at menarche.

Author, Year, Ref.	Location	Sample size	Age range (year)	Age at Menarche (Mean ± SD)	Factors related to age at menarche	The measurement method	Quality assessment score
Bayat et al., 2012, (25)	Markazi province	1223	14-20	13.21± 1.16	BMI had a significant positive correlation with age at menarche. The family's socioeconomic status had a significant negative correlation with age at menarche.	Height and weight were measured for calculating BMI, and there were five sub-groups: <15, 15.1-20, 20.1-25, 25.1-30, and >30. Economic status was determined based on the daily intake of dairy and meat (good, average, and poor)	6
Pejhan et al., 2013, (34)	Sabzevar	130	11-18	12.5 ± 1.4	BMI had a significant negative correlation with girls' age at menarche.	Height and weight were measured for calculating BMI, and there were three sub-groups: Underweight: <18; normal weight: 18-24.9; and overweight: >25	6
Javadifar and Heidari, 2009, (31)	Abadan	236	11-18	NA	No significant relationship was found between BMI and girls' age at menarche. No significant relationship was found between socioeconomic status and age at menarche.	Height and weight were measured for calculating BMI, and BMI was distributed based on 5, 15, 50, 85, and 95 percentiles. Socioeconomic status was determined based on mother's level of education and occupation, and the scores were divided into three groups of low, moderate, and high.	6
Hozoori (2017) (30)	Qom	370	12-16	12.3 ± 1.00	BMI had a significant negative correlation with girl's age at menarche. The mother's and daughter's age at menarche had a significant positive relationship.	Height and weight were measured for calculating BMI, and there were four sub-groups: Underweight: <5 percentile; normal weight: 5-85; overweight: 85-95; and obese: >95 Mother's age at menarche was determined retrospective method.	9
Khakbazan et al., 2006, (33)	Tehran	580	NA	12.1± 1.2	A significant negative relationship was found between BMI and girls' age at menarche.	Height and weight were measured for calculating BMI, and there were three sub-groups: Underweight: <19; normal weight: 19-24.9; and overweight: ≥ 25	6

Author, Year, Ref.	Location	Sample size	Age range (year)	Age at Menarche (Mean ± SD)	Factors related to age at menarche	The measurement method	Quality assessment score
Dahri et al., 2010, (26)	Mashhad	1300	11-15	13.00± 0.07	A significant negative relationship was found between BMI and girl's age at menarche.	Height and weight were measured for calculating BMI, and there were three sub-groups: Normal: <85 percentile; overweight: 85-95; and obese: ≥ 95	5
Zameni et al., 2018, (35)	Mazandaran	630	NA	11.77 ±1.05	BMI and socioeconomic status had a significant negative relationship with girl's age at menarche.

