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Relationship between years since menopause and lipid variation in postmenopausal women

A cross-sectional study

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Abstract

Lipid alteration in postmenopausal women is commonly due to hormonal changes. This study aimed to explore the association between the years since menopause and lipid profiles in postmenopausal women. In this cross-sectional study, a total of 1033 postmenopausal women were recruited from the Women's Hospital of Zhejiang University in China between 2015 and 2022. Each participant was interviewed using questionnaires regarding sociodemographic and reproductive data. Anthropometric measurements, lipid profiles, and reproductive hormone levels were assessed. Participants were divided into 3 groups based on the length of time since menopause: 2, 2 to 5.9, and 6 years. Differences in lipid profiles and reproductive hormones among the groups were compared. Logistic and linear regression analyses were used to examine the relationship between years after menopause and lipid profile. High-density lipoprotein cholesterol (HDL-C) and luteinizing hormone levels were significantly lower in postmenopausal women with time since menopause of ≥6 years than those <2 years ($P < .05$), whereas low-density lipoprotein cholesterol levels were significantly higher ($P < .05$). A longer time after menopause was independently associated with lower HDL-C levels (β, –0.059, standard error, 0.023, $P = .01$) after adjustment for age, body mass index, and other confounders. Compared to women who had menopause for <2 years, those who were postmenopausal for >6 years had lower HDL-C levels after adjustment for age, body mass index, and other covariates (β, –0.123, 95% confidence interval, [–0.221, –0.014], $P = .014$). Longer time since menopause was associated with an atherogenic lipid profile with appreciably low levels of HDL-C subfraction. Future multicenter studies are necessary to examine postmenopausal population and determine how differences in lipids influence the risk of cardiovascular disease in this group.

Abbreviations: Apo A-I = apolipoprotein A-I, Apo B = apolipoprotein B, BMI = body mass index, CI = confidence interval, CVD = cardiovascular disease, HDL-C = high-density lipoprotein cholesterol, LDL-C = low-density lipoprotein cholesterol, Lp(a) = lipoprotein(a), TC = total cholesterol, TG = triglycerides.

Keywords: lipid profile, HDL-C, LDL-C, postmenopausal women, years after menopause

1. Introduction

Cardiovascular disease (CVD) is the most significant contributor to global mortality[1] and the leading cause of death in China.[2] Although CVD increases in frequency with age for both sexes, the risk of CVD is more prominent in postmenopausal women than in men of the same age and in premenopausal women.[3] Menopause is defined as the absence of menstruation >12 months, which is a natural phenomenon in women as a consequence of progressive ovarian function loss.[4] With increased human longevity, women now live approximately one-third of their lifespan after menopause.[5] On this ground, the association of years after menopause with CVD has recently attracted attention in research. A cross-sectional study consisting of 2498 postmenopausal women reported that compared to women who had menopause for <1 year, those with an elapsed time since menopause of 2 to 3 years had higher CVD prevalence.[6] Similarly, the China Kadoorie Biobank study of 303,000 Chinese women demonstrated that higher risks of both fatal and nonfatal CVD were found in women who had menopause for >5 years than in those <5 years since menopause.[7] Collectively, most existing

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All subjects gave their informed consent for inclusion before participating in the study. The study was conducted by the Declaration of Helsinki, and the protocol was approved by the Ethics Committee of Women's Hospital, School of Medicine, Zhejiang University (approval number: 20140006).

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studies suggested that women with a longer time since menopause have a higher risk of CVD.

Dyslipidemias, defined as elevated plasma concentrations of total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), triglycerides (TG); or low plasma concentration of high-density lipoprotein cholesterol (HDL-C); or a combination of these features, are major risk factors for CVD.[8] Menopause-associated CVD risk is largely attributed to the changes in atherogenic lipid profiles.[9,10] The limited number of investigations on the association between years after menopause and lipid profiles have been inconclusive. Cagnacci et al[11] found that HDL-C levels decreased as the number of years after menopause increased. Nevertheless, Yu et al[12] suggested there was no association between years after menopause and lipid profile after adjusting for confounding factors such as age, education level, smoking, and alcohol consumption. Few other studies concerning the relationship between years after menopause and lipid profiles in Chinese women have been conducted, and such relationship is yet to be elucidated.

