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The Correlation between the Mothers' and their Daughters' Ages of Menarche: A Systematic Review and Meta-analysis

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Abstract

Background: Due to the increased effect of environmental factors on the age of menarche and the correlation between the mothers' and daughters' age of menarche, we aimed at performing a meta-analysis to compare the mean age of menarche between the mothers and their daughters, examining the correlation between them.

Objective: This systematic review was conducted to determine the heritability of daughters' age of menarche.

Materials and Methods: In this systematic review and meta-analysis, a complete search was carried out in PubMed, Scopus, Google Scholar, Web of Science, Science Direct, and CINAHL electronic databases in English with no time limitation. A meta-regression analysis was then performed to evaluate the effect of age and sample size. 13 studies with a total sample size of 9719 for calculating the standardized mean difference and 15 articles with a total sample size of 8840, related to the research objectives, were analyzed in this meta-analysis.

Results: The pooled mean of the daughters' age of menarche was 12.62 yrs. (95% CI: 12.37 – 12.87) and that of the mothers' age of menarche was 13.58 yrs. (95% CI: 13.31 – 13.81). The standardized mean difference between the mothers' and daughters' ages of menarche was -0.72 (CI: -0.99 to -0.44). The results of the meta-analysis revealed that, overall, there is a significant positive correlation between the mothers' and daughters' ages of menarche (r=0.27 [CI 95%: 0.17-0.36]).

Conclusion: The daughters' ages of menarche were positively correlated to those of their mothers, but the other environmental factors that may affect this decreasing trend should also be taken into account. Health policy-makers should plan to identify strong predictors, which can be effective in reducing the age of menarche.

Key Words: Heredity, Menarche, Menstruation, Mother, Daughter, Meta-analysis.

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1- INTRODUCTION

It is difficult to accurately measure the stages of puberty and how children pass through these stages (1). Epidemiological studies often use the age of menarche, i.e. the age of the first menstruation, as the onset of puberty signs, as this phenomenon is recalled perfectly even years later (1). In the past century, the age of menarche has decreased, probably due to the improved public health status and standards of living (2-4). This reduction is a public health concern because a younger age of menarche is associated with a higher risk of serious diseases in adulthood, such as obesity, increased blood pressure, breast cancer, diabetes mellitus, and cardiovascular diseases (5-9).

Menarche can be affected by parental genetic heredity (10). In healthy girls with good nutrition, menarche is largely dependent on genetics (11). The genetic aspect of the age of menarche is usually evaluated by examining the similarity between the mothers' and daughters' age of menarche. Various studies have shown that mothers' age of menarche is associated with that of their daughters (12-18), but like any other complex phenomenon, the age of menarche is determined by genetic and environmental factors as well as the interaction of these two. Although the secular trend of the age of menarche indicates the stronger effect of environmental factors, studies report contradictory findings on this subject (19, 20). Some studies show that despite the reduced age of menarche in daughters compared to their mothers, the age of menarche of mothers is still positively correlated with that of their daughters (11, 14). Some studies regard the existence of a correlation between mothers' and daughters' age of menarche to be relative and believe that the similarity in the environmental factors affecting the life of mothers and daughters, such as similar diets and exercise habits, contribute to this phenomenon (21). Mothers' age of menarche may predict the age of menarche in non-obese girls only; therefore, a high body mass index (BMI) in the pre-puberty stage may modify some genetic characteristics that determine the age of menarche (11).

Due to the increased effect of environmental factors on the age of menarche and the correlation between mothers' and daughters' age of menarche, we aimed to perform a meta-analysis to analyze the mean age of menarche in daughters and mothers and examine the correlation between these two characteristics.

2- MATERIALS AND METHODS

This systematic review and meta-analysis was designed based on PRISMA (22) to investigate the relationship between the mothers' and daughters' age of menarche. The inclusion and exclusion criteria were designed based on PICOS.

2-1. Search strategy

A search was carried out in PubMed, Scopus, Science Direct, Web of Science, Google Scholar, and CINAHL electronic databases to retrieve observational studies published on the relationship between mothers' and daughters' age of menarche in English from inception until June 2020, with no time limitation. Before beginning the study, the search was carried out with the aid of a professional librarian. The reviewers separately performed the search. The search in PubMed was carried out using MeSH keywords: ("Age at Menarche" OR "Menarche" OR "Menstruation") AND ("Girl" OR "Daughter" OR "Teenagers" OR "Adolescent") AND ("Mother" OR "Genetics"). After retrieving the full text of all the articles, their reference lists were also examined to identify similar articles on this topic.

2-2. The inclusion and exclusion criteria for selecting the articles

All the articles published in Persian and English with an observational design including cross-sectional, case-control, and cohort studies, that had evaluated the relationship between mothers' and daughters' age of menarche were deemed eligible for entering the meta-analysis without any time restriction. The studies had to present information such as the age of the mothers and daughters at the time of menarche and a correlation coefficient. The exclusion criteria were: 1. Research designs such as Animal studies, laboratory studies, review studies, clinical trials, case reports, and letters to the editor, 2. studies lacking clear and accurate methodology and data, and studies with unreliable and incomplete results 3. Studies examining the age at menarche without determining the factors related to it.