Physical activity and mother's age at menarche had a significant positive relationship with girl's age at menarche. | Height and weight were measured for calculating BMI, and there were four sub-groups: ≤5 percentile: 5-85; 85-95; ≥95
Socioeconomic status was determined based on four components: income level, social class, residence, and level of education: poor (low status), moderate, high, and excellent
Physical activity was measured by a pedometer worn by the girls on their hands for 7 days: ≥ 10000 steps: active; < 10000 steps: inactive
Mother's age at menarche was determined by retrospective method. | 7 |
| Abdollahzadeh and Yazdi, 2014, (24) | Sabzevar | 400 | 10-17 | 12.88±1.26 | A significant negative relationship was found between BMI and girl's age at menarche. | Height and weight were measured for calculating BMI, and there were four sub-groups: Underweight: <15 percentile; normal: 15-85; overweight: 85-95; and obese: ≥ 95 | 5 |
| Farahmand et al., 2009, (28) | Tehran | 370 | 10-16 | 12.6±1.1 | A significant negative relationship was found between BMI and girl's age at menarche. | Height and weight were measured for calculating BMI, and there were four sub-groups: Underweight: <15 percentile; normal: 15-85; overweight: 85-95; and obese: ≥ 95 | 9 |
| Ghergherechi and Shoaree, 2011, (29) | Tabriz | 1000 | 7-17 | 12.58±1.30 | A significant negative relationship was found between BMI and girl's age at menarche.
The mother's and daughter's age at menarche had a significant positive relationship. | Height and weight were measured for calculating BMI, and there were four sub-groups: Underweight: <50 percentile; normal: 50-85; overweight: 85-95; and obese: ≥ 95
Mother's age at menarche was determined by retrospective method. | 8 |
| Kabir et al., 2007, (32) | 24 provinces | 629 | NA | 13.18±0.06 | BMI had a significant negative correlation with girls' age at menarche.
The mother's and daughter's age at menarche did not have a significant relationship.
The daughter's age at menarche had a significant positive relationship with the age of onset of exercise. | Height and weight were measured for calculating BMI
Mother's age at menarche was determined by retrospective method.
The level of physical activity in the girls was measured based on the following items: Type of sport, amount of exercise in the week before menarche, duration of exercise | 7 |
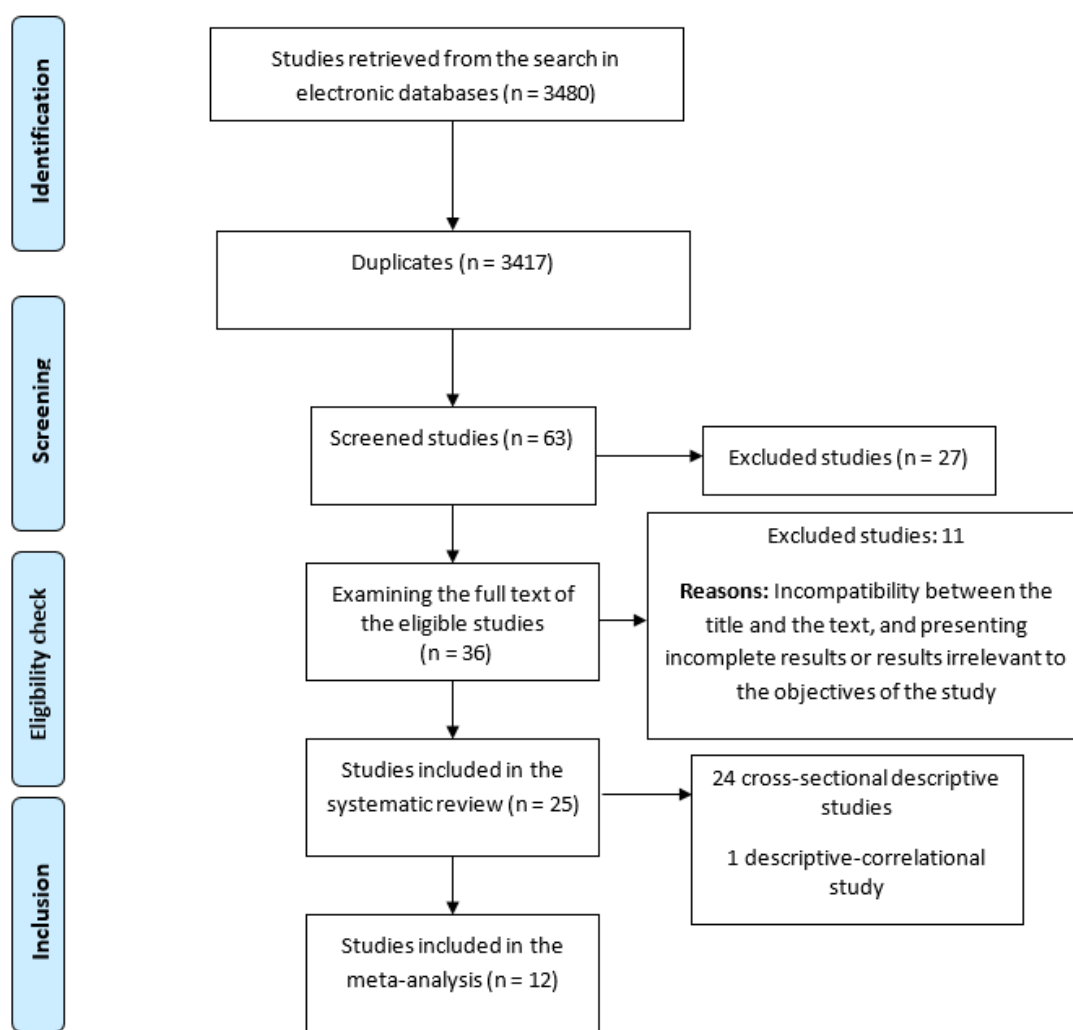| Danesh et al., 2009, (27) | Shahr-e Kord | 778 | 11-18 | 15.1±7.12 | A significant negative relationship was found between socioeconomic status and girl's age at menarche. | Socioeconomic status was measured based on parents' occupation and family size. | 5 |

NA: Not Applicable, BMI: body mass index, SD: Standard deviation.