In this study, postmenopausal women from Southeast China were divided into 3 groups based on the number of years since menopause, and their serum lipid profiles were compared. By correcting other confounding variables, we performed logistic and linear regression tests to compare the lipid profile between the groups. This study would deepen our knowledge on lipid abnormalities associated with the length of menopause and expand our understanding on the risk of CVD in postmenopausal women.

2. Materials and methods

2.1. Study design and population

This cross-sectional study was carried out from January 2015 to January 2022. A total of 2680 women with menopause-related symptoms admitted to the outpatient clinics of gynecological endocrinology at the Women's Hospital, Zhejiang University School of Medicine, were enrolled. Each patient was asked whether their menstruation had stopped for at least 12 months without menopausal hormone therapy. One thousand two hundred forty-three postmenopausal women without menopausal hormone therapy were initially recruited for this study. The exclusion criteria were: surgical menopause or hysterectomy, malignant tumors or a history of malignant tumors; a history of chemotherapy or radiotherapy; depressive disorder, schizophrenia, or other psychological diseases; other severe systematic or major organ diseases. Among the 1243 postmenopausal women recruited into the study, 81 women who had previously undergone a hysterectomy or surgical menopause and 34 women who had malignant tumors or a history of malignant tumors or a history of chemotherapy or radiotherapy were excluded. Furthermore, 42 women were excluded due to psychological diseases, and 53 women with severe systematic or major organ diseases were excluded from this study. Ultimately, a total of 1033 participants were included in this cohort. The flowchart illustrates the inclusion and exclusion criteria of cohort candidates summarized in Figure 1. The study was approved by the Human Committee of Women's Hospital, Zhejiang University School of Medicine (No. 20140006). Each participant had signed a written informed consent before data collection.

2.2. Data collection

Sociodemographic characteristics were collected from participants via face-to-face interview at their first outpatient visit by trained medical personnel using a standardized questionnaire that included personal basic information (age, education, occupation, income), menstrual history and reproductive history (age at menarche, age at menopause, number of children). Years after menopause were determined by subtracting the age at menopause from the age at the enrollment. According to previously

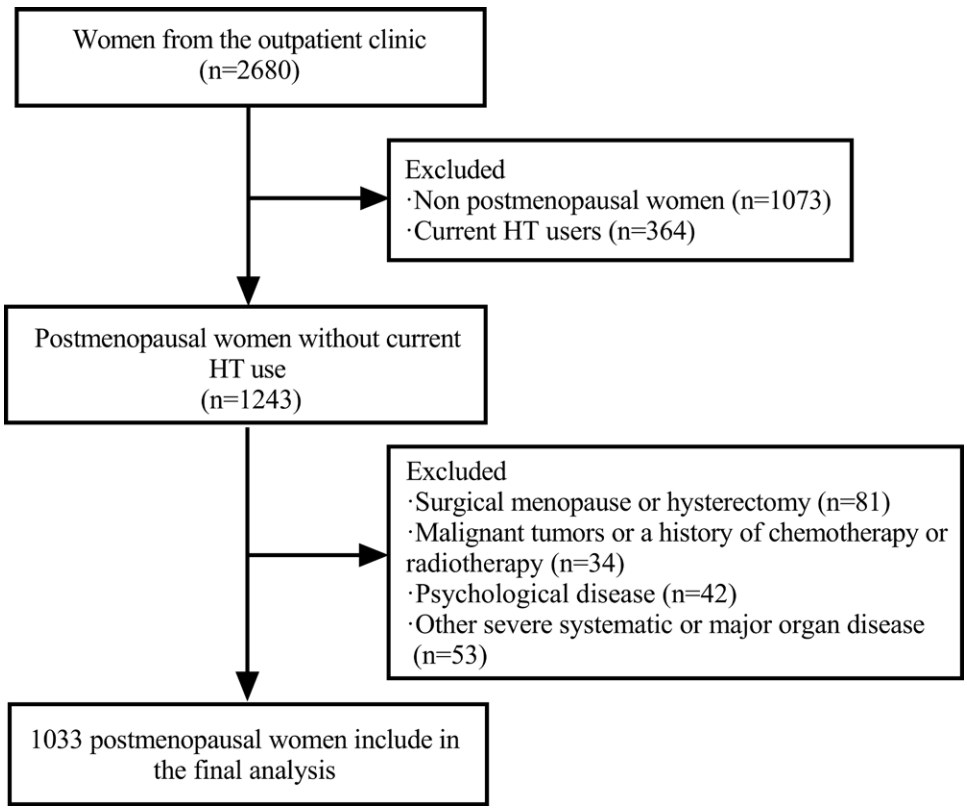

Figure 1. Flow chart of study participants.

