scientific reports

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Effects of key physiological parameters on cardiovascular disease and osteoporosis risk in perimenopausal and postmenopausal women

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The essential cause of menopause is ovarian failure, which can cause decline in sex hormones (especially estrogen) that can increase the risk of metabolic diseases, such as cardiovascular disease and osteoporosis. This study screened 1511 eligible patients from 2148 perimenopausal and postmenopausal women, measuring various physiological and biochemical indicators to analyze differences among age groups (40–44, 45–49, and 50–54 years) with laboratory techniques. The study found no significant difference in the incidence of cardiovascular disease betweenperimenopausal and postmenopausal women. But the incidence of osteoporosis was higher in postmenopausal women and was associated with age ($p < 0.05$). Additionally, follicle-stimulating hormone (FSH), luteinizing hormone (LH), estradiol (E_2), total cholesterol (TC), lumbar spine bone mineral density (BMD) (T1), right femoral BMD (T2) and femoral neck BMD were significantly correlated in both groups. Significant differences were observed in FSH, LH, E_2, TC, low-density lipoprotein (LDL), L2-L4, T_1, femoral neck reduction and T_2 among women in different age groups. Correlation analysis indicated that age increased the risk of cardiovascular disease and osteoporosis in bothperimenopausal and postmenopausal women. This study contributes to a deeper understanding of the pathogenesis of cardiovascular disease and osteoporosis in perimenopausal and menopausal women.

Keywords Perimenopausal, Postmenopausal, Cardiovascular disease, Osteoporosis, Estradiol

Menopause is an important stage in a woman's life, which is mainly divided into two stages, namely perimenopause and postmenopause[1]. Perimenopause refers to the stage when a woman transitions from regular menstruation during the reproductive period to menopause, which usually occurs in women between the ages of 40 and 55 [2]. Postmenopause is the stage in the female reproductive system when the menstrual cycle stops[2]. The typical characteristics of perimenopausal and postmenopausal women are decreased ovarian function and disordered sex hormone secretion. These changes can have adverse effects on women's psychological and physical health[3]. Common symptoms of menopause and perimenopause include irregular menstruation, back and leg pain, hot flashes, mood swings, insomnia and depression[4,5].

Women in perimenopause and menopause for a long time may suffer from metabolic-related diseases such as hypertension, coronary heart disease and osteoporosis[6–8]. And the risk of other types of diseases can also increase, such as cardiovascular disease, menopausal symptoms, vaginal atrophy and urinary tract infections. The secretion level of sex hormones in perimenopausal and postmenopausal women decreases which affects the blood lipid metabolism, vascular function and cardiovascular health of the female population[9–11]. Estrogen plays an important role in maintaining lipid metabolism balance. The decrease in estrogen levels may lead to an increase in total cholesterol (TC), triglycerides (TG) and low-density lipoprotein (LDL) levels, while the

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level of high-density lipoprotein (HDL) decreases[12,13]. Some studies have shown that the increase in TC and LDL increases the risk of cardiovascular disease in postmenopausal women[14,15]. Estrogen has a protective effect on vascular endothelial cells and vascular walls, promotes the proliferation and repair of endothelial cells, and maintains the elasticity and stability of vascular walls[16]. The decrease in estrogen levels further can cause impaired vascular endothelial function, weaken the elasticity and stability of vascular walls and increase the risk of arteriosclerosis and cardiovascular disease[17]. In addition, the occurrence of postmenopausal osteoporosis is also related to the decrease in estrogen levels which leads to reduced bone strength and increased fracture risk[18]. As an important biochemical marker of bone turnover and formation, osteocalcin is involved in bone mineralization and calcium homeostasis[19]. Studies have found that serum total osteocalcin in postmenopausal women is closely related to glucose and lipid metabolism, and is negatively correlated with TC, LDL, fasting blood glucose (FPG) and postprandial blood glucose (PBG)[20].

The incidence of cardiovascular disease and osteoporosis inperimenopausal and postmenopausal women is mainly caused by estrogen levels, and conventional treatments have greater side effects on women during this period[21,22]. Therefore, an increasing number of studies have begun to use hormone replacement therapy (HRT) to treat cardiovascular disease and osteoporosis inperimenopausal and postmenopausal women. Studies have found that estrogen has a positive effect on cardiovascular health. It can improve blood lipid metabolism, reduce LDL levels and increase HDL levels[23]. This mechanism helps reduce the risk of atherosclerosis and lowers the incidence of cardiovascular disease. Hormone replacement therapy (HRT) is considered an effective treatment for postmenopausal osteoporosis and fractures[24]. HRT can help balance bone resorption and formation, significantly improve bone density and reduce the incidence of fractures by supplementing estrogen[25]. Studies have shown that postmenopausal women who receive HRT have a significantly reduced risk of fractures in key areas such as the hip and spine[26,27].