3- RESULTS

3-1. Search results and the characteristics of studies

A total of 3,480 studies were retrieved. After examining the titles and abstracts, 36 articles were retained for close examination of their full text. Eleven articles were removed due to the incompatibility of the titles and full text, or due to presenting incomplete results or results irrelevant to the objectives of the study. Subsequently, 25 articles related to the main data were examined. Finally, out of the 25 articles retrieved with the search strategy, 12 articles relevant to the objectives of the study with a total sample size of 17,672 were analyzed in the present meta-analysis, as others were excluded for having incomplete data and lack of necessary quantitative data in some articles. There were 4 articles in English and 8 articles in Persian. The process of article selection is illustrated in **Figure.1**.

Fig.1: PRISMA flowchart.

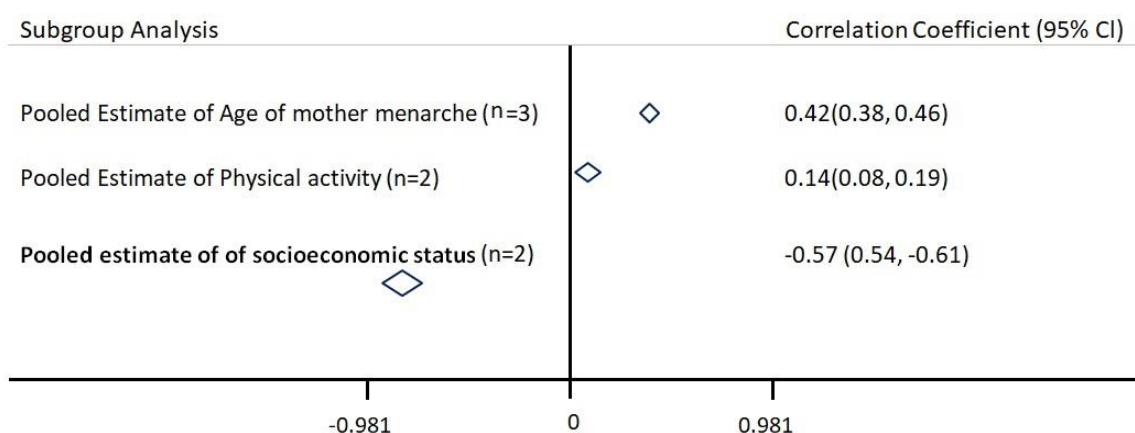Out of the 12 examined articles, 11 were cross-sectional (24-34), and one was descriptive-correlational (35). The oldest article was published in 2006 and the most recent one in 2018. The sample size varied from 130 to 1,300, and the participants'