documented literature, participants were divided into 3 groups according to years since menopause (group 1: <2 years; group 2: 2 –5.9 years; group 3: ≥6 years).[6,7,13] Anthropometric indices, including body weight, height, and waist circumference, were measured by well-trained examiners with subjects wearing light, thin clothing, and no shoes. Body mass index (BMI) was calculated as weight/height^2 (kg/m^2). The waist circumference was measured horizontally at the midpoint of the lowest ribs margin and the iliac crest.

2.3. Biochemical measures

Venous blood sample from all participants was performed in the morning after 12-hour overnight fasting. All serum metabolic parameters and reproductive hormones were measured during the first visit. Serum levels of TG, TC, HDL-C, LDL-C, lipoprotein(a) [Lp(a)], apolipoprotein A-I (Apo A-I), and apolipoprotein B (Apo B) were analyzed by using standard enzymatic and colorimetric methods on Abbott Architect C16000/C1600757 Automatic Biochemical Analyzer (Abbott Diagnostics, Abbott Park, IL). The serum concentrations of reproductive hormones, including estradiol, follicle-stimulating hormone, luteinizing hormone, and progesterone, were determined by electrochemiluminescent immunoassay using a Roche Cobas 8000 e602 Analyzer (Roche Diagnostics, Meylan, France). According to the guidelines, fasting TC values of ≥6.2 mmol/L were used to characterize hypercholesterolemia,[14] while serum TG levels ≥1.7 mmol/L were used to define hypertriglyceridemia.[15]

2.4. Statistical analysis

Data were expressed as means ± standard deviation for normally distributed continuous variables and as median (interquartile range) for non-normally distributed continuous variables. Categorical variables were shown as numbers (percentage, %). Analysis of variance test was used for continuous normally distributed variables among 3 groups. Non-normally distributed continuous variables were analyzed using the non-parametric Kruskal–Wallis test. Pearson chi-square test and Fisher exact test were used for categorical variables comparison among cohort groups. The relationship between the years after menopause and the lipid profile was investigated using linear regression analyses for continuous dependent variables and logistic regression analyses for categorical dependent variables. Three models with adjustments for the different sets of potentially confounding factors were used: the crude model; model 1 adjusting for age and BMI; and model 2, additionally adjusting for age at menarche, number of children, and educational attainment. For all regression, variables of TG, Lp(a) were log-transformed using the natural logarithm. All variables were checked for multicollinearity before multivariate analysis, and those variables exhibiting collinearity were excluded.

Statistical analysis was performed using SPSS software (version 25.0; IBM, Armonk, NY), and P values <.05 were considered to indicate statistically significant differences.

3. Results

3.1. Participant characteristics

A total of 1033 postmenopausal women were included in this study with a mean ± standard deviation age of 50.3 ± 6.0 years. Most participants (67.10%), had an educational level of high school and above, and 48.50% of the included cases were retired. The median (interquartile range) age at menopause was 49.0 (45.0–51.0) years, and the median years since menopause was 1.8 (0.7–3.9). There were substantial disparities in the age among the 3 groups (P < .001), with the third group being the oldest. Compared to women with a menopause duration of ≥6 years, women with <2 and 2 to 5.9 years after menopause had a later onset of menopause (P = .002) (Table 1).

3.2. Lipid profile among postmenopausal women years after menopause

The metabolic parameters and reproductive hormones of the 3 groups were stratified according to the years after the onset of menopause (Table 1). Women who are at postmenopausal stage for >6 years had significantly lower levels of HDL-C than the other 2 groups (P = .013). In contrast, LDL-C levels were most predominantly seen in group 3 (P = .013). The lowest luteinizing hormone levels were also observed in group 3 (P = .008). There was no significant difference among the 3 groups in terms of TG, TC, Apo A-I, Apo B, Lp(a), estradiol, and follicle-stimulating hormone levels.

