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ORIGINAL ARTICLES

Comparison of metabolic risk factors, lipid indices, healthy eating index, and physical activity among premenopausal, menopausal, and postmenopausal women

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Abstract

Introduction: In this study, we aimed to compare metabolic risk factors, lipid indices, healthy eating index, and physical activity among premenopausal, menopausal, and postmenopausal women.

Methods: In this cross-sectional study, a total of 4,732 women participating in the Hoveyzeh Cohort Study were placed into three groups of premenopausal (n=736), menopausal (n=396), and postmenopausal (n=917) women, according to the inclusion and exclusion criteria.

Results: The prevalence of metabolic syndrome was 43.3%, 55.6%, and 62.8% in premenopausal, menopausal, and postmenopausal women, respectively. After menopause, the prevalence of hypertension (50.2%), dyslipidemia (61.2%), diabetes (37.7%), and abdominal obesity according to the Iranian guidelines (75.9%) was higher than before menopause. Based on the results, cardiovascular disease had the highest prevalence after menopause (23%). The weight-adjusted waist index (WWI) had the highest odds ratio (OR) among indices, with values of 2.94 and 1.93 in menopausal and postmenopausal women, respectively (P<0.001). According to the Healthy Eating Index-2015 (HEI-2015), the total consumption of fruits, vegetables, seafood, and protein was higher in premenopausal women than in postmenopausal women, and the consumption of foods containing sugar was higher in menopausal women than in premenopausal women. The results showed that the level of physical activity was the highest and the lowest in premenopausal and postmenopausal women, respectively (P<0.001).

Conclusion: Menopause leads to an increase in the prevalence of metabolic syndrome. The Atherogenic Index of Plasma (AIP), Triglyceride Glucose (TyG) index, WWI, and physical activity index increased in postmenopausal women compared to premenopausal women. The TyG index, WWI, and HEI-2015 did not show significant differences between the groups, based on the multiple regression analysis.

Keywords: Healthy Eating Index, Metabolic Syndrome, Menopausal, Postmenopausal, Premenopausal.

What is new? What is important?

- Metabolic syndrome has a high prevalence after menopause.
- Among the components of the metabolic syndrome, abdominal obesity (75.9%) and dyslipidemia (61.2%), respectively, had the highest prevalence compared to other components of this syndrome in all three groups: premenopausal, menopausal, and postmenopausal.
- Cardiovascular disease had the highest prevalence after menopause (23%).
- (WWI) had the highest odds ratio (OR) among indices, with values of 2.94 and 1.93 in menopausal and postmenopausal women respectively (P<0.001).
- Consumption of fruits, vegetables, seafood, and protein was higher in premenopausal women than in postmenopausal women.
- Consumption of foods containing sugar was higher in menopausal women than in premenopausal women.

INTRODUCTION

According to the National Cholesterol Education Program's Adult Treatment Panel III (NCEP ATP III) criteria, metabolic syndrome is defined as the presence of at least three of the following five conditions: abdominal obesity, with a waist circumference (WC) ≥88 cm in women or ≥102 cm in men; triglyceride (TG) level ≥ 150 mg/dL or use of TG-lowering drugs; high-density lipoprotein (HDL) <50 mg/dL in women and HDL<40 mg/dL in men; blood pressure ≥130/85 mmHg or use of medications to control blood pressure; and fasting plasma glucose (FPG) ≥100 or use of medications to treat high blood sugar [1]. It is known that metabolic syndrome increases the risk of cardiovascular disease and cancer as two leading causes of mortality among women [2]. According to various studies, the prevalence of this syndrome increases with age and menopause [3].

Menopause is defined as the absence of menstruation for 12 consecutive months. A woman's medical history is the most reliable method for determining her menopausal status [4,5]. After menopause, cardiovascular events become more common in women than in men due to an increase in the prevalence of metabolic syndrome during menopause [6]. While in several studies comparing premenopausal and postmenopausal women, no significant difference has been reported in the risk of coronary artery disease, in some studies, a decrease in the level of HDL and an increase in systolic blood pressure, cholesterol, and TG levels were associated with an increased risk of coronary artery disease after menopause [7].

Almost 75% of women over the age of 60 years are overweight, and the onset of menopause can lead to an increase in fat mass. This sharp increase in fat mass during menopause can be a risk factor for cardiovascular disease [7]. While some of the structural changes that occur in the body during menopause cannot be altered, behavior and lifestyle, particularly diet and physical activity, are among factors that can be modified during this period to reduce risk factors, such as weight gain and osteoporosis [8]. Studies have shown that it is preferable to consider the overall dietary pattern of individuals with metabolic syndrome rather than focusing on specific food compositions, as people's diets consist of various combinations of foods and nutrients [9–11].

