Research Article

Impact of Selected Environmental Factors on the Timing of Natural Menopause Among Women: A Descriptive Cross-sectional Study

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Abstract

Background: The onset of natural menopause is a multifactorial biological milestone influenced by a dynamic interplay of genetic predisposition, environmental exposures, and socio-economic conditions. Accurately identifying the average age of menopause and its principal determinants is vital for anticipating age-related health risks and tailoring preventive strategies in women's healthcare.

Objectives: This study aimed to determine the mean age at natural menopause and to investigate key environmental, biological, and lifestyle-related predictors influencing menopausal timing among women in Kerman province, Iran.

Methods: A descriptive cross-sectional study was conducted in 2023 involving 265 women aged 35 to 70 years residing in Kerman province. Data were collected through systematic random sampling using a comprehensive checklist that included demographic information, reproductive and obstetric history, lifestyle behaviors, and socio-economic status. Statistical analyses were performed to assess associations between menopausal age and potential predictive variables.

Results: Participants' mean age was 40.81 ± 9.09 years with a mean menopause age of 55.4 ± 7.61 years. Multivariable analysis revealed that longer menstrual bleeding (OR = 1.26, P = 0.032), higher maternal menopausal age [odds ratios (OR) = 1.48, P = 0.021], and older participant age (OR = 1.63, P < 0.001) significantly increased the likelihood of menopause, highlighting key predictors of delayed menopausal onset.

Conclusions: This study identifies maternal menopausal age and menstrual traits as primary factors influencing menopause timing in southeastern Iranian women, with limited impact from socioeconomic and lifestyle factors. Regional differences stress the importance of localized research. Despite limitations, the findings call for larger, longitudinal studies to improve midlife women's health interventions.

Keywords: Menopause, Onset Age, Women

1. Background

Menopause is a common and important phenomenon of aging in a woman's life that marks a transition to a new biological state and a gradual reduction of reproductive activity due to the loss of ovarian follicular reserve (1, 2). It is diagnosed after 12 months of amenorrhea. In this phenomenon, neither physical nor pathological reasons play a main role (3). Menopause usually occurs within the age range of 50 - 51 years old (4). However, it should be noted that menopause may happen later, over 55 years in about 5% of women (late menopause) or, in contrast, earlier between 40 - 45 years in 5% of them (early menopause) (5). Natural menopausal age depends on genetic, biological, and environmental factors (6). Many studies have shown that genetics is a determinant factor of menopausal age, so some women experience premature menopause for unknown reasons, which could be a

result of a genetic defect or mutation (7-9). A cross-sectional study showed that a mother's menopause age onset may potentially affect a daughter's menopausal age; as a result, menopause age can be inherited (10). Besides genetic factors, environmental factors including cigarette smoking, ovarian surgery, socioeconomic status, birth weight, and other various factors have been identified to influence menopause age (11-15).

To address this important point, we have expanded the introduction to provide a broader global perspective. Menopause, as a key marker of women's midlife health, has been recognized by the World Health Organization (WHO) as a significant transition with implications for quality of life, chronic disease risk, and healthcare planning (16). The sustainable development goals (SDGs), particularly goal 3 (good health and well-being), emphasize the importance of gender-specific health strategies across the life course, including midlife and aging (17). Furthermore, global studies have shown variations in the timing of menopause based on socioeconomic, environmental, and ethnic factors (18, 19).

2. Objectives

While prior research has explored determinants of natural menopause, few have addressed the combined effects of environmental and socio-cultural factors in localized settings. This study uniquely investigates how regional variables — such as climate, altitude, maternal menopausal age, and menstrual characteristics — affect menopausal timing in southeastern Iran, addressing a critical knowledge gap and providing context-specific evidence to inform targeted women's health interventions.

3. Methods

3.1. Population Characteristics and Data Collection Procedures

This study was conducted in Kerman province, the largest province in Iran by area, with Kerman as its administrative center. Located in the southeastern region of the country, Kerman province had a population of 3,164,718 according to the 2016 census conducted by the Statistical Center of Iran. To obtain a representative sample of individuals living in 84 cities of this province, it was divided into eight regions according to geographical directions. Then, the numbers of women were randomly selected from each region (each region included approximately 10 cities).