Although estrogen has significant benefits in treating cardiovascular disease and osteoporosis in postmenopausal and postmenopausal women, there are certain risks, such as breast cancer, cardiovascular events and thrombosis[28,29]. In order to further understand the pathogenesis of metabolic diseases in postmenopausal and postmenopausal women and solve the side effects during HRT treatment, this study selected perimenopausal and postmenopausal women aged 40–54 years old in West China Second University Hospital from October 2020 to October 2024 as research subjects. This study explored the impact of different age stages on female menopause and the pathogenesis of perimenopausal women and postmenopausal women by measuring various physiological and biochemical indicators. The results of this study can provide data support for the study of the pathogenesis of cardiovascular disease and bone disease in clinical perimenopausal and postmenopausal women, and provide a scientific basis for solving the health problems of women.

Methods
Study participants
The subjects of this study were 2148perimenopausal and postmenopausal women aged 40 to 54 years who were registered in West China Second Hospital, China from October 2020 to October 2024 (Table S1). Perimenopausal women show irregular menstruation and decreased estrogen levels, while postmenopausal women have been amenorrhea for more than 1 year[30,31]. The study subjects excluded women who met any of the following conditions: (1) other endocrine diseases, such as hypothyroidism and Cushing's syndrome; (2) severe debilitating diseases, such as cancer, liver and kidney dysfunction; (3) smoking or drinking habits; (4) history of estrogen replacement therapy; (5) women who could not remember their last menstrual cycle. This study has been approved by the Ethics Committee of West China Second Medical College, Sichuan University (Number: KL059), and all procedures involving human participants were in accordance with ethical standards. All participants signed written informed consent.

Data collection of the metabolic related diseases
Postmenopausal and perimenopausal women are at increased risk of developing metabolic-related diseases, such as cardiovascular disease and skeletal system diseases[32,33], especially hypertension and coronary artery disease[34]. Clinically, systolic blood pressure over 140 mmHg or diastolic blood pressure over 90 mmHg is considered hypertension[35]. In addition, the diagnosis of coronary heart disease is usually based on its common symptoms (such as chest pain, chest tightness, dyspnea and fatigue) combined with coronary angiography[36]. Dual-energy X-ray absorptiometry (DEXA) is an instrument widely used to measure bone density and screen for osteoporosis[37]. According to the standards of the World Health Organization (WHO), a T-score between -1 and -2.5 indicates osteopenia, while T-score below -2.5 is diagnosed as osteoporosis[38].

Measurements of anthropometric indexes
The weight and height of all participants who met the screening criteria were measured using a standard stadiometer and scale. The body mass index (BMI) was calculated based on the ratio of weight (kg) to height (m[39]) squared. The waist circumference (between the 10th rib (lower costal arch) and ilium (iliac crest)) was measured with a measuring tape applied to the subject's skin while the subject was breathing naturally. The hip circumference was measured with a flexible measuring tape passed horizontally around the widest part of the hips (the distance in the two upper ilium) with the subject's feet together. The waist-to-hip ratio (WHR) is the ratio of waist circumference to hip circumference. The subject's body fat fraction (BFR) was measured using the electrical impedance measurement technique[40]. The subject's bone mineral density (BMD) was measured using DEXA at the lumbar spine L_2 to L_4 (L_2-L_4) BMD and T_1 values, and at the femoral neck BMD and T_2 values.

Laboratory measurements

The researchers used a sterilized syringe to draw 10 ml of fasting blood samples from the subjects through the vein, as well as 10 ml of blood samples within 120 min after oral administration of 75 g of glucose. The electrochemical method was used to detect the blood samples of the subjects to obtain the concentrations of fasting blood glucose (FPG) and postprandial blood glucose (PBG), the colorimetric method was used to detect the levels of total cholesterol (TC) and triglycerides (TG) in the blood, and the chemical analysis method was used to detect the levels of high-density lipoprotein (HDL) and low-density lipoprotein (LDL) in the blood.

we used enzyme-linked immunosorbent assay (ELISA)[41] to detect the levels of various sex hormones in fasting blood samples of these subjects to measure blood sex hormones (follicle stimulating hormone (FSH), luteinizing hormone (LH), estradiol (E2), testosterone (T)) in perimenopausal and postmenopausal women. The collection time of sex hormone blood samples of perimenopausal women must be 6 months after amenorrhea or more than 3 cycles.