2-3. Study selection

The search for articles and the stages of selection of the articles were pursued separately by R.P. and S.N. All the studies that had evaluated the relationship between mothers' and daughters' age of menarche were included. The results of the search were screened based on the inclusion criteria. All the references were entered to EndNote (version x8). First, screening was performed based on the article titles; then, the duplicates were removed and the abstracts were reviewed. Any disagreements in the selection of the abstracts were resolved by a third researcher. Finally, the full texts of the articles were examined for processing the data. The inter-rater kappa coefficient was 87%.

2-4. Data extraction

The required information was extracted, by the reviewers, from the texts of the articles, and the extracted information was once again examined to minimize the error. The following data were extracted from each article: Authors, year of publication, title, study design (cross-sectional, case-control, cohort), characteristics of the studied population, the mean age of menarche in the mothers and daughters, and the correlation coefficient. To prevent extraction errors, all the reviewers performed the quality control of the final data used in the meta-analysis and the original articles.

2-5. Quality assessment

All the studies presented in this meta-analysis were examined in terms of the quality of their methodology and their presentation of the results. Two reviewers who were blinded to the name of the authors and the journals independently investigated the quality of the articles. All the observational studies, including cross-sectional and cohort studies, were evaluated based on the Newcastle-Ottawa Scale (NOS) (21). NOS examines three dimensions, namely selection, comparison of the study groups, and determining the outcome of interest. Studies obtaining ≥70% of the total score were considered to have a high quality, those with 40-70% a moderate quality, 20-40% a low quality, and those <20% a very low quality (**Tables 1, 2**).

2-6. Statistical analysis

All the analyses were performed in Stata 14.0. The mean and SD of the mothers' and daughters' age of menarche and the correlation coefficient with 95% CI were extracted. Cochran's Q-test of heterogeneity was performed to determine heterogeneity, and the I^2 statistic was used to quantify the heterogeneity. Based on Higgins' classification, an $I^2>0.7$ was taken as a high degree of heterogeneity (23).

Table-1: Quality assessment of included studies using the Newcastle–Ottawa Quality Assessment Scale for cross-sectional studies

Author (year) (ref)	Selection				Comparability	Outcome		Total scores
	Representativeness of the samples	Sample size	Non-responders	Ascertainment of the exposure (risk factor)	A: study controls for age B: control for any additional factor	Assessment of the outcome a) Independent blind assessment. ** b) Record linkage. ** c) Self-report. *	Statistical test	
Chang (2008) (18)	*	-	*	-	**	**	*	7
Ainy,(2007) (25)	*	*	-	-	*	*	*	5
Salces,(2001) (13)	*	*	-	-	**	***	*	8
Sánchez- Andrés, (1997) (26)	*	*	-	*	**	*	*	7
Eid Al-Agha,(2015) (27)	*	*	-	*	**	*	*	7
John, (2014) (28)	*	*	-	*	**	*	*	7
Hozoori, (2017) (29)	*	*	*	*	**	*	*	8
KIM, (1998) (30)	*	*	-	*	**	*	*	7

Table-2: Quality assessment of included studies using the Newcastle–Ottawa Quality Assessment Scale for cohort studies

Study	Selection				Comparability	Outcome			Total scores
Author (year) (ref)	Representativeness of the exposed cohort	Selection of the non-exposed cohort	Ascertainment of exposure	No outcome of interest at the start of the study	A: Study controls for age B: Study controls for other confounders	Outcome assessment	follow-up long enough for outcomes	Adequacy of follow up of cohorts	
Tehrani et al. (2010) (31)	*	*	*	-	**	*	*	*	8
Damon (1969) (32)	*	*	*	*	**	*	*	**	10
Towne, (2005) (33)	*	*	*	*	**	*	*	-	8
Pouta et al. (2005) (16)	*	*	*	*	*	*	*	*	8
Ramezani Tehrani, (2014) (34)	*	*	*	*	**	-	*	*	8

A random-effects model was used to estimate the pooled estimates. Moreover, to calculate the mean difference in the mean age of menarche between the mothers and their daughters, the standardized mean difference based on Cohen's recommendation was utilized (24).

The meta-regression method was adopted to evaluate the effect of age and sample size as the factors affecting the heterogeneity of different factors. The meta-bias command was used to examine the existence of publication bias; if there was publication bias, the degree of prevalence was adjusted by the metatrim command using the trim and fill method. The significance level was set at P<0.05 for all the statistical analyses.