3.2. Data Collection

This study was performed by a door-to-door approach (home visit), and checklists were completed through interviews with women. The inclusion criteria encompassed women residing in the study area who were within the menopausal age range of 35 to 70 years and had no difficulties in comprehension or communication. Individuals diagnosed with mental disabilities or psychotic disorders were excluded from the study.

Ethical approval for this study was obtained from the Ethics Committee of Kerman University of Medical Sciences (approval No.: IR.KMU.REC.1397.148). Initially, the purpose of the interview was explained to the participants to complete the lists, ensuring that information was kept confidential, and then verbal informed consent was obtained from participants. A checklist containing 27 questions was completed by each woman. Evaluated variables were related to the personal profile (woman's age, birthplace, "Sayyidah" — an honorific title traditionally bestowed upon Muslim women who are recognized as direct descendants of the Islamic Prophet Muhammad, specifically through his grandson — disease history, marital status, marriage age, address), pregnancy status (history of cesarean section, history of abortion, oral contraceptive pills, history of curettage, age of first pregnancy, age of last pregnancy, breastfeeding), lifestyle behaviors (smoking, smoking exposure, physical activity), reproductive history (genital surgery, irregular menstrual cycles, mother's age of menopause, marital satisfaction, menstruation duration — the interval between two menstruations, bleeding period length — the duration of bleeding in each menstruation, first menarche age), and socio-economic data (education, employment status, satisfaction with earnings).

The content validity method was used to determine the scientific validity of the checklist, and the test-retest method was used to determine the reliability. The responses of illiterate people were confirmed by a witness. Individuals with missing or incomplete information were omitted from the analytical dataset.

3.3. Statistical Analysis

To assess differences in continuous and categorical demographic variables, independent samples *t*-tests and chi-square tests were employed, respectively. Bivariable (univariate) and multivariable logistic regression analyses were conducted to identify independent predictors of menopausal status. Variables with a P-value less than 0.20 in the bivariable analysis were considered for inclusion in the multivariable model. Multicollinearity among predictor variables was assessed using the variance inflation factor (VIF), and no significant multicollinearity was detected.

The final model was selected using a backward elimination approach based on the likelihood ratio test and the lowest value of Akaike's information criterion (AIC). Potential interaction effects with a significance level of P < 0.10 were also evaluated and incorporated into the final model as appropriate. As a sensitivity analysis, results from stepwise forward selection were compared with those of the backward selection model to confirm model robustness. Odds ratios (OR) and corresponding 95% confidence intervals (CI) were calculated. A P-value of less than 0.05 was considered indicative of statistical significance. All statistical analyses were conducted using the Statistical Package for the Social Sciences (SPSS), version 20.

4. Results

Descriptive and demographic characteristics of the study population are presented in Table 1. The mean age of the participants was 40.81 ± 49.09 years. The age of menopause was 55.4 ± 7.61 years. Most women (both menopausal and non-menopausal) had high educational levels (more than 11 years and higher; n = 57, 72.2%) and lived in cold regions (n = 188, 66.4%). However, 49% of the women were housewives, and 30% of women were involved in paid work. The percentage of women who smoked (n = 45, 15.9%) and those exposed to smoking (n = 96, 33.9%) were much lower than those who did not smoke (n = 238, 84.1%) and those not exposed to smoking (n = 187, 66.1%), respectively. In addition, the proportion of women who do not engage in any kind of exercise was higher (n = 164, 58%) than those who do regular physical exercise (n = 119, 42%). Also, in the population of postmenopausal women, the average mother's age at menopause was 48.21 ± 6.26.

Table 1 shows the descriptive statistics studied. The results of the chi-square test (bivariable logistic regression) show that age, education, birthplace, job status, smoking, disease history, history of cesarean section, breastfeeding, address, genital surgery, marital status, marriage age, last pregnancy age, bleeding period length, and mother's age at menopause variables were statistically significant between menopausal and non-menopausal women.

The results of the multivariable logistic regression analysis are presented in Table 2. An increase of one day in the duration of the menstrual bleeding period was associated with a 1.26-fold higher likelihood of menopause (OR = 1.26; 95% CI: 1.11 - 2.47). Additionally, each one-year increase in the age at which the participant's mother experienced menopause was associated with a 1.48-fold increase in the odds of menopause (OR = 1.48; 95% CI: 1.04 - 2.21). Furthermore, for each additional year of the participant's age, the odds of being menopausal increased by 1.63 times (OR = 1.63; 95% CI: 1.37 - 1.95).