Statistical analysis

SPSS 21.0 (Statistical Package for Social Sciences, Inc., Chicago, IL, USA) was used for data analysis and significance testing[42], and Graphpad prism5 (Statistical and Graphing Software, China) was used for graphics[43]. Normally distributed data are expressed as mean ± standard deviation (SD), while discrete data are expressed as median (interquartile range). Chi-square tests assessed whether there were significant differences in the proportions of relevant diseases between groups[44]. Bivariate correlation analysis evaluated the effects of hormones and age on four indicators: TC, LDL, T_1, and T_2. All statistical tests in this study were performed at a significance level of 0.05, with Bonferroni correction for multiple comparisons[45].

Results

Subjects

A total of 2148 postmenopausal and perimenopausal female patients were recruited from West China Second University Hospital from 2020 to 2024, and 637 were excluded from the study (Table 1). Finally, 1511 women met the screening criteria for follow-up study, including 1103 perimenopausal women and 408 postmenopausal women. Among the 1108 perimenopausal women, 98 women had cardiovascular disease, and 268 women had osteopenia and osteoporosis. Among the 1108 postmenopausal women, 68 women had cardiovascular disease, and 86 women had osteopenia and osteoporosis. This result indicates that perimenopausal and postmenopausal females have an increased probability of suffering from cardiovascular and skeletal system diseases, and the risk of suffering from skeletal system diseases is much greater than that of cardiovascular diseases.

To explore the relationship between age and cardiovascular and skeletal system diseases inperimenopausal and postmenopausal women, we analyzed the incidence of cardiovascular and skeletal system diseases at different age stages. The number of perimenopausal women suffering from cardiovascular diseases and skeletal diseases was 98 and 268, respectively. The number of postmenopausal women suffering from cardiovascular diseases and skeletal diseases was 68 and 171, respectively. The study found that the risk ofperimenopausal and postmenopausal women suffering from cardiovascular and skeletal system diseases increased with increasing age, and the incidence of postmenopausal women was significantly higher than that of perimenopausal women. This result indicates that both age and menstrual status have an impact on women's risk of disease.

Metabolic related diseases in perimenopausal and postmenopausal women

In order to further analyze the impact of age on the prevalence of cardiovascular and skeletal system diseases in perimenopausal and postmenopausal women, we further analyzed the prevalence rates at different age stages (Fig. 1). In cardiovascular diseases, the incidence rates of perimenopausal women in the 40–44 group, 45–49 group and 50–54 group were 26 (4.81%), 53 (11.47%) and 19 (18.81%), while the incidence rates of postmenopausal women were 21 (14.79%), 47 (23.50%) and 68 (16.66%). skeletal diseases, the incidence rates of menopausal women in the 40–44 group, 45–49 group and 50–54 group were 108 (19.96%), 129 (27.98%) and 31 (30.69%), while the incidence rates of perimenopausal women were 13 (19.69%), 59 (41.55%) and 99 (49.50%). The results of the study showed that the risk of cardiovascular disease and bone disease in perimenopausal and postmenopausal women increased with age, and the probability of postmenopausal women suffering from the disease was higher than that of perimenopausal women.

Correlation analysis of the association between cardiovascular disease and perimenopausal and postmenopausal women showed that women's risk of cardiovascular disease was not significantly related to their menstrual cycle stage. Correlation analysis of skeletal system diseases shows that the incidence rate of women aged 45 to 49 and 50 to 54 years old is related to the menstrual stage, and the incidence rate of postmenopausal

Age	Number		Cardiovascular diseases		Skeletal system	
	Peri-M	Post-M	Peri-M	Post-M	Peri-M	Post-M
40–44	541	66	26 (4.81%)	0	108 (19.96%)	13 (19.69%)
45–49	461	142	53 (11.47%)	21 (14.79%)	129 (27.98%)	59 (41.55%)
50–54	101	200	19 (18.81%)	47 (23.50%)	31 (30.69%)	99 (49.50%)
Total	1103	408	98 (8.88%)	68 (16.66%)	268 (24.30%)	171 (41.91%)