3.3. Association between years after onset of menopause and lipid profile

Multivariable linear and logistic regression analyses were conducted to investigate the association between years since menopause and lipid profile levels. In the unadjusted models, HDL-C level showed a significantly negative relationship with the years since menopause (β, –0.062, P = .003), whereas LDL-C level had a positive relationship with the years after menopause (β, 0.125, P = .0043). After adjustment for age and BMI in model 1, the negative association between HDL-C and years since menopause was still significant (β, –0.061, P = .022). Additionally, further controlling for the age at menarche, number of children, and educational attainment revealed, lower levels of HDL-C in women with longer years after menopause (β, –0.059, P = .01). When age and BMI were adjusted, the positive association between the years after menopause and LDL-C levels became in significant (Table 2).

The crude and adjusted results of linear and logistics regression for the association of years since menopause and lipid profile were also noted (Table 3). In the crude model, women with years since menopause between 2 and 5.9 years and ≥6 years were significantly associated with lower serum levels of HDL-C as compared to those who had menopause for <2 years (2–5.9 years, β, –0.071; 95% confidence interval [CI], [–0.133, –0.010], P = .024; ≥6 years, β, –0.115; 95% CI, [–0.207, –0.022], P = .015, respectively). Meanwhile, time since menopause between 2 and 5.9 years and ≥6 years were associated with higher serum levels of LDL-C in the unadjusted model (2–5.9 years, β, 0.138; 95% CI, [0.133, 0.262]; P = .03; ≥6 years, β, 0.240; 95% CI, [0.052, 0.427], P = .012; respectively). After adjusting for age and BMI (model 1), menopause for ≥6 years was still significantly associated with lower serum HDL-C levels (β, –0.124; 95% CI, [–0.221, –0.028], P = .012). Additionally, when further controlling for age at menarche, number of children, and educational attainment (model 2), women with a duration of ≥6 years from menopause were also significantly associated with lower HDL-C levels (β, –0.123; 95%CI, [–0.221, –0.014], P = .014). Lastly, the time since menopause was not associated with LDL-C after adjusting for age and BMI (model 1). No significant association was observed between the time since menopause and serum levels of TG, TC, Apo A-I, Apo B, and Lp(a).

4. Discussion

The study involved 1033 postmenopausal women recruited from Southeast China. We identified that longer years since menopause was significantly associated with lower serum levels of HDL-C independent of age, BMI, age at menarche, number of children, and educational attainment. Furthermore, we also found that women with years since menopause for ≥6

Table 1

Characteristics of participants by groups of year since menopause.

Characteristics	Group 1 menopause < 2 yr	Group 2 menopause 2–5.9 yr	Group 3 menopause ≥ 6 yr	
	n = 476	n = 365	n = 192	*P* value
Age, yr	48.1 ± 6.1	51.3 ± 6.1	60.0 ± 4.9	**<.001**
Education level, n (%)				**.032**
≤Elementary	142 (29.8)	139 (38.1)	59 (30.7)	
High school	153 (32.1)	109 (29.9)	87 (45.3)	
College/university	181 (38.0)	117 (32.1)	46 (24.0)	
Having a job, n (%)	305 (64.1)	163 (44.7)	64 (33.3)	**<.001**
Monthly income (yuan), n (%)				.137
<2000	72 (15.1)	67 (18.4)	41 (21.3)	
2000–5000	202 (42.4)	181 (49.6)	86 (44.8)	
>5000	202 (42.4)	117 (32.0)	65 (33.9)	
Number of children, n (%)				.263
0	30 (6.3)	29 (7.9)	3 (1.6)	
1	385 (80.9)	302 (82.8)	165 (85.9)	
≥2	61 (12.8)	34 (9.3)	24 (12.5)	
Age at menarche, yr	14.7 ± 1.5	14.8 ± 1.8	14.7 ± 1.7	.307
Age at menopause, yr	49.0 (45.0, 52.0)	49.0 (46.0, 51.0)	46.0 (43.0, 50.0)	**.002**
BMI, kg/m^2	22.00 ± 2.83	22.19 ± 2.46	21.87 ± 2.45	.989
Waist circumference, cm	77.20 ± 7.80	77.75 ± 7.67	77.18 ± 6.56	.720
TG, mmol/L	1.03 (0.76, 1.50)	1.02(0.78, 1.32)	1.03 (0.76, 1.46)	.123
TC, mmol/L	5.20 ± 0.86	5.21 ± 0.97	5.30 ± 0.80	.237
HDL-C, mmol/L	1.55 ± 0.34	1.55 ± 0.36	1.47 ± 0.25	**.013**
LDL-C, mmol/L	2.73 ± 0.67	2.89 ± 0.82	2.90 ± 0.59	**.013**
Apo A-I, g/L	1.50 ± 0.23	1.46 ± 0.27	1.47 ± 0.19	.208
Apo B, g/L	0.90 ± 0.21	0.89 ± 0.23	0.92 ± 0.18	.188
Lp(a) mg/L	195.00 (109.00, 340.00)	165.50 (83.00, 264.50)	237.00 (85.00, 435.00)	.384
E2, pmol/L	34.6 (18.35, 75.68)	38.59 (18.35, 57.87)	25.45 (18.35, 53.68)	.266
FSH, IU/L	77.08 ± 33.34	76.91 ± 27.59	70.94 ± 25.39	.263
LH, IU/L	38.22 ± 16.43	35.97 ± 11.90	32.48 ± 12.21	**.008**
P, nmol/L	0.92 (0.67, 1.37)	0.84 (0.67, 1.30)	0.83 (0.63, 1.25)	.357
Hypertriglyceridemia, n (%)	74 (15.5)	80 (21.9)	38 (20.0)	.154
Hypercholesterolemia, n (%)	105 (22.1)	106 (29.0)	47 (24.4)	.188