The Healthy Eating Index-2015 (HEI-2015) is recognized as a new food index [12].

Studies have shown that adherence to the HEI-2015 can reduce the incidence of metabolic syndrome, cardiovascular disease, diabetes, and cancer [13]. In recent years, research has been conducted on new cardio metabolic and lipid indicators, including the Atherogenic Index of Plasma (AIP), Lipoprotein Combine Index (LCI), and Lipid Accumulation Product (LAP), to evaluate, screen, and predict cardiovascular disease and insulin resistance in individuals. These indicators reflect the balance between atherogenic and anti atherogenic factors.

Recently, AIP has been used as a powerful marker to predict the risk of cardiovascular disease [14,15]. Additionally, the Cardiometabolic Index (CMI) is an index of visceral fat distribution and a risk factor for cardiovascular disease, diabetes, high blood pressure, and left ventricular hypertrophy. This index includes the measurement of WC-to-height ratio, as well as the TG-to-HDL ratio [16]. Moreover, the Triglyceride Glucose (TyG) index and other related indices are new, low-cost markers with high sensitivity and specificity for detecting insulin resistance and confirming the presence of metabolic syndrome [17]. In studies investigating this index, it has been associated with atherosclerosis and cardiovascular disease [18].

In Iran, the prevalence of metabolic syndrome has been estimated at 69% among postmenopausal women. Evidence suggests that the prevalence of this syndrome is high and increasing during the transition from pre menopause to post menopause [19]. However, due to racial and genetic differences among different regions, which can affect the prevalence of metabolic syndrome and each of its components, as well as the cultural differences in nutrition and physical activity patterns among the people of this region, and the lack of similar studies among menopausal and postmenopausal women in the southwest of Iran, we conducted this study on a large sample size from the Hoveyzeh Cohort Study (HCS). In this study, the prevalence of metabolic syndrome and its components was compared among three groups of premenopausal, menopausal, and postmenopausal women. Additionally, nutritional indicators, lipid indices, and physical activity levels were examined and compared among the three groups.

MATERIAL AND METHODS

STUDY DESIGN

In this study, data from the first phase of the HCS were used to compare the prevalence of metabolic syndrome and its components, lipid indices, physical activity, and HEI-2015 among premenopausal, menopausal, and postmenopausal women.

STUDY SETTING AND PARTICIPANTS

In this cross-sectional study, a total of 4,732 outpatient women were examined in terms of their demographic characteristics and the prevalence of metabolic syndrome and its components. These components include central obesity, with a waist circumference (WC) ≥88 cm in women; triglyceride (TG) level ≥150 mg/dL or use of TG-lowering drugs; high-density lipoprotein (HDL) <50 mg/dL in women and HDL<40 mg/dL in men; blood pressure ≥130/85 mmHg or use of medications to control blood pressure; and fasting plasma glucose (FPG) ≥100 or use of medications to treat high blood sugar [1]. Also, the definition of regional obesity was defined based on Iranian studies as a WC>95 [19].

From the HCS population (May 2016 – Agust 2018), 2049 women aged 40–70 years [20], who met the inclusion criteria, were divided into three groups, based on the Persian cohort questionnaire. The participants were divided into three groups based on their menopausal status. The first group included 917 postmenopausal women, who had experienced menopause for at least three years. The second group included 396 menopausal women, who had experienced menopause for 1–3 years. The third group included 736 premenopausal women, aged 40–49 years, who still had their menstrual cycles. In these groups (premenopausal, menopausal, and postmenopausal), the prevalence of metabolic syndrome and its components was calculated, based on the ATP III criteria. Next, the results were compared between the three groups.

In order to evaluate the accuracy of information related to menopausal status, a questionnaire was used to collect information about the menstrual history, the time of menstruation cessation, and menstruation irregularities. The results were then matched according to age group, history of hysterectomy, hormone replacement therapy (HRT) ،taking the contraceptive pills, psychiatric diseases, eating disorders, and menopause at the age of <40 years. Women who were pregnant, breastfeeding, acute illness, unwilling to cooperate, or did not remember their age at menopause were excluded from the study. The protocol of this study was approved by the Ethics Committee of Ahvaz Jundishapur University of Medical Sciences and was in accordance with the Declaration of Helsinki guidelines (ethics code: IR.AJUMS.HGOLESTAN.REC.1400.100).