Table 1. Prevalence rate of cardiovascular and skeletal disorders in perimenopausal and postmenopausal women at different age groups. Note: Peri-M means perimenopausal and Post-M means postmenopausal.
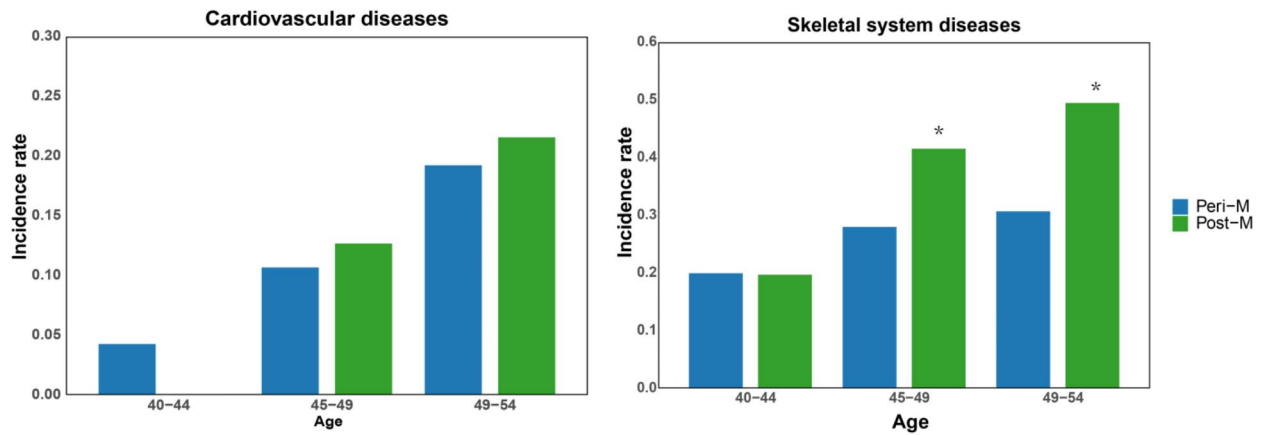
Fig. 1. The prevalence rate of cardiovascular and skeletal diseases in perimenopausal and postmenopausal women at different age groups (**A**) Cardiovascular disease. (**B**) Skeletal diseases. Note: * means $p < 0.05$, Peri-M means perimenopausal, Post-M means postmenopausal.

	Peri-M Mean ± SD	Post-M Mean ± SD	P value
E_2(pg/ml)	65.76(31.83–93.85)	38.08(11.9–60.85)	0.000***
T(ng/ml)	0.41(0.23–0.45)	0.39(0.24–0.46)	0.258
FSH(IU/L)	44.84(10.20–73.10)	74.07(50.53–95.43)	0.000***
LH(IU/L)	25.93(18.13–42.12)	37.62(27.15–46.92)	0.000***
TC(mmol/L)	4.79 ± 0.84	5.00 ± 0.81	0.000***
TG(mmol/L)	1.29(0.82–1.56)	1.39(0.88–1.66)	0.193
HDL(mmol/L)	1.66 ± 0.39	1.64 ± 0.37	0.458
LDL(mmol/L)	2.68 ± 0.81	2.84 ± 0.75	0.000***
FPG(mmol/L)	5.32(5.0–5.6)	5.33(5.00–5.65)	0.305
PBG(mmol/L)	6.65(5.62–7.18)	6.67(5.93–7.82)	0.921
BMI(kg/m^2)	22.61 ± 2.65	22.51 ± 2.87	0.085
WC(cm)	75 (70–80)	76(69–80)	0.768
HC(cm)	91(87–94)	91(86–93)	0.567
WHR	0.83 ± 0.05	0.83 ± 0.05	0.897
BFR	32.97(29.81–35.42)	32.33(27.13–34.75)	0.203
L_2-L_4(BMD)	1.15 ± 0.16	1.07 ± 0.16	0.000***
T_1	−0.03 ± 1.19	−0.37 ± 1.24	0.000***
Neck of femur(BMD)	0.93 ± 0.13	0.87 ± 0.12	0.000***
T_2	−0.33 ± 1.01	−0.59 ± 0.98	0.000***

Table 2. Physiological and biochemical indicators of perimenopausal and postmenopausal women. Note: Normally distributed data were expressed as means ± SD, skewed distribution were reported as median (interquartile range), *** indicated that p is less than 0.001.

women is significantly higher than that of perimenopausal women. This shows that women's physiological stage will have an impact on women's skeletal system diseases.