Values are presented as mean ± standard deviation or median (interquartile range) or number (%).

Variables were compared across groups using analysis of variance for normally distributed data; non-parametric Kruskal–Wallis (KW) test was used for non-normally distributed data; and Pearson chi-square test was used for categorical variables.

P values <.05 are shown in bold.

Apo A-I = apolipoprotein A-I, Apo B = apolipoprotein B, BMI = body mass index, E2 = estradiol, FSH = follicle-stimulating hormone, HDL-C = high-density lipoprotein cholesterol, LDL-C = low-density lipoprotein cholesterol, LH = luteinizing hormone, Lp(a) = lipoprotein(a), P = progesterone, TC = total cholesterol, TG = triglycerides.

Table 2

Association of years since menopause with lipid profile.

	Crude model		Model 1		Model 2	
Variable	β (SE)/OR (95% CI)	*P* value	β (SE)/OR (95% CI)	*P* value	β (SE)/OR (95% CI)	*P* value
TG	0.051 (0.027)	.059	0.018 (0.029)	.535	0.015 (0.029)	.614
TC	0.086 (0.051)	.093	0.039 (0.056)	.490	0.038 (0.058)	.510
HDL-C	**−0.062 (0.021)**	**.003**	**−0.061 (0.022)**	**.007**	**−0.059 (0.023)**	**.010**
LDL-C	**0.125 (0.043)**	**.003**	0.081 (0.047)	.085	0.074 (0.048)	.126
Lp(a)	−0.089 (0.090)	.320	−0.108 (0.100)	.281	−0.087 (0.105)	.410
Apo A-I	−0.016 (0.018)	.368	−0.001 (0.004)	.852	−0.011 (0.018)	.535
Apo B	0.024 (0.015)	.097	0.008 (0.016)	.621	0.003 (0.017)	.858
Hypertriglyceridemia	1.02 (0.96, 1.09)	.543	1.01 (0.94, 1.10)	.689	1.00(0.93, 1.09)	.937
Hypercholesterolemia	1.02 (0.96, 1.09)	.486	0.99 (0.93, 1.07)	.884	1.00 (0.93, 1.07)	.956

Years since menopause, TG, TC, HDL-C, LDL-C, Lp(a), Apo A-I, Apo B as continuous variables; hypertriglyceridemia, hypercholesterolemia as categorical variables; TG, Lp(a) were natural log-transformed.

Model 1: adjusted for age, body mass index. Model 2: adjusted for age, body mass index, age at menarche, number of children, educational attainment.

P values <.05 are shown in bold.