3- RESULTS

3-1. Search results and the studies' characteristics

A total of 3020 studies were retrieved. After examining the titles and abstracts according to the purpose of the research, 500 articles were retained for a close examination of their full text. In this stage, 462 articles were removed due to the incompatibility of the titles with the full text or due to presenting incomplete or irrelevant results not dealing with the study's objectives and duplication of the study. Subsequently, 38 articles related to the main data were examined. Due to the existence of incomplete data and the absence of the necessary quantitative data in some articles, out of all the articles retrieved by the search strategy, 13 articles with a sample size of 9719 for calculating the standardized mean difference and 15 articles with a total sample size of 8840 related to the research objectives were entered into this meta-analysis. Eight studies were cross-sectional (13, 18, 25-30), and five were cohort studies (16, 31-34). **Figure 1** illustrates the process of article selection. **Table 3** presents the characteristics of the studies entered into this meta-analysis conducted on mothers' and daughters' age of menarche.

3-2. Meta-analysis results

The results of the extracted studies showed that the pooled mean of the daughters' age of menarche was 12.62 yrs. (95% CI: 12.37 – 12.87) and the pooled mean of the mothers' age of menarche was 13.58 yrs. (95% CI: 13.31 – 13.81). Based on the findings, the overall standardized mean difference of the mothers' and daughters' age of menarche was -0.72 yrs. (CI: -0.99— -0.44). Based on the results, the daughters' age of menarche was generally about 0.7 years lower than that of their mothers (**Figure 2**).

Table 1 and **Figure 3** present the correlation between the mothers' and daughters' age of menarche. Based on the findings, overall, there was a significant positive correlation between the mothers' and daughter's age of menarche (r=0.27 [CI95%: 0.17-0.36]); in other words, the daughters of mothers with an older age of menarche experienced menarche at an older age as well.

Due to the incompatibility and diversity in the criteria used in various studies and the lack of information on the variables (e.g. mean) in some studies, the effects of the other variables on the relationship between mothers' and daughters' ages of menarche was not analyzed by meta-regression or subgroup analysis. **Figure 4** displays the results of the meta-regression between the standardized mean difference in the mothers' and daughters' age of menarche, the time of publication (r= -0.001; p=0.940), and the sample size (r= 0.001; p=0.595) of the studies. Based on the results, the time of publication and the sample size did not affect heterogeneity.

Figure 5 depicts the results of the meta-regression between the correlation coefficient of the mothers' and daughters' ages of menarche and the time of publication (r= 0.001; p=0.714) and the sample sizes (r= -0.001; p=0.997) of the studies. Based on the results, the time of publication and sample size did not affect heterogeneity.