Physiological and biochemical indicators of perimenopausal and postmenopausal women

To explore the effects of various physiological and biochemical indicators on sexual function in perimenopausal and postmenopausal women, we analyzed the physiological and biochemical indicators of these two groups of women (Table 2). The results showed that there was no significant difference in FPG, PBG, BMI, WC, HC, BFR, TG and HDL between perimenopausal and postmenopausal women ($p > 0.05$).

However, the difference in sex hormone levels between perimenopausal and postmenopausal women is very significant. The levels of E_2, FSH and LH in perimenopausal women were 65.76 pg/ml, 44.8436 IU/L and 25.93IU/L respectively, while the levels in postmenopausal women were 38.08 pg/ml, 74.07 IU/L and 37.62 IU/L respectively. This result shows that E_2 in postmenopausal women is significantly lower than that in perimenopausal women ($p < 0.001$), while FSH and LH are significantly higher than in perimenopausal women ($p < 0.001$). Among the blood lipid indicators, only the content of TC was significantly different between

the two groups ($p < 0.001$), which were 4.79 mmol/L and 5.00 mmol/L respectively. In addition, there were significant differences in four bone mineral density indicators between perimenopausal and postmenopausal women ($p < 0.001$). The L_2-L_4 BMD, T_1 value, femoral neck BMD, and T_2 value in perimenopausal women were 1.15, −0.03, 0.93, and −0.33, while the corresponding values in postmenopausal women were 1.07, −0.37, 0.87, and −0.59. These results indicated that there are differences in certain physiological indicators between perimenopausal and postmenopausal women, which may be related to the occurrence of various metabolic diseases.

Physiological and biochemical indicators of perimenopausal and postmenopausal women at different ages

The differences in various physiological and biochemical indicators of perimenopausal and postmenopausal women of different age groups were further analyzed to explore the effect of age on metabolic-related diseases in women (Table 3). The three sex hormone indicators (E_2, FSH and LH) showed significant differences in perimenopausal and postmenopausal women of different age groups. The values of E_2 in perimenopausal and postmenopausal women aged 40–44, 45–49 and 50–54 were 72.81 pg/ml, 45.23 pg/ml and 23.06 pg/ml. FSH was 41.31 IU/L, 51.9 IU/L and 77.38 IU/L in these three age groups, while LH was 23.54 IU/L, 29.26 IU/L and 39.91 IU/L. This result shows that E2 of perimenopausal and postmenopausal women decreases with age, while FSH and LH increase with age. The three blood lipid indexes TC ($p < 0.001$), TG ($p < 0.05$), and LDL ($p < 0.001$) in perimenopausal and postmenopausal women of different age groups all showed an increasing trend with age, and there were significant differences with age. Among them, the content of TC in different age stages was 4.76 mmol/L, 4.84 mmol/L, and 5.04 mmol/L. The values of L_2-L_4, T_1, T_2 and femoral neck in perimenopausal and postmenopausal women of different age groups decreased with age, and there were significant differences with age in L_2-L_4 ($p < 0.001$), T1 ($p < 0.001$), femoral neck ($p < 0.05$), and T_2 ($p < 0.05$). There were no significant differences in T, TG, HDL, FPG, BMI, HC, WC, WHR, and BFR between perimenopausal and postmenopausal women of different age groups ($p > 0.05$).

Effects of age and E2 on perimenopausal and postmenopausal women related indicators

In order to further explore the impact of different ages on the physiological indicators of perimenopausal and menopausal women and the development of cardiovascular disease and osteoporosis, we combined the significantly related physiological indicators of women of different ages and selected 4 indicators for further analysis. TC and LDL are related indicators of cardiovascular disease. Excessive levels can lead to atherosclerosis and increase the risk of heart disease and stroke. T_1 and T_2 are important indicators for assessing bone density and bone health. The T_1 value usually refers to the bone density of the lumbar spine, while the T_2 value is related to the bone density of the femur or other parts. Low T_1 and T_2 values generally indicate an increased risk of osteoporosis. The four indicators of perimenopausal women and postmenopausal women aged 40 to 44 years are basically the same (Fig. 2), the TC and LDL of postmenopausal women are higher than those of perimenopausal women with age increases, while the values of T_1 and T_2 lower than perimenopausal women.