5. Discussion

Although numerous studies have examined the determinants of menopausal age, few have investigated the impact of environmental and regional factors within Iranian populations. The findings of this study, focusing on geographic conditions, family history, and behavioral characteristics of women in Kerman province, address a significant gap and highlight the necessity of considering these local factors for a better understanding and effective management of women's health during this critical period. Given that menopause is not only a physiological event but also a key factor influencing long-term health outcomes, it is crucial to take these factors into account.

Menopause is a physiological and inevitable process experienced by all women. Early onset of menopause, characterized by a significant decline in estrogen production, has been associated with an increased risk of osteoporosis [20], cardiovascular disease [21], and potentially an earlier onset of Alzheimer's disease [22]. Hormone replacement therapy (HRT) is currently employed as an intervention to mitigate some of these adverse health outcomes.

However, due to the financial cost and increased risk of breast and endometrial cancer following exogenous hormone therapy [23], their usage should be limited by women and public health professionals. The minority of women who experience very early natural menopause face the emotional stress of unexpectedly losing fertility. Therefore, this study aimed to determine the mean age of menopause as well as related factors. Several studies

Table 1. Characterization and Comparison of Variables Between Two Groups of Menopausal and Non-menopausal Women [a]

Variables	Menopause (N = 79)	Non-menopause (N = 186)	P-Value
Education			< 0.001
High (more than 11 y and higher)	57 (72.2)	90 (48.4)	
Low (lesser than 11 y)	22 (27.8)	96 (51.6)	
Birth place			0.012
Tropical region	37 (46.8)	57 (30.6)	
Cold region	42 (53.2)	129 (69.4)	
Job status			< 0.001
Housekeeper	49 (62)	77 (41.4)	
Employee	30 (38)	109 (58.6)	
Sayyidah			0.509
No	73 (92.4)	168 (90.3)	
Yes	6 (7.6)	18 (9.7)	
Smoking			0.046
No	72 (91.1)	151 (81.2)	
Yes	7 (8.9)	35 (18.8)	
Smoking exposure			0.268
No	56 (70.9)	116 (62.4)	
Yes	23 (29.11)	70 (37.6)	
Marital satisfaction			0.234
No	9 (11)	13 (7)	
Yes	70 (88.6)	173 (93)	
Satisfaction with earnings			0.962
No	5 (6.3)	9 (4.8)	
Yes	74 (93.7)	177 (95.2)	
Disease history (kidney, diabetes, and blood pressure)			0.008
No	48 (60.8)	147 (79)	
Yes	31 (39.2)	39 (21)	
History of cesarean section			0.001 <
No	62 (87.5)	94 (50.5)	
Yes	17 (21.5)	92 (49.5)	
Breastfeeding (age)			0.026
2 >	21 (26.3)	76 (41.1)	
2 ≤	58 (73.4)	109 (58.9)	
Address			0.004
Courtyard house	64 (81)	11 (63.4)	
Apartment	15 (19)	68 (36.6)	
Oral contraceptive pills			0.231
Yes	14 (17.7)	48 (25.8)	
No	65 (82.3)	138 (74.2)	
Abortion history			0.572
Yes	29 (82.3)	61 (32.8)	
No	50 (63.3)	125 (67.2)	
D&C history			0.138
Yes	21 (26.6)	34 (18.3)	
No	58 (73.4)	152 (81.7)	
Regular physical activity			0.69
Yes	32 (40.5)	105 (56.5)	
No	47 (59.5)	81 (43.5)	
Genital Surgery			0.001 <
Yes	33 (41.2)	1 (0.5)	
No	47 (59.5)	202 (99.5)	
Irregular menstrual cycles			0.142
No	63 (79.7)	136 (73.1)	
Yes	16 (20.3)	50 (26.9)	
Marital status			0.009
No	-	10 (5.4)	
Yes	79 (100)	176 (94.6)	
Women age	55.4±7.61	42.78±6.59	0.001 <
Marriage age	20.33±3.71	21.62±3.73	0.011
First menarche age	13.6±1.92	13.62±2.22	0.938
Last pregnancy age	32.76 ± 5.09	30.17 ± 4.31	0.001 <
First pregnancy age	22.43 ± 5.56	23.25 ± 4.16	0.240
Menstruation duration (d)	28.49 ± 4.31	28.44 ± 2.99	0.974
Bleeding period length (d)	6.53 ± 1.78	5.93 ± 1.51	0.005
Mother's age of menopause	48.21 ± 6.26	54.81 ± 9.89	0.001 <