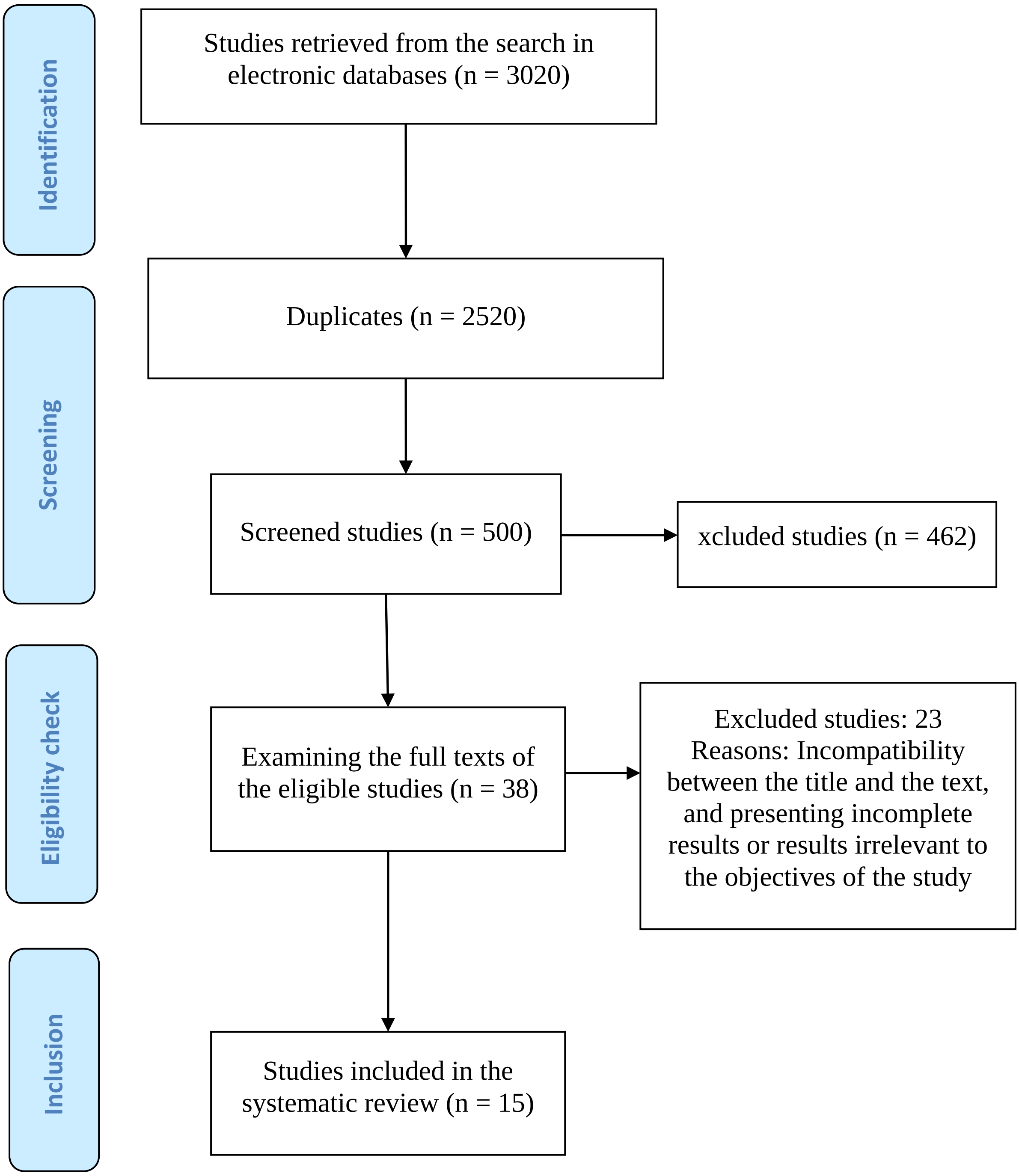

Fig. 1: PRISMA flowchart

Table-3: Characteristics of the studies included in the meta-analysis

Author (year) (ref)	Country	Study design	Sample size		Mean age at menarche in daughters (y)	Mean age at menarche in mothers (y)	Pearson correlation (r) (95% CI)
			n daughters	n mothers			
Tehrani et al. (2010)(31)	Iran	Cohort	770	770	13.17± 1.36	13.61±1.50	0.27 (0.20-0.39)
Damon (1969)(32)	USA, Canada, Europe	Cohort	78	66	12.88±1.08	14.38±1.39	0.24 (0.02-0.44)
Chang (2008)(18)	Taiwan	Cross-sectional	200	200	13.00±1.26	14.50±1.50	NA
Ainy, (2007)(25)	Iran	Cross-sectional	406	406	13.2±1.4	13.6±1.5	0.25 (0.16-0.34)
Ramezani Tehrani, (2014)(34)	Iran	Cohort	402	402	13.06 ± 1.24	13.15 ± 1.23	0.66 (0.59-0.73)
Salces, (2001)(13)	Spain	Cross-sectional	196	100	12.34±1	12.88 ±1.57	NA
Sánchez- Andrés, (1997)(26)	Spain	Cross-sectional	267	200	13.03±١,٢٨	13.45±1.51	NA
Azcorra, (2017)(35)	Mexico	NA	246	246	12.05±1.53	12.53±1.54	NA
Eid Al-Agha, (2015)(27)	Saudi Arabia	Cross-sectional	165	165	11.57 ± 1.48	12.97 ± 1.71	0.26 (0.12-0.41)
Cameron, (1996)(15)	South Africa	NA	146	146	12.52±1.25	13.20 ±1.57	0.23 (0.07-0.39)
John, (2014)(28)	India	Cross-sectional	400	400	12.38±1.26	14.31 ±1.24	0.02 (-0.08-0.12)
Ersoy, (2005)(11)	Turkey	NA	1017	1717	12.82± 1.07	13.6±1.39	0.26 (0.20-0.32)
Hong et al. (2019)(36)	China	NA	304	304	12.0 ±0.9	14.4 ±1.6	0.21 (0.10-0.32)
Hozoori, (2017)(29)	Iran	Cross-sectional	370	370	12.3 ± 1	NA	0.26 (0.16-0.39)
KIM, (1998)(30)	England	Cross-sectional	28	21	NA	13.5±15.9	0.59 (0.09-0.85)
Towne, (2005)(33)	USA	Cohort	95	95	12.75±1.15	NA	0.14 (0.04-0.24)
Chasiotis, (1998)(37)	Germany	NA	68	68	NA	NA	0.60 (0.49-0.71)
Chasiotis, (1998)(37)	Germany	NA	68	68	NA	NA	-0.07 (-0.23-0.09)
Pouta et al. (2005)(16)	Finland	cohort	4523	4523	NA	NA	0.20 (0.18-0.24)