	40–44 Mean ± SD	45–49 Mean ± SD	50–54 Mean ± SD	P value
E_2(pg/ml)	72.81(35.21–91.35)	45.23(14.10–86.90)	23.06(11.80–35.55)	0.000***
T(ng/ml)	0.38(0.23–0.44)	0.36(0.21–0.42)	0.32(0.19–0.44)	0.976
FSH(IU/L)	41.31(8.28–78.54)	21.90(13.10–73.25)	77.38(35.28–93.24)	0.000***
LH(IU/L)	23.54(8.52–45.36)	29.26(12.34–49.3)	39.91(26.32–52.41)	0.000***
TC(mmol/L)	4.76 ± 0.82	4.84 ± 0.80	5.04 ± 0.76	0.000***
TG(mmol/L)	1.01(0.68–1.47)	1.27 (0.96–1.82)	1.38(1.23–1.86)	0.045*
HDL(mmol/L)	1.65 ± 0.36	1.68 ± 0.39	1.65 ± 0.36	0.563
LDL(mmol/L)	2.67 ± 0.78	2.71 ± 0.75	2.89 ± 0.68	0.000***
FPG(mmol/L)	5.34(4.91–5.46)	5.34(4.96–5.61)	5.34(4.92–5.58)	0.321
PBG(mmol/L)	6.62 (5.59–6.57)	6.66(6.19–6.71)	6.87(6.67–6.97)	0.000***
BMI(kg/m^2)	22.51 ± 2.69	22.72 ± 2.68	22.45 ± 2.65	0.996
WC(cm)	75(70–79)	75(70–80)	76(71–81)	0.253
HC(cm)	90.15 ± 5.80	90.82 ± 6.03	90.75 ± 6.04	0.358
WHR	0.83 ± 0.05	0.83 ± 0.05	0.83 ± 0.05	0.758
BFR	32.78(29.52–35.36)	33.39(29.85–35.60)	33.01(30.10–35.43)	0.291
L_2-L_4(BMD)	1.15 ± 0.12	1.14 ± 0.15	1.05 ± 0.13	0.000***
T_1	−0.05 ± 1.12	−0.23 ± 1.20	−0.81 ± 1.32	0.000***
Neck of femur(BMD)	0.92 ± 0.12	0.89 ± 0.12	0.87 ± 0.12	0.025*
T_2	−0.30 ± 1.03	−0.39 ± 1.01	−0.60 ± 1.01	0.031*

Table 3. Physiological and biochemical indicators of perimenopausal and postmenopausal women at different ages. Note: Normally distributed data were expressed as means ± SD, skewed distribution were reported as median (interquartile range), *** indicated that p is less than 0.001.
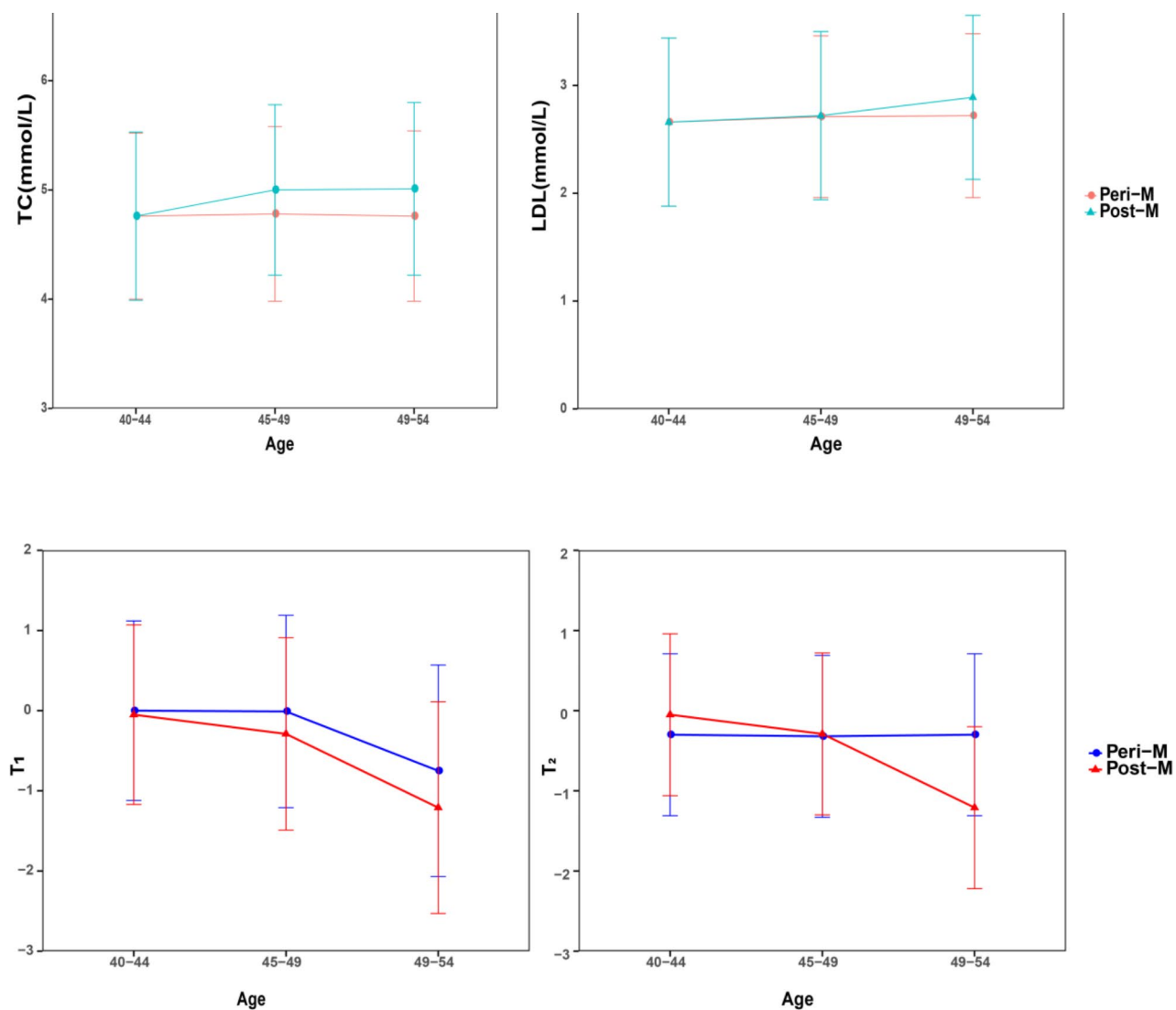
Fig. 2. Distribution of four indicators among perimenopausal and postmenopausal women at different ages. (**A**) TC. (**B**) LDL. (**C**) T_1. (**D**) T_2.