age varied from 7 to 20 years. Some of the articles had examined multiple factors determining the age at menarche. Three articles had investigated mother's age at menarche (29, 30, 35), 10 articles BMI (24-26, 28, 30-35), two articles physical activity (32, 35), and three articles the socioeconomic status (25, 27, 35). The characteristics of the studies in the meta-analysis on the factors related to age at menarche are given in **Table. 2**. The quality assessment scores indicated that four studies had a high quality, and eight had an average quality. Age at menarche was measured using retrospective method in all the studies and based on recalling the age of the first menstruation in years and months, which was asked of the mother or the daughter.
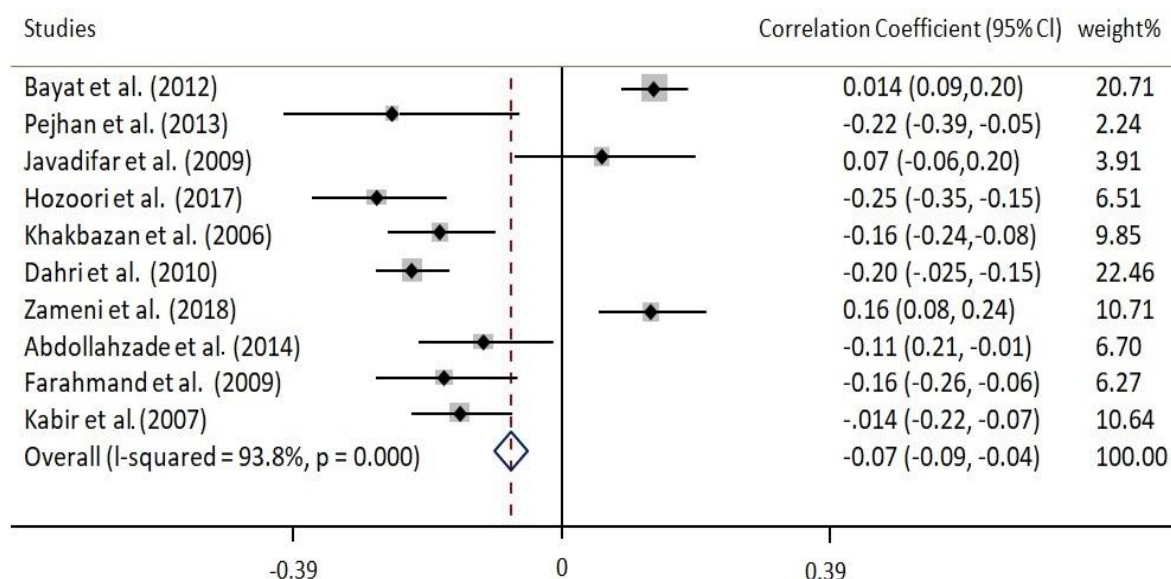
3-2. Results of the meta-analysis

Three studies had examined the relationship between mother's and daughter's age at menarche (29, 30, 35). Based on the analysis of results, a significant positive relationship existed between mother's and daughter's age at menarche (r = 0.42; 95% CI = 0.38, 0.46) (**Figure. 2**). Ten articles had investigated the relationship between BMI and age at menarche (24-26, 28, 30-35). The results of the meta-analysis of these studies

showed that with one unit of increase in BMI, age at menarche reduced by 0.07 years (r = -0.07; 95% CI: -0.09, -0.04) (**Figure. 3**). Two studies had explored the correlation between physical activity and age at menarche (32, 35). Based on the findings, a significant positive correlation existed between girls 'physical activity and their age at menarche (r = .17; 95% CI: 0.09, 0.25) (**Figure. 2**). One study had examined the age of onset of physical activity (32) while another one had calculated physical activity for two weeks with a pedometer worn by the girls on their hands (35). Three studies had investigated the correlation between socioeconomic status and age at menarche (25, 27, 35). Results of the meta-analysis showed that a significant negative correlation existed between socioeconomic status and age at menarche (r = -0.75; 95% CI: -0.54, -0.61) (**Figure.2**). Socioeconomic status was measured differently in different studies. It was measured based on the daily meat and dairy intake in the study by Bayat et al. (2012) (25), based on parents' occupation and family size in the study by Danesh et al. (2009) (27), and based on four components of income level, social class, residence status, and level of education in the study by Zameni et al. (2018) (35).

Fig. 2: Pooled Estimate of Correlation Coefficient and 95% Confidence Interval. The diamond mark and length of the diamond respectively indicate the pooled Correlation Coefficient and 95% Confidence Interval in each variable.

Fig. 3: Pooled Estimate of Correlation Coefficient and 95% Confidence Interval. The midpoint of each line segment shows the Correlation Coefficient estimate, the length of the line segment indicates the 95% Confidence Interval in each study, and the diamond mark illustrates the pooled proportion of BMI. BMI: body mass index.