NA: not applicable

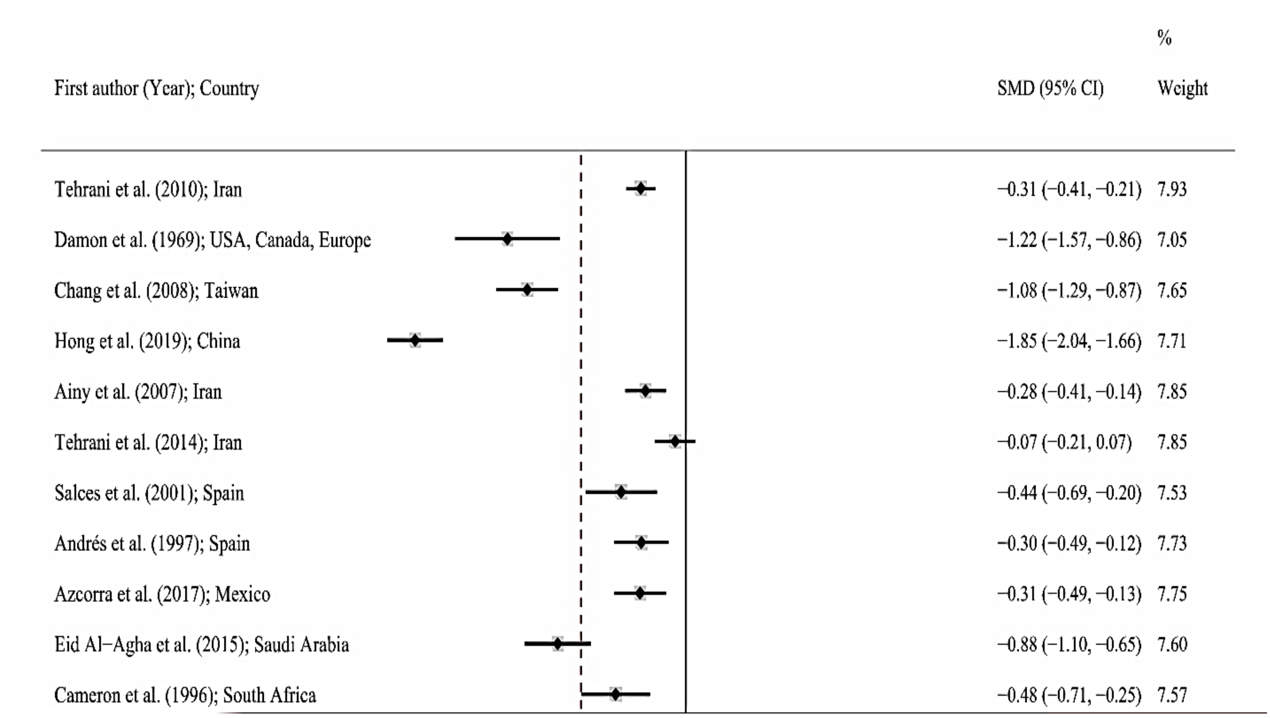

Fig. 2: Standardized mean difference between the mothers' and daughters' ages at menarche

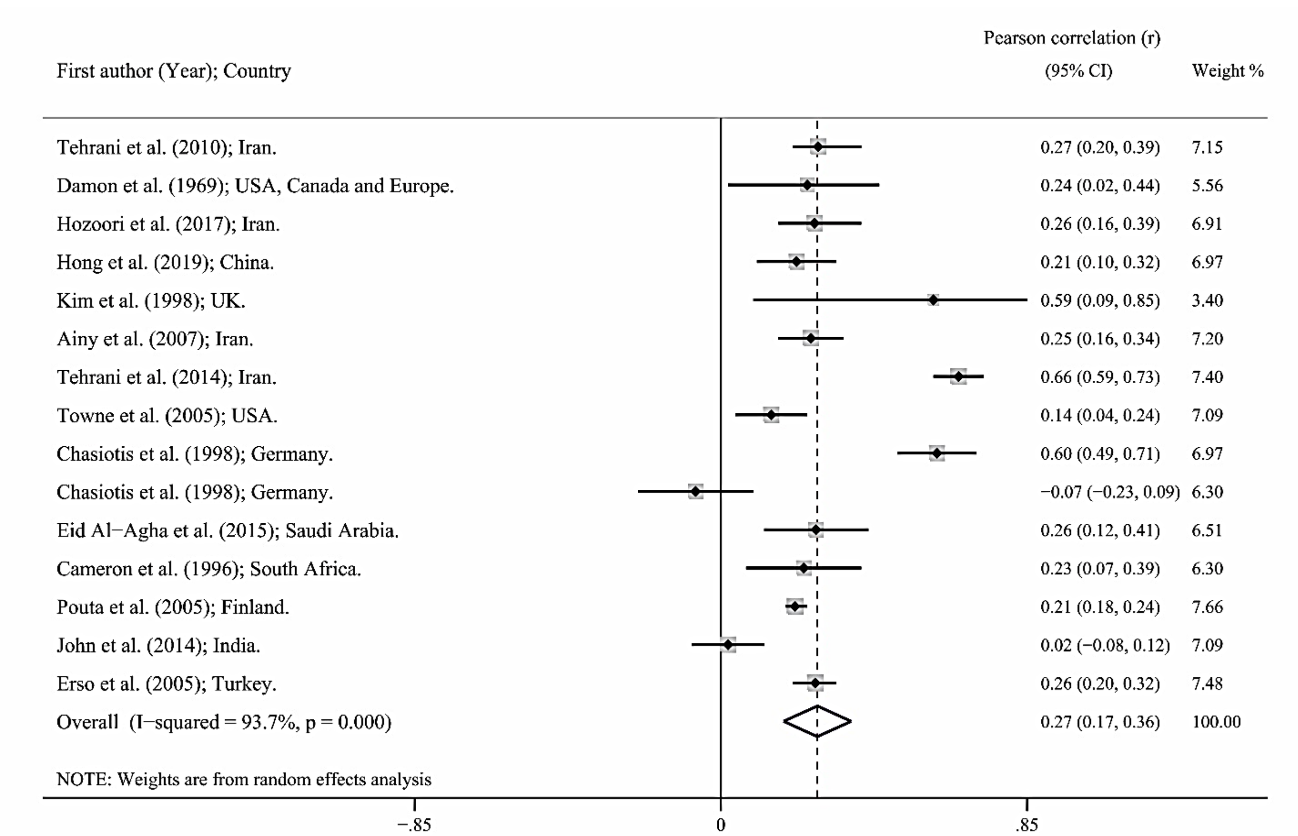

Fig. 3: Correlation coefficient between the mothers' and daughters' ages at menarche