r	TC		LDL		T_1		T_2	
	Peri-M	Post-M	Peri-M	Post-M	Peri-M	Post-M	Peri-M	Post-M
E_2	0.0453	−0.0523	−0.0021	−0.0613	0.0461	0.1155	0.0364	0.1246
Age	0.5321	0.2103	0.0904	0.1876	−0.2045	−0.1798	−0.0312	−0.0405

Table 4. The differences of correlation in the E_2 and age with four indicators.

This study further analyzed the correlation between E_2 and age with the four indicators. The results showed that among perimenopausal and menopausal women, E2 and age were significantly related to the four indicators ($p < 0.001$) (Table S2). It was found that the correlation coefficient between age and the four indicators in perimenopausal and menopausal women were higher than the correlation coefficients between E_2 and the four indicators (Table 4). This result suggests that age plays a key role in the development of metabolic diseases in perimenopausal and postmenopausal women.

Discussion

This study analyzed the incidence of metabolic diseases (cardiovascular diseases and skeletal system diseases) in 1,151 perimenopausal and postmenopausal women at different ages. The study found that the risk of postmenopausal women was significantly higher than that of perimenopausal women. In addition, the estrogen

and bone density of perimenopausal and postmenopausal women showed a downward trend with age, while TC and LDL levels increased.

Cardiovascular disease

The incidence of cardiovascular disease is closely related to age[46]. The elasticity of human blood vessels decreases and the degree of arteriosclerosis increases with age growing, which leads to an increased risk of cardiovascular disease[47]. And some studies have found that the incidence of heart disease, high blood pressure and stroke is significantly higher in the elderly than in young people[48].

A woman's menstrual cycle also has an important impact on cardiovascular disease risk[49]. Estrogen plays a key role in female physiology and has a protective effect on the cardiovascular system[49]. Changes in estrogen levels during different phases of the menstrual cycle may affect lipid profiles, vascular function, and inflammatory responses. Estrogen levels drop significantly in perimenopausal and postmenopausal women, which results in a significantly increased risk of cardiovascular disease. The main risk factor for cardiovascular disease is dyslipidemia, which is mainly manifested by the increase in TC, TG and LDL levels, and the decrease in HDL levels. The results of this study indicate that TC and LDL levels increase significantly in postmenopausal women, and these levels may further increase with age. Studies have found that the decline in estrogen levels in women during perimenopause and postmenopause can lead to an increased risk of cardiovascular disease[50]. Especially in postmenopausal women, the incidence of myocardial infarction and coronary heart disease has increased significantly[51].