Apo A-I = apolipoprotein A-I, Apo B = apolipoprotein B, CI = confidence Interval, HDL-C = high-density lipoprotein cholesterol, LDL-C = low-density lipoprotein cholesterol, Lp(a) = lipoprotein(a), OR = odds ratio, SE = standard error, TC = total cholesterol, TG = triglycerides.

years were independently associated with lower HDL-C levels than those with duration since menopause for <2 years. Our findings provide evidence that a longer duration since menopause is associated with a more atherogenic lipid profile in postmenopausal women. Given that dyslipidemia is one of the most important risk factors for CVD, prevention and sensible management of dyslipidemia, such as a healthy diet, regular exercise, and avoidance of tobacco smoking in, women aged ≥45 years are strongly recommended to be screened for dyslipidemia, or in patients with hyperlipidemia requiring drugs to

Table 3

Association of years since menopause in different groups with lipid profile.

Variable	Model	Menopause < 2 yr	Menopause 2–5.9 yr	Menopause ≥ 6 yr
			β (95% CI)/OR (95% CI)	β (95% CI)/OR (95% CI)
TG	Crude model	0.00	0.072 (–0.007, 0.151)	0.082 (–0.036, 0.200)
	Model 1	0.00	0.041 (–0.040, 0.123)	0.014 (–0.109, 0.138)
	Model 2	0.00	0.038 (–0.046, 0.122)	0.009 (–0.117, 0.135)
TC	Crude model	0.00	0.072 (–0.078, 0.222)	0.185 (–0.040, 0.409)
	Model 1	0.00	0.021 (–0.139, 0.182)	0.093 (–0.150, 0.336)
	Model 2	0.00	0.000 (–0.166, 0.165)	0.110 (–0.138, 0.357)
HDL-C	Crude model	0.00	**–0.071 (–0.133, –0.010)***	**–0.115 (–0.207, –0.022)***
	Model 1	0.00	–0.059 (–0.122, 0.005)	**–0.124 (–0.221, –0.028)***
	Model 2	0.00	–0.057 (–0.122, 0.009)	**–0.123 (–0.221, –0.014)***
LDL-C	Crude model	0.00	**0.138 (0.013, 0.262)***	**0.240 (0.052, 0.427)***
	Model 1	0.00	0.080 (–0.053, 0.212)	0.162 (–0.040, 0.365)
	Model 2	0.00	0.046 (–0.091, 0.183)	0.174 (–0.033, 0.381)
Apo A-I	Crude model	0.00	–0.042 (–0.090, 0.006)	0.000 (–0.070, 0.070)
	Model 1	0.00	–0.042 (–0.092, 0.008)	–0.008 (–0.085, 0.068)
	Model 2	0.00	–0.034 (–0.085, 0.017)	–0.003 (–0.080, 0.075)
Apo B	Crude model	0.00	0.011 (–0.032, 0.055)	0.06 (–0.004, 0.123)
	Model 1	0.00	–0.005 (–0.050, 0.041)	0.028 (–0.042, 0.097)
	Model 2	0.00	–0.019 (–0.066, 0.028)	0.026 (–0.045, 0.098)
Lp(a)	Crude model	0.00	–0.102 (–0.281, 0.076)	0.019 (–0.257, 0.296)
	Model 1	0.00	–0.070 (–0.307, 0.294)	–0.157 (–0.347, 0.032)
	Model 2	0.00	–0.370 (–0.273, 0.199)	0.031 (–0.196, 0.257)
Hypercholesterolemia	Crude model	1.00	1.441 (0.973, 2.135)	1.151 (0.629, 2.107)
	Model 1	1.00	1.332 (0.875, 2.027)	0.920 (0.477, 1.772)
	Model 2	1.00	1.277 (0.829, 1.967)	0.969 (0.449, 1.882)
Hypertriglyceridemia	Crude model	1.00	1.525 (0.984, 2.366)	1.368 (0.711, 2.633)
	Model 1	1.00	1.510 (0.940, 2.426)	1.280 (0.620, 2.642)
	Model 2	1.00	1.397 (0.861, 2.265)	1.201 (0.579, 2.489)

TG, TC, HDL-C, LDL-C, Lp(a), Apo A-I, Apo B as continuous variables; years since menopause, hypertriglyceridemia, hypercholesterolemia as categorical variables; TG, Lp(a) were natural log-transformed. Model 1: adjusted for age, body mass index. Model 2: adjusted for age, body mass index, age at menarche, number of children, educational attainment.