Homogeneity of the studies assessed by Q test indicated a high level of heterogeneity ($I2 = 93.8\%$, $P < 0.001$); therefore, the random effects model was adopted for merging the results of the studies in the meta-analysis. **Table. 3** presents the meta-regression results according to which the relationship between age at menarche and the relevant factors was not affected b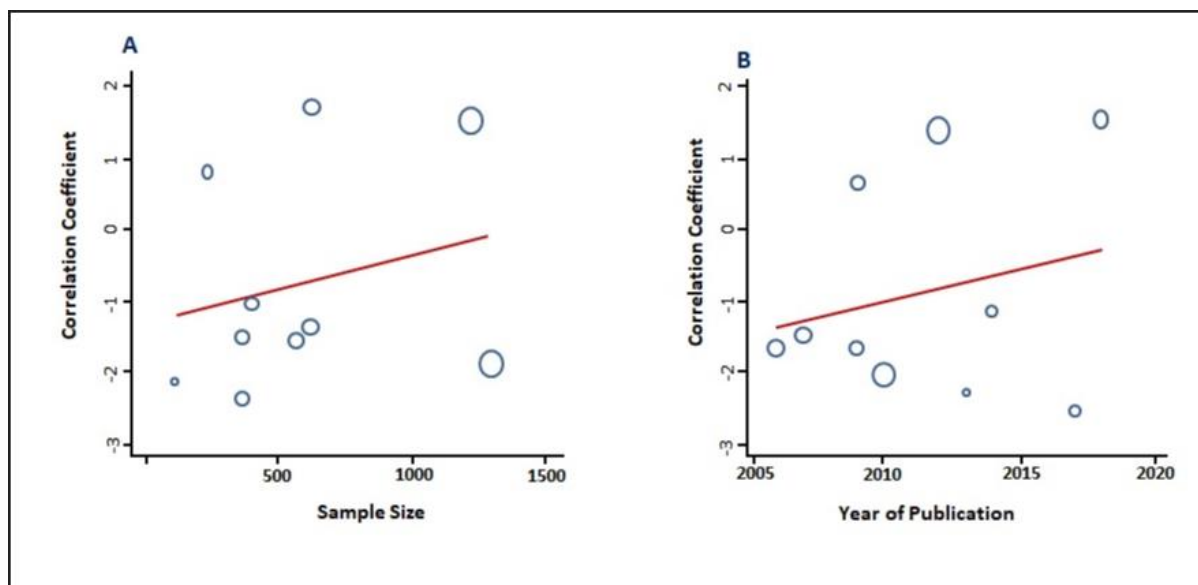y an increase in the year of publication of the articles and their sample size ($P > 0.05$) (**Figure.4**). Based on Begg's test, no publication bias was found in articles examining the relationship between BMI and age at menarche ($z = 0.09$; $P > 0.05$) (**Figure. 5**). Moreover, based on this test, no publication bias was observed in articles examining the relationship between age at menarche and other factors ($Z = 1.21$, $P > 0.05$).

Table-3: Meta-regression results of the correlation coefficient of factors related to the age at menarche based on sample size and the articles' year of publication.
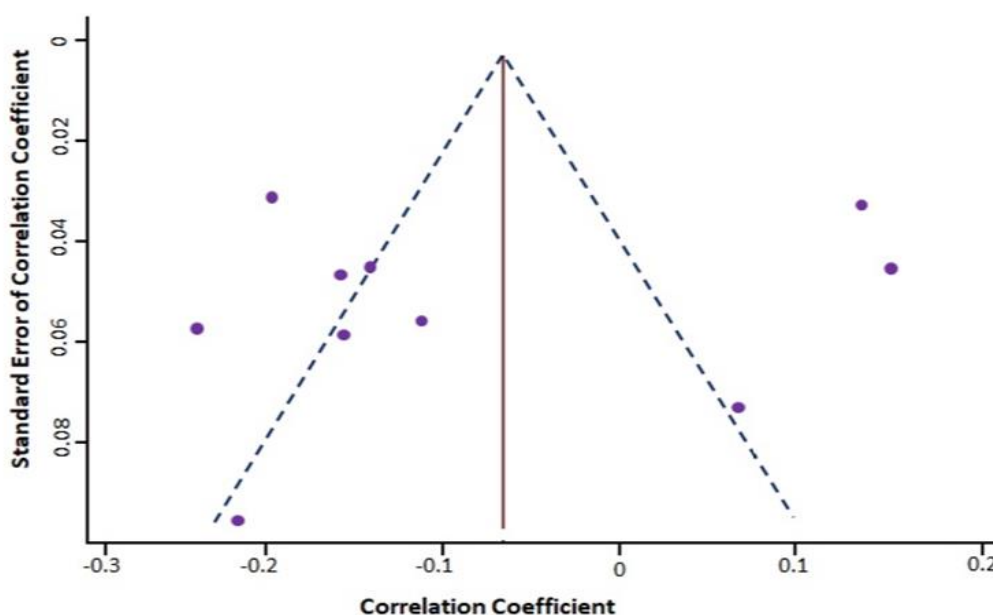
Variable in each article		Correlation coefficient	SD	P-value
BMI	Year of publication	9×10^{-3}	0.013	0.506
	Sample size	9×10^{-5}	0.001	0.178
Other relevant factors	Year of publication	-8×10^{-3}	0.015	0.597
	Sample size	6.64×10^{-2}	.3773	0.845