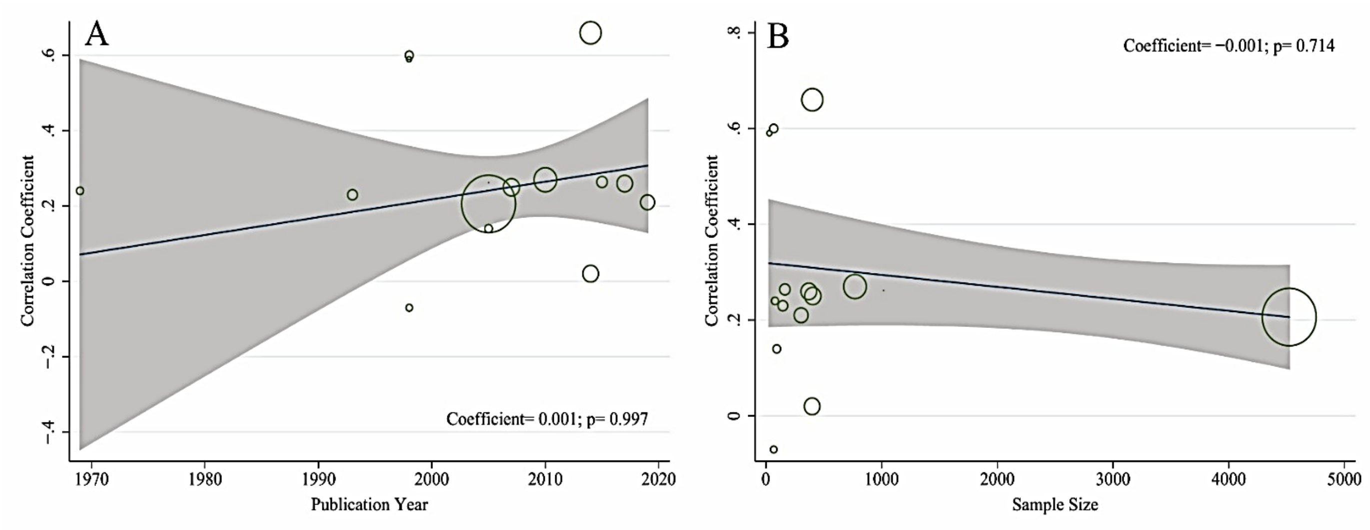

Fig. 4: Meta-regression between the standardized mean difference of the mothers' and daughters' menarche ages with the articles' publication time and the sample sizes

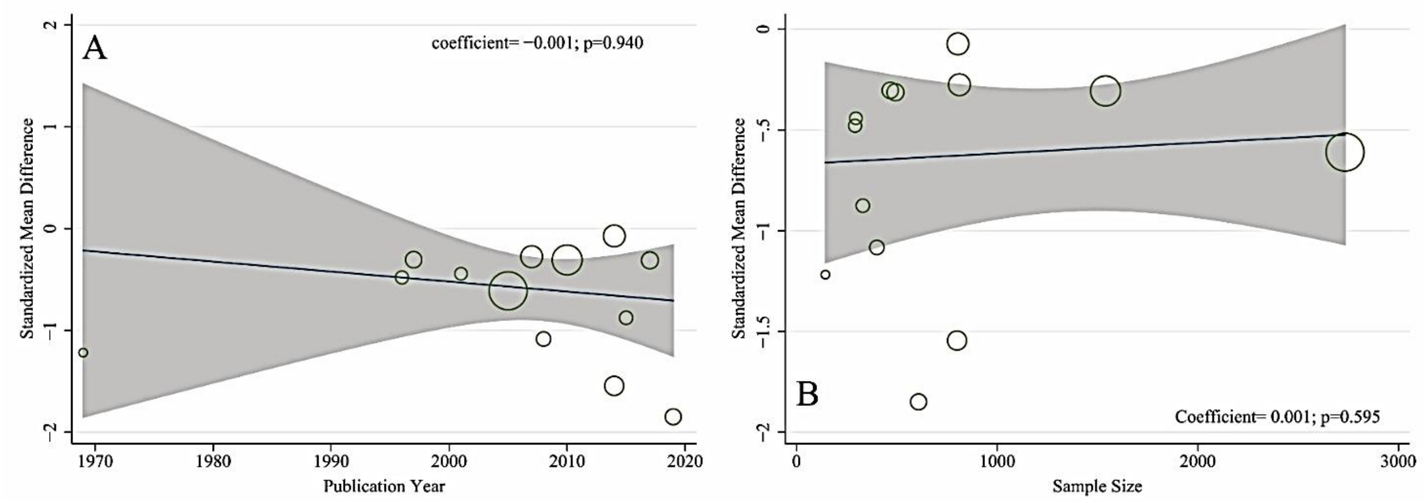

Fig. 5: Meta-regression among the correlation coefficient of the mothers' and daughters' menarche ages, the publication time of the articles, and the sample sizes