Apo A-I = apolipoprotein A-I, Apo B = apolipoprotein B, CI = confidence Interval, HDL-C = high-density lipoprotein cholesterol, LDL-C = low-density lipoprotein cholesterol, Lp(a) = lipoprotein(a), OR = odds ratio, TC = total cholesterol, TG = triglycerides.

* $P < .05$.

reach therapeutic goals to alter cardiovascular morbidity and mortality.[16–19]

HDL-C is composed of approximately the same proportion of proteins and lipids, including phospholipids, free cholesterol, cholesterol esters, and Apo A-I.[20–22] It is vital in transporting cholesterol from surrounding tissues to the liver for recycling or excretion in the form of bile acids to reduce cholesterol levels in the blood vessel walls, and development of atherosclerosis. HDL-C is also involved in anti-atherosclerosis by anti-inflammation, antithrombotic, endothelial protection, and antioxidative effects.[23–25] Multiple studies have confirmed that lower serum HDL-C levels have been an independent risk factor for CVD in the past several decades.[26–28] although the relationship between menopause and HDL-C levels remains unclear. In our study, years since menopause were found to be independently associated with HDL-C levels in postmenopausal women. These results could be partially attributed to the effect of the estrogenic decline on lipoprotein metabolism. Estrogen plays a vital role in protecting against atherosclerosis by exerting anti-inflammatory effects, activating rapid vasodilatation, stimulating endothelial growth and migration, and increasing and decreasing HDL-C and LDL-C levels, respectively.[29–32] In a cross-sectional study, Cagnacci et al recruited 951 postmenopausal women between 2002 and 2009 to test the risk factors associated with CVD,[11] and found that HDL-C was inversely related to the years since menopause, which was in line with our results. A similar result was found in another study performed in rural Chinese females, which revealed that compared to women who had been on menopause for <1 year, those with elapsed time since menopause of 2 to 3 years had higher levels of HDL-C.[6] Nevertheless, because of the relatively small age range (40–59 years), the long-term effect from the time since menopause could not be determined. It is challenging to determine whether the observed differences resulted from ovarian or chronological aging or both. Kat et al conducted a cross-sectional study in which 65,466 women were recruited at different stages of menopausal transition within the same yearly age range to distinguish the effects of ovarian or chronological aging on lipids. They found that both chronological age and menopause were independently associated with lipid levels.[33] In addition, a cross-sectional study conducted by Kaya et al found that lipid levels differed according to the severity of menopause-related symptoms.[34] Taken together, more prospective studies with a larger sample size are needed to investigate the association between time since menopause and HDL-C levels in the future.

In the current study, a positive correlation was found between serum LDL-C levels and the number of years since menopause. However, this correlation was not observed after controlling for age and BMI, indicating that age and BMI may contribute to increased LDL-C levels in postmenopausal women. Our results are consistent with previous cross-sectional studies on the elapsed time since menopause and serum LDL-C levels in French,[35] Chinese,[6] and Brazilian[36] population-based samples of postmenopausal women. A cross-sectional study of 9097 Chinese participants who presented within a year since menopause, was associated with increased levels of LDL-C after adjusting for BMI ($P < .01$); however, this study made no adjustments for age.[37] Hence, aging is a significant risk factor for impaired metabolism.[38,39] In addition to age and BMI, a previous study by Alay et al reported that LDL-C was negatively correlated with bone mass density of the lumbar spine.[40]

The strength of this study is that we specifically assessed the association between time since menopause and lipid profile in postmenopausal women, and adjusted for confounding

variables that may have contributed to variations in lipid profile. However, the present study has some limitations. First, as this was a cross-sectional study, it was difficult to draw a firm conclusion about the chronology of the lipid changes observed. Another limitation of our study is the lack of data on lifestyle factors, such as physical exercise, diet, and smoking, which may also affect blood lipid levels. In addition, age at menopause was based on self-reporting, which may have led to recall bias. Lastly, the present study was limited by the relatively small sample size.

5. Conclusions

In summary, we investigated the association between the duration since menopause and various lipid profiles, including HDL-C and LDL-C, in a sample of 1033 postmenopausal people. Our findings suggest that a longer duration since menopause is associated with alterations of the lipid profile (lower HLD-C and higher LDL-C levels) in postmenopausal women. However, more studies, especially large prospective studies, are needed to explore this relationship and further reveal the underlying mechanisms.

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Author contributions

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