In this study, demographic information and other data related to literacy level, height (measured using a wall-mounted Seca 206 scale), weight (measured using a hand-held Seca 755 scale in a standing position), WC (measured according to the NIH definition), fasting blood sugar (FBS), and blood lipids were collected after 12 hours of fasting, based on the protocol defined in the Persian cohort. Systolic blood pressure and diastolic blood pressure were measured after 15 minutes of rest. Moreover, to evaluate and compare physical activity among the three groups, a physical activity questionnaire based on metabolic equivalent tasks (MET) was used for premenopausal, menopausal, and postmenopausal women separately.

Food intake and food groups were evaluated using the Food Frequency Questionnaire (FFQ) and scored as 'healthy' based on the HEI-2015. This index has 9 adequacy and 4 moderation components.

9 adequacy components including the following is: 1) total fruit (all types of fruit); 2) whole fruits (all types fruit except fruit juice); 3) total vegetables (all kinds of vegetables); 4) green vegetables and legumes (dark green leafy vegetables in addition to beans; for beans, the values were calculated on the condition that their consumption amount is from the standard amount of protein foods 5) whole grains; 6) dairy products; 7) foods protein, soy, beans 8) seafood and plant proteins 9) fatty acids. 4 moderate components consisting of 1) refined grains 2) sodium 3) added sugars 4) saturated fats. Also, the HEI score < 50 was considered as poor, 50 to 80 as needs improvement, and > 80 as good. The scoring method is shown in Table 5 [10–12].

Finally, the nutritional data were entered in Nutritionist IV software. In our study, the standard International Physical Activity Questionnaire (IPAQ) was used to examine physical activity. Additionally, lipid indices were calculated as follows [18,19,21]:

LAP: [WC–65] × [TG] in men, [WC–58] × [TG] in women

AIP: Log(TG/HDL-C)

LCI: TC×TG×LDL/HDL-C

CMI: TG/HDL × (Waist/height ratio)

TyG index: In[(FBS×TG)/2]

TyG-BMI: TyG index × BMI

TyG-WC: TyG index × WC

Weight-adjusted waist index (WWI): WC/$\sqrt{Weight}$

Table 1

Healthy Eating Index-2015 components, point values, and standards for scoring

Component	Maximum points	Standard for maximum score	Standard for minimum score of zero
Adequacy			
Total Fruits	5	≥0.8 c equivalents/1,000 kcal	No fruit
Whole Fruits	5	≥0.4 c equivalents/1,000 kcal	No whole fruit
Total Vegetables	5	≥1.1 c equivalents/1,000 kcal	No vegetables
Greens and Beans	5	≥0.2 c equivalents/1,000 kcal	No dark green vegetables or beans and peas
Whole Grains	10	≥1.5 oz equivalents/1,000 kcal	No whole grains
Dairy	10	≥1.3 c equivalents/1,000 kcal	No dairy
Total Protein Foods	5	≥2.5 oz equivalents/1,000 kcal	No protein foods
Seafood and Plant Proteins	5	≥0.8 c equivalents/1,000 kcal	No seafood or plant proteins
Fatty Acids	10	(PUFAs[a]+MUFAs[b])/SFAs[c] ≥2.5	(PUFAs+MUFAs)/SFAs ≤1.2
Moderation			
Refined Grains	10	≤1.8 oz equivalents/1,000 kcal	≥4.3 oz equivalents/1,000 kcal
Sodium	10	≤1.1 g/1,000 kcal	≥2.0 g/1,000 kcal
Added Sugars	10	≤6.5% of energy	≥26% of energy
Saturated Fats	10	≤8% of energy	≥16% of energy

[a]PUFAs: Polyunsaturated fatty acids
[b]MUFAs: Monounsaturated fatty acids
[c]SFAs: Saturated fatty acids

DATA ANALYSIS

All data were analyzed using IBM SPSS VERSION 24 (IBM SPSS statistics, Armonk, (USA). For data analysis, ANOVA test was used for quantitative variables, and Chi-square test was used for qualitative variables. Post-hoc LSD test was also used to compare variables between the three groups. Additionally, multiple regression analysis was used to conduct a detailed investigation and adjust for confounding factors.

RESULTS

A total of 4,732 women participated in this study. After considering the inclusion and exclusion criteria, the participants were divided into three groups based on the flowchart. Group 1 consisted of 736 premenopausal women, group 2 consisted of 396 postmenopausal women, and group 3 consisted of 917 postmenopausal women (Figure 1).