SD: standard deviation, BMI: body mass index.

Fig. 4: A: Meta-regression Graph for Correlation Coefficient of Menarche Age and BMI based on the study sample size. **B**: Meta-regression Graph for Correlation Coefficient of Menarche Age and BMI based on the year of publication. BMI: body mass index.

Fig. 5: Funnel plot with pseudo 95% confidence limits for Correlation Coefficient of Menarche Age and BMI. BMI: body mass index.

4- DISCUSSION

The present meta-analysis was conducted to determine the factors related to age at menarche in Iranian adolescent girls. The majority of articles had examined only some of the known factors related to age at menarche. The factors extracted from the meta-analysis of the studies included mother's age at menarche, BMI, physical activity, and socioeconomic status. Based on the findings of the present meta-analysis, socioeconomic status, mother's age at menarche, physical activity, and BMI are the factors most relevant to Iranian girls'age at menarche, respectively. Nutrition in adolescence was also investigated in the studies but was not

entered in the meta-analysis due to incomplete quantitative results. The results of the present meta-analysis demonstrated a moderate positive relationship between mother's and daughter's age at menarche (29, 30, 35). Age at menarche is a strong hereditary characteristic (36). A study on twins' age at menarche showed that 57%-82% of the variance of the age of puberty could be explained by hereditary factors (37). Despite the recent identification of neuropeptide pathways involved in activating puberty, factors which stimulate this central process are not completely known yet (38). Yermachenko and Dvornyk (2014), in their meta-analysis, concluded that, mother's age at menarche is an indirect cause of early menarche in girls because mother's age at menarche and girl's obesity are related, and obesity is a risk factor for an earlier onset of puberty (13), and BMI before puberty may modify some of the genetic characteristics affecting menarche (39).

Based on the present meta-analysis, BMI has a negative correlation with age at menarche; in other words, an increase in BMI decreases age at menarche. Results of a meta-analysis by Li et al. (2017) revealed that early puberty was more prevalent in obese girls than those with a normal weight, but this relationship was not significant; moreover, obesity had a significant relationship with the onset of breast development (21). Results of the present meta-analysis showed that, despite the significant relationship between BMI and age at menarche, their correlation was weak. Based on some studies, the body fat percentage and waist circumference are better predictors for age at menarche than BMI (13, 14). Increased body fat leads to early puberty through the following mechanism: leptin secreted from body fat directly affects the hypothalamus and the pituitary gland, thus increasing the production of the gonadotropin-releasing hormone, Luteinizing hormone (LH), and

Follicle-stimulating hormone (FSH), which stimulates the enzymes needed for androgen synthesis in adrenal glands, increases the secretion of sex hormones and causes the onset of puberty (41, 42). Based on the present study, other factors have a strong association with age at menarche; therefore, it is recommended that they receive more attention in future studies. Results of the present meta-analysis revealed that physical activity of Iranian girls has a weak correlation with their age at menarche. A delay in the age at menarche has been reported in girls who performed intense and regular physical exercise in childhood and adolescence, while light and moderate physical exercise did not have such an effect. This may be attributed to intense physical exercise which is associated with lack of nutrition (receiving insufficient energy) and reduced body fat (43-45), and this can explain the delayed menarche in athletes.