3-3. Publication bias

Egger's test did not show any significant publication bias for the correlation coefficient of the mothers' and daughter's ages of menarche (r=0.744; P=0.615) or the standardized mean difference between the mothers' and their daughters' ages of menarche (r=-4.77; P=0.316).

3-4. Sensitivity analysis

Figure 6 illustrates the results of the sensitivity analysis for the standardized mean difference between the mothers' and daughters' ages of menarche (**Fig. A**) and the correlation coefficient of the mothers' and daughters' ages of menarche (**Fig. B**). By removing each study presented in the figure, the standardized mean difference between the mothers' and daughters' ages of menarche varies from -0.77 (CI:-1.11 to -0.43) to -0.62(CI:-0.91 to -0.33). Moreover, by removing each study, the correlation coefficient of the mothers' and daughters' ages of menarche varies from 0.24 (CI: 0.15 to 0.33) to 0.29 (CI: 0.18 to 0.40).

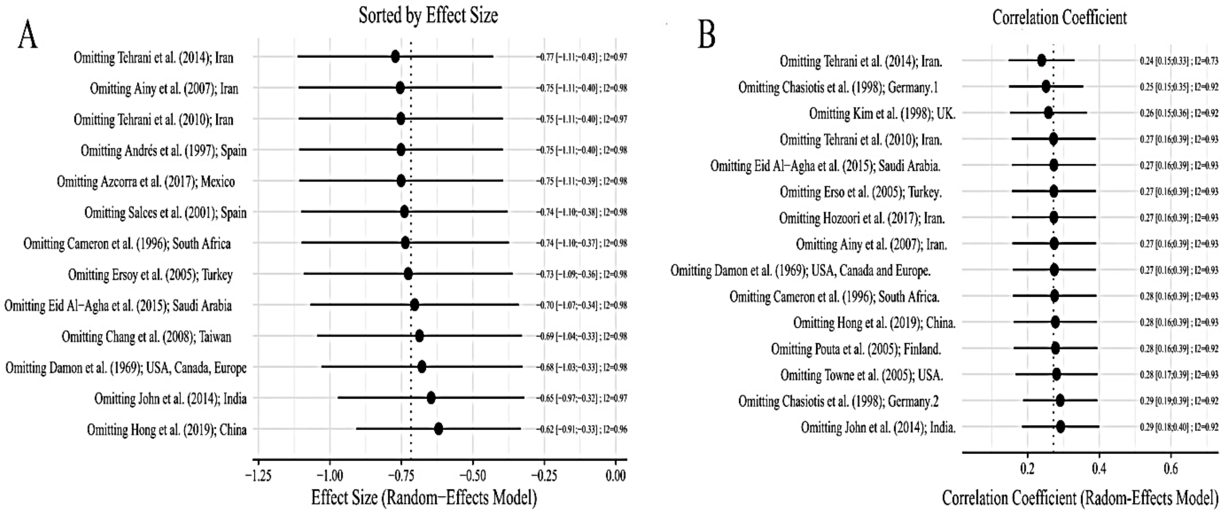

Fig. 6: Sensitivity analysis for the standardized mean difference between menarche ages of the mothers and daughters (Figure A) and the correlation coefficient of the mothers' and daughters' ages at menarche time (Figure B)

4- DISCUSSION

The present meta-analysis was conducted to determine the heritability of daughters' age of menarche. The findings revealed that a significant positive correlation exists between the mothers' and daughters' age of menarche; that is, the daughters of mothers who have gone through puberty earlier also tend to experience puberty earlier (r=0.27). Treloar reported the correlation coefficients obtained for mothers' and daughters' age of menarche in previous studies (38). The highest correlation pertained was in the Netherlands (39). Other studies had reported a correlation coefficient of 0.2, which is consistent with the results of the present study (38). Findings indicated that the ages of menarche among dizygotic twins show a correlation coefficient of 0.18. The results of this study also revealed that the correlation coefficient of mothers' and daughters' age of menarche is similar to that of dizygotic twins. Researchers have concluded that genetic differences affect the age of menarche significantly, and the correlation between monozygotic twins is higher than that between the dizygotic twins (38).