[a] Values are expressed as No. (%) or mean ± SD.

have shown that the average age of menopause and related factors could differ in different societies. The hypothesis that postulates menopause is associated with both genetic and environmental factors is relevant

Table 2. Multivariable Logistic Regression Model for Identifying the Factors Affecting Menopause

Variables	β	S.E (β)	OR (per Day or per Year)	95% CI for OR	P-Value
Age	0.491	0.089	1.63	1.37 - 1.95	0.001 <
Education; low vs. high	-1.36	1.045	0.257	0.03 - 1.99	0.194
Birth place; tropical region vs. cold region	0.786	0.705	2.194	0.55 - 8.74	0.265
Job status; employee vs. housekeeper	1.294	1.023	3.645	0.491 - 10.02	0.206
Smoking; no vs. yes	-0.517	1.579	0.596	0.027 - 13.16	0.743
Disease history; yes vs. no	-1.128	0.742	0.324	0.076 - 1.385	0.128
Cesarean section delivery; yes vs. no	-0.413	0.761	0.662	0.149 - 2.93	0.587
Address apartment vs. non-apartment	0.502	0.798	1.65	0.346 - 7.89	0.529
Irregular menstrual cycles; yes vs. no	0.247	0.782	1.28	0.276 - 5.93	0.752
Smoking exposure; yes vs. no	-0.788	0.829	0.455	0.09 - 2.31	0.342
Bleeding period length	0.234	0.237	1.26	1.11 - 2.47	0.032
Mother's age at menopause	0.394	0.062	1.48	1.04 - 2.21	0.021

Abbreviation: OR, odds ratio.

and cannot be ignored (24).

In the current study, the mean age at natural menopause was 55.4 ± 7.61 years. This value represents the average age across the study population. Other studies conducted in different cities of Iran reported lower mean ages: Tehran (47.77 ± 4.3), Shiraz (48.3 ± 5.3), and Zahedan (47.3 ± 6.3) (21-23, 25-27). Mohammad et al. reported that the mean age of menopause in Iran is 50.4 (28). The differences between these results and ours may be explained by variations in sampling methods, sample sizes, and recall accuracy regarding menopausal age.

Internationally, the average age of menopause also varies: United States (51.4), Saudi Arabia (48.94), and Turkey (47.0). These disparities likely reflect differences in genetic background, environmental exposures, cultural practices, and social factors. There are significant differences in culture, lifestyle, physical factors, and climatic conditions that could potentially affect differences in menopause age.

In this study, there was not a marked relationship between the personal profile data (woman's age, education, birthplace, sayyidah status, history of disease, marital status, and marriage age) and menopause age. Additionally, we observed that the menopausal age of women was not different between sayyidah and non-sayyidah women. It appears that our small sample size prevents an accurate comment on the effect of the sayyidah factor on menopausal age. This result is consistent with a study conducted in Mashhad city, which also confirms this finding. In contrast, a previous study conducted in Tehran city reported a significant relationship between them (24).

The present work also analyzed the effect of birthplace, address, and history of disease on natural menopause age. None of these three factors were related to menopause. In concordance with our data, Ewa Szwejser and Krzysztof Szostek obtained similar results (29). In our study, it was observed that marital status and marriage age did not affect menopausal age, while some studies exhibited an obvious relationship. This difference could be due to the effect of the secretion of pregnancy hormones on menopausal age (24, 25).

Also, we found that socioeconomic status (education, employment, satisfaction with earnings) did not significantly influence menopause age. The sample size may be affecting this finding. In disagreement with our data, several studies determined that lower educational attainment and non-employment status were significantly associated with earlier menopausal age. They suggested that low socioeconomic status and limited educational attainment may serve as indicators of increased social and physical stressors, which could potentially impact the age at onset of menopause (18).

Additionally, our data exhibited that there isn't a remarkable relationship between lifestyle behavior (smoking, smoking exposure, physical activity) and menopause age, which may be due to the low frequency of smoking and physical activity among the Iranian women in this study. In disagreement with previous studies, smoking women experienced earlier menstruation stopping about 1 - 2 years in comparison to nonsmokers. However, substantial evidence indicates that alkaloid compounds present in tobacco smoke, such as nicotine and anabasine, may contribute to

reduced estrogen levels by interfering with ovarian follicular estrogen synthesis (18, 26, 30).