Estrogen is involved in many aspects of cardiovascular regulation, such as blood lipid regulation, vasodilation, antioxidant and anti-inflammatory effects[52]. Estrogen can reduce the risk of atherosclerosis by lowering total cholesterol and LDL levels and increasing HDL levels[53]. Moreover, estrogen can promote the function of vascular endothelial cells, enhance the elasticity and dilation capacity of blood vessels, and thus improve hemodynamics[54]. Estrogen levels drop significantly in perimenopausal and postmenopausal women. Women of childbearing age have higher estrogen levels during their menstrual cycle, which provides them with relatively good cardiovascular protection. Perimenopausal and postmenopausal women face a higher risk of cardiovascular disease, especially myocardial infarction and coronary heart disease[55]. This phenomenon indicates that estrogen deficiency is an important factor leading to the increased risk of cardiovascular disease in postmenopausal women[56]. Changes in estrogen levels can also affect endothelial function and inflammatory response. Studies have found that endothelial cell function in postmenopausal women decreases, which leads to increased levels of inflammation. A decrease in estrogen can lead to lipid metabolism disorders in the human body and aggravate dyslipidemia[57].

Skeletal system disease

Osteoporosis is a disease characterized by reduced bone density and microarchitectural destruction of bone tissue which leads to bone fragility and an increased risk of fractures[58]. Changes in bone density are closely related to age, and the disease is more common in older people, especially women[59]. The arrival of menopause has a significant impact on bone density. Estrogen plays an important role in maintaining bone density by inhibiting bone resorption and promoting bone formation to maintain bone health[60,61]. Women's bone density usually remains at a relatively high level before menopause. However, significant decreases in estrogen levels lead to accelerated bone resorption that can cause a rapid decrease in bone density in perimenopausal and postmenopausal women[62]. In this study, we found that the BMD of the lumbar spine and femoral neck in perimenopausal and postmenopausal women decreases with age, and the incidence of osteopenia and osteoporosis in postmenopausal women are higher than that in perimenopausal women. Studies have found that postmenopausal women's bone density decline by 10–20% in the first five years[63]. During this period, perimenopausal and postmenopausal women have a significantly increased risk of osteoporosis, especially fractures of the spine, hips, and wrists.

Decreased bone density is a common problem faced by postmenopausal women, especially in the lumbar spine and femoral neck[64]. The bone density of perimenopausal and postmenopausal women is significantly lower than that of younger women[65]. The main reason for this phenomenon is the significant decrease in estrogen levels after menopause which causes the skeletal system to lose its important protective role. Additionally, women in early menopause face a higher risk of osteoporosis and fractures than women of childbearing age[66]. Because women of childbearing age usually have relatively stable estrogen levels, their bone density remains at a high level. Studies have found that women of childbearing age generally have higher bone density and stronger bone repair capabilities[67]. Women of childbearing age have a significantly lower risk of fractures than postmenopausal women when facing the same external stress.

Conclusion

Perimenopausal and postmenopausal women have a significantly increased risk of metabolic diseases, especially cardiovascular disease and osteoporosis. And as age increases, the risk of disease continues to increase for these groups of women. This study found that the incidence of cardiovascular disease and osteoporosis in menopausal women is higher than that in perimenopausal women, and the incidence of osteoporosis is closely related to women's physiological stage. In addition, estrogen levels and bone mineral density were significantly lower in perimenopausal and postmenopausal women than in normal women, while TC and LDL levels were elevated. The study also found that there is a significant correlation between estrogen and TC, LDL and bone density. This study not only provides a scientific basis for understanding the health risks of perimenopausal and postmenopausal women, but also provides important guidance for clinical research and the formulation of public health policies.

Data availability

The raw data during the current study are available in supplementary material table S1.

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Author contributions

Xiaoyan Luo and Liangzhi Xu conceived and designed the research. Hong Mou analyzed the data and wrote the original draft. Jun Zhang and Yichuan Guo revised the manuscript. All authors have read and agreed to the published version of the manuscript.

Funding

Declarations

Competing interests

The authors declare no competing interests.

Institutional review board statement

Not applicable.

Informed consent

This study was approved by West China Second Medical College of Sichuan University.

Ethical statement

The study protocol was approved by the medical ethics committee of West China Second University Hospital, Sichuan University in accordance with ethical guidelines.

Additional information

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1038/s41598-025-86613-8.

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