The mean age of women participating in this study was 53.97 (SD=7.36) years. Table 2 presents the mean and standard deviation (SD) of the participants' age. Based on the results, the mean height, weight, hip circumference, and WC were higher in premenopausal and menopausal women compared to postmenopausal women, and the difference was statistically significant. The mean WC of menopausal and postmenopausal women was higher than that of premenopausal women. Also, the mean WC of menopausal women was higher than that of postmenopausal women, and the difference was statistically significant (P<0.001). In this study, the prevalence of metabolic syndrome was 54.4%, as well as the prevalence of components of metabolic syndrome, including blood pressure 38.5%, dyslipidemia 59.2%, abdominal obesity 96.5%, and diabetes 30.1%. Moreover, the results showed that the average level of physical activity was significantly higher in premenopausal women compared to menopausal and postmenopausal women. Also, menopausal women had a higher average level of physical activity compared to postmenopausal women (P<0.001).

The prevalence of hypertension, diabetes, dyslipidemia (TG≥150 mg/dL, or HDL<50 mg/dL, or both), and metabolic syndrome was the highest in postmenopausal women and the lowest in premenopausal women, except for HDL<50 mg/dL, and the difference was statistically significant. The results indicated a significant difference in the prevalence of dyslipidemia between the three groups, with the highest average being observed in the

postmenopausal group (P<0.001). Moreover, the prevalence of hypertriglyceridemia was the highest in the postmenopausal group, and it increased significantly from pre menopause to post menopause (P=0.003).

The prevalence of abdominal obesity according to the Iranian guidelines was the highest in the menopausal group (78.5%), and the difference between the groups was statistically significant (P=0.044). The prevalence of metabolic syndrome was 43.3%, 55.6%, and 62.8% in premenopausal, menopausal, and postmenopausal women, respectively. Also, the prevalence of cardiovascular disease was the highest (23%) in the postmenopausal group and the lowest (16%) in the premenopausal group (P=0.001) (Table 2).

Table 3 presents the anthropometric and laboratory indices of the three groups. The mean values of FBS, TG, waist-to-height ratio (WHtR), and AIP index were significantly higher in the menopausal and postmenopausal groups compared to the premenopausal group. Also, the mean systolic blood pressure, WWI, and waist-to-hip ratio (WHR) were significantly higher after menopause than before menopause. Moreover, the TyG index was significantly higher in menopausal and postmenopausal women compared to premenopausal women (P<0.001).

In a comparison between the groups based on the HEI-2015 and its components, the results showed that the mean score of total fruit consumption was significantly higher in the premenopausal group compared to the menopausal and postmenopausal women (P=0.007). The average score of vegetable consumption in premenopausal and menopausal women was higher than that of postmenopausal women, and the difference was statistically significant (P=0.036). Additionally, the average score of added sugar was higher in menopausal and postmenopausal women compared to the premenopausal group, and the difference was statistically significant (P=0.002) (Table 4).