The time of puberty is multi-factorial and is affected by many genetic and environmental determinants. Many researchers regard genetics as an important factor in the age of menarche, but there is also a strong association between bio-social variables and the age of menarche. One study reported that sex hormone-binding globulin is associated with the age of menarche and girls with longer TAAAA allele repeats have delayed menarche (40). Another study found that single-nucleotide polymorphism (SNP) in the leptin receptor (LEPR) gene delays menarche in Korean women (41). The strongest personal signal, i.e. an SNP close to LIN28B, changed the age of menarche 0.11 years per each allele; overall, the 123 superior SNPs explained

2.7% of the variance in the population at the time of puberty (42). One study found hundreds of changes related to the age of menarche, including two rare mutations in MKRN3 and DLK1 genes that are inherited from the father. Researchers concluded that further studies are required for understanding the role of genetics in the age of menarche and the interaction between genetic composition and the environment is changing the age of menarche (43).

The results of this review study showed that the daughters' mean age of menarche was 12.62 yrs. and that of their mothers was 13.58 yrs. The daughters’ age of menarche was reduced by 0.7 years compared to their mothers. As reported by previous studies, a considerable reduction has occurred in the age of menarche during the 19th and 20th centuries in most countries (44-46). The findings of Thomas’ study in 67 countries revealed that the daughters’ age of menarche was 13.53±0.98 years; that study, however, did not mention the mothers’ age of menarche (47). The comparison between the results of the present study and those of Thomas shows that the daughters’ age of menarche is decreased, although the reviewed studies did not include all these 67 countries. The results of a study in Indonesia showed that girls of the new generation reach menarche at a younger age compared to previous years (means of age at menarche was respectively 15.57, 13.75, 14.40, 14.11, 13.42 and 12.28 in 1963, 1984 to 1993, 1994 to 2003, 2004 to 2013) (48). The age of menarche has had a decreasing trend in different countries over the past years, which suggests that, in addition to genetics and heritability, factors such as the living environment during childhood and socioeconomic changes highly contribute to the reduction of the age of menarche, which may even cover the effects of genetics (49). In the present study, a positive correlation of 0.2 was found between the mothers’ and daughters’ age of menarche, which may highlight the dominant effect of other environmental determinants on daughters’ age of menarche. Some factors that may affect the degree of correlation between mothers’ and daughters’ ages of menarche, which was noted in the reviewed studies but not analyzed in the present study due to the inconsistent data, included weight, height, stressful life events, physical activity, and the family’s socioeconomic status. As observed in Ersoy’s study, mothers’ age of menarche might predict daughters’ age of menarche only in the cases of girls with a normal BMI (11). A higher BMI in the pre-puberty stage is a moderating variable for genetic factors that further demonstrates the genetic aspects at play. Ersoy also showed that the correlation between the mothers’ and daughters’ ages of menarche is stronger in girls who are physically active and consume red meat (11). A relationship has been reported between the mothers’ age of menarche and the daughters’ obesity, as there is a three-time higher risk of obesity in the daughters of mothers who have a younger age of menarche, which can also increase the risk of early puberty in daughters (46, 50). In a study in Iran, a significant negative correlation was found between daughters’ weight, BMI, and waist circumference, on the one hand, and their age of menarche, on the other, which was equal to the degree of correlation between mothers’ and daughters’ age of menarche (29). Therefore, if daughters are not obese or do not have a high BMI based on environmental conditions or diseases, the effect of the mother’s age of menarche on the daughter’s early menarche will be less salient, and the impact of these environmental effects on the age of menarche will be more prominent.

In addition to the mothers’ age of menarche, the mothers’ and daughters’ ages and the daughters’ height can also predict the daughters’ age of menarche (31). Chang, furthermore, reported that the place of residence and ethnicity of grandmothers affect the age of menarche (18). Stress affecting the family's quality of life and a lower emotional intimacy between daughters and mothers before the age of six may, moreover, affect the daughters' age of menarche (30).

Family size can slightly influence the girls' age of menarche (34). In the study by Salces, social variables, BMI, and body fat were found to affect the degree of correlation between mothers' and daughters' age of menarche (13). According to John, daughters' weight, height, and skinfold thickness have a stronger correlation with their ages of menarche, as compared to their mothers' ages of menarche (28). A young age of menarche is a considerable risk factor for many important outcomes. The early onset of puberty is a major medical and social problem and can pose risks such as developing type-2 diabetes, breast cancer, fertility problems, cardiovascular diseases, obesity, psychological disorders, behavioral problems, early onset of sexual activity, and smoking in adolescence (36, 51-55). Based on the findings of the present study and the existing knowledge, there is a trend of decreasing age of menarche. Therefore, recognizing strong predictors can help control this decreasing trend.

4-1. Limitations

Many studies included in this research were cross-sectional and thus offered a low level of evidence. Another limitation was the risk of confounding due to the environmental and personal differences in lifestyles. Also, the results of the studies were heterogeneous, although this limitation was ameliorated using a random-effects model.

5- CONCLUSION

Although daughters' ages of menarche are correlated to those of their mothers, attention should also be paid to other environmental factors that may influence this decreasing trend. Health policy-makers should plan to identify strong predictors effective in reducing the age of menarche.

6- ACKNOWLEDGEMENTS

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7- THE FUNDING SUPPORT OF THE STUDY

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8- CONFLICT OF INTEREST

The authors report no conflict of interest.

9- THE AUTHOR CONTRIBUTIONS

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

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