Furthermore, some reports have shown that physical activity could increase menopause age. Exercise could result in a decrease in menopausal complications such as osteoporosis, obesity, and cardiovascular issues by improving bone density as well as increasing flexibility and muscle strength. Thus, it may be postulated that ovarian function may also be affected (31, 32).

In our survey, pregnancy factors (history of cesarean section, abortion, usage of oral contraceptive pills, curettage, age of first pregnancy and last pregnancy, as well as breastfeeding) didn't have any marked effect on a woman's menopausal age. In contrast to our data, several studies have demonstrated that a higher age at first and last full-term pregnancy, the use of oral contraceptive pills, and extended durations of breastfeeding are associated with a delayed onset of natural menopause (32). It is thought that the relationship between these factors may be related to their effects on the number of menstrual cycles.

In agreement with us, other previous studies didn't reveal any relationship between the history of cesarean section, abortion, and curettage, and the age at natural menopause. Our findings showed that among reproductive history indicators, the length of the bleeding period and maternal menopausal age could affect menopausal status and increase the chance of menopause. Daughters of mothers who experience early menopause tend to exhibit diminished ovarian reserve between the ages of 35 and 49 (24-26). This familial pattern is likely attributable to shared genetic variations (32). Consistent with the heritability of menopausal timing, the present study demonstrated a significant association between the age at menopause and that of the participants' mothers (33).

This research has shown that women who had shorter menstrual cycles experienced menopause at least 1 to 2 years earlier, probably due to a higher rate of menstrual cycles and ovulation. Also, the relationship between menarche age, irregular menstrual cycles, and menopause was not significant in this study, consistent with Shobeiri et al., while other studies reported significant associations (32).

5.1. Conclusions

This study highlights the complex interplay of genetic, environmental, and behavioral factors influencing menopausal age among women in southeastern Iran. Our findings emphasize the significant role of maternal menopausal age and menstrual characteristics in determining menopause timing, while socioeconomic status, lifestyle behaviors, and reproductive history showed limited impact within this population. The observed regional differences underscore the importance of localized research to inform culturally and geographically appropriate health policies.

Despite limitations such as sample size and cross-sectional design, this research contributes valuable insights into menopause determinants in Iranian women and calls for larger, longitudinal studies to further elucidate these relationships and support effective health interventions targeting midlife women. The findings of this study can serve as a foundation for developing targeted preventive and care programs aimed at improving the quality of life for women during midlife.

5.2. Strength

Building on these findings, this study's primary strength lies in its targeted examination of a distinct regional cohort in southeastern Iran, integrating a wide array of environmental, demographic, and behavioral variables frequently neglected in broader national and international research. By comprehensively addressing geographic context, familial menopausal history, and lifestyle determinants, the findings offer nuanced, locally relevant insights that can meaningfully inform tailored health policies and intervention strategies for menopausal women in this unique population.

5.3. Limitations

Despite these strengths, it is important to acknowledge certain limitations that may impact the interpretation of our results. The modest sample size may have constrained the statistical power necessary to detect significant associations for certain factors, including socioeconomic indicators and lifestyle behaviors. Moreover, reliance on self-reported menopausal age introduces the potential for recall bias, which could affect data accuracy. The cross-sectional nature of the study further limits causal inference.

To overcome these limitations, future research employing longitudinal designs with larger, more heterogeneous samples is essential to validate and

extend these findings, ultimately enhancing the understanding of menopause determinants in diverse populations.

Acknowledgements

Footnotes

Authors' Contribution: M. E. supervised the study. P. F. contributed to material preparation, data collection, and wrote the draft of the manuscript. T. D. contributed to the data analysis and interpretation, whereas E. M. and Sh. S. E. extensively reviewed the manuscript. All the authors read and approved the final manuscript.

Conflict of Interests Statement: The authors declare no conflict of interest.

Data Availability: The dataset presented in the study is available on request from the corresponding author during submission or after publication.

Ethical Approval: The study was approved by the Ethical Committee of Kerman University of Medical Sciences (approval number: IR.KMU.REC.1397.148).

Informed Consent: Verbal informed consent was obtained from participants.

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