In the studies conducted in Iran, no single criterion was used for measuring physical exercise and its relationship with age at menarche. Some studies had examined the type of physical activity (46), while some others had investigated the duration of activity (35, 47), and the age of onset of physical activity (32); therefore, it is relatively difficult to interpret the results. It is recommended that adolescent girls' physical exercise be examined in addition to their nutritional status and anthropometric indices, so that a better conclusion can be drawn in terms of the interactive effects of the factors on age at menarche. The present study demonstrated a negative correlation between age at menarche and socioeconomic status of Iranian girls. This finding is not consistent with the results reported from developed countries (48). Socioeconomic status is among the most important factors determining health and mortality. Some sources claim that socioeconomic status is a combination of three indices: level of

education, occupation, and income (6). In wealthy countries, families with a lower economic status are faced with problems such as obesity, addiction, smoking, and stress, which increases the odds of menarche at younger ages (6, 48). However, the results are different in Iran as a developing country in that age at menarche is reduced according to socioeconomic status, nutritional status, and health improvement. Socioeconomic conditions have different effects on age at menarche, and it is impossible to separate these conditions from other related factors, e.g. family size, living conditions, and nutritional status. Based on these results, it is recommended that a study be conducted to identify other factors classified under socioeconomic status, e.g. place of residence, level of income, nutritional status and level of education, so that a better understanding of the causes of a reduced age at menarche could be achieved, and a more reasonable solution could be proposed.

Although 10 studies confirmed the correlation between BMI and age at menarche in girls, such a correlation cannot be confirmed with certainty due to the cross-sectional nature of these studies and the weak correlation between the two mentioned factors. Moreover, in this meta-analysis, it is difficult to draw a definite conclusion as to which one of these factors decreases girls' age at menarche and is a stronger predictor: physical activity, socioeconomic status, and mother's age at menarche because of the limited number of studies, insufficient comparative data, and measurement of data with different methods. Therefore, longitudinal studies on a larger scale are required to examine the relationship between these factors and Iranian girls' age at menarche. In addition to the factors investigated in Iranian studies, meta-analyses in other countries have revealed that social factors, including exposure to some psychosocial stressors

before puberty [such as immigration, living environment, father's absence, hardship in childhood, violence, parental conflicts (49)] as well as inappropriate health behaviors [such as smoking, alcohol use, drug use, and exposure to cigarette smoke during pregnancy] can affect age at menarche (49); however, none of the reviewed studies had examined these factors. Therefore, further studies may be required to identify the effects of these factors on the age at menarche.

4-1. Study Limitations

Based on our knowledge, the present study is the first meta-analysis to investigate the factors related to age at menarche in Iran; however, we should mention its potential limitations. Only cross-sectional studies were reviewed here, and cohort studies were excluded due to their limited number. Moreover, in each study, only some factors related to menarche were examined; the heterogeneity resulting from using different criteria for measuring each factor, regional diversity, and the difference in sample size and age range in the studies included in the present meta-analysis could not be analyzed. It was also impossible to access unpublished articles and reports.

5- CONCLUSION

Results of the present meta-analysis revealed that a weak correlation exists between girls' age at menarche and variables of BMI and physical activity, while a moderate correlation was found between girl's age at menarche and variables of socioeconomic status and mother's age at menarche. Regarding the stronger relationship between family's socioeconomic status and girl's age at menarche, which was found in the present study, the decreasing trend of the girls' age at menarche can be mitigated by teaching optimal health behaviors and lifestyle to families, especially mothers, based on their socioeconomic status. In this way, the

negative outcomes related to early puberty, e.g. obesity in adulthood and diabetes can be reduced. As there are not enough comparative data, it is recommended that longitudinal studies be conducted in different regions of Iran using similar measurement criteria to examine all the factors together. Moreover, it is necessary to conduct more studies to identify other factors related to the reduced age at menarche, including factors related to the living environment in early childhood.

6- AUTHORS' CONTRIBUTIONS

S.N. and M.D. were responsible for planning the meta-analysis. S.N. and A.B. carried out final literature searches with P.M.'s assistance. Data entry was carried out by S.N. and checked by M.D. The statistical analysis was conducted by P.M. and H.A.M. and discussed with F.R.T. All authors read and approved the final manuscript.

7- ACKNOWLEDGMENTS

8- CONFLICT OF INTEREST: None.

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