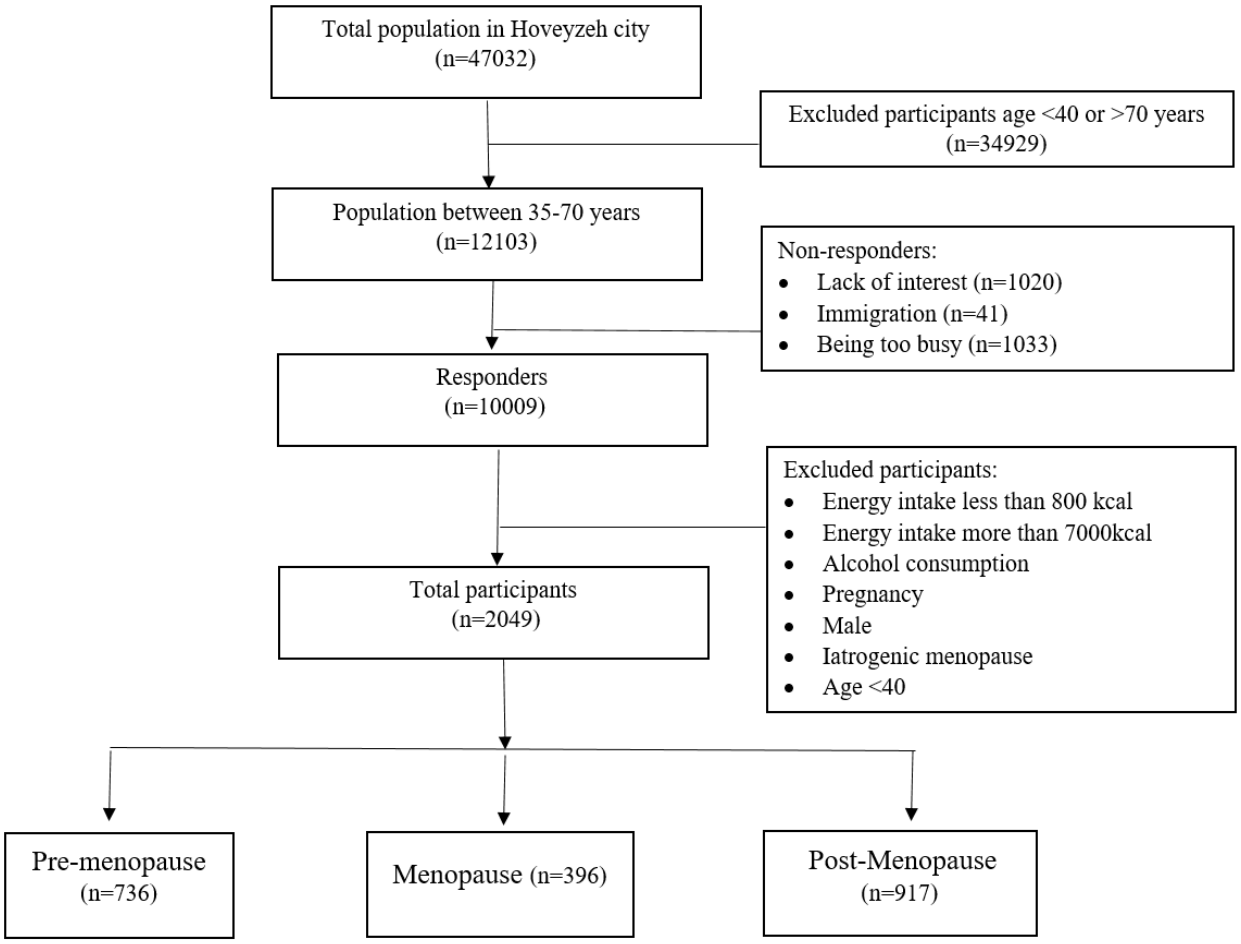


Fig. 1. Flow chart of participant selection.

Table 2

Baseline characteristics between menopause groups in a cross sectional study of Hoveyzeh Cohort Study

Variables	**Total (N=2049)**	**Pre-menopause (N=736)**	**Menopause (N=396)**	**Post-menopause (N=917)**	**P-value[a]**
Age (years)	53.97 ± 7.36	46.71 ± 1.36 [a, b]	53.31 ± 4.35 [c]	60.06 ± 5.64	<0.001
Marital status n (%)					
Single	65 (3.2)	41 (5.6)	12 (3.0)	12 (1.3)	<0.001
Married	1579 (77.1)	635 (86.3)	330 (83.3)	614 (67.0)	
Widow	353 (17.2)	39 (5.3)	45 (11.4)	269 (29.3)	
Divorced	52 (2.5)	21 (2.9)	9 (2.3)	22 (2.4)	
Education (years)	1.39 ± 2.70	2.28 ± 3.17 [a, b]	1.42 ± 2.81 [c]	0.66 ± 1.91	<0.001
Body mass index	29.53 ± 5.59	30.18 ± 5.68 [b]	30.05 ± 5.80 [c]	28.78 ± 5.35	<0.001
Waist circumference (cm)	102.40 ± 12.23	101.22 ± 12.19 [a, b]	104.17 ± 12.26 [c]	102.58 ± 12.17	<0.001
Hip circumference (cm)	105.54 ± 10.52	107.34 ± 10.50 [b]	106.60 ± 10.58 [c]	103.63 ± 10.24	<0.001
Wrist circumference (cm)	17.15 ± 1.35	17.29 ± 1.41 [b]	17.19 ± 1.26 [c]	17.01 ± 1.33	<0.001
Physical activity (MET)	35.84 ± 4.18	37.26 ± 3.92 [a, b]	36.00 ± 3.91 [c]	34.63 ± 4.12	<0.001
History use Contraceptive Drug, n (%)	1215 (59.3)	538 (73.1)	255 (64.4)	422 (46.0)	<0.001
Hypertension, n (%)	788 (38.5)	183 (24.9)	145 (36.6)	460 (50.2)	<0.001
Diabetes, n (%)	617 (30.1)	150 (20.4)	121 (30.6)	346 (37.7)	<0.001
Metabolic syndrome, n (%)	1115 (54.4)	319 (43.3)	220 (55.6)	576 (62.8)	<0.001
Dyslipidemia, n (%)	1213 (59.2)	417 (56.7)	235 (59.3)	561 (61.2)	<0.001
TG≥150 mg/dl	858 (41.9)	272 (37.0)	174 (43.9)	412 (44.9)	0.003
HDL≤ 50 mg/dl	799 (39.0)	289 (39.3)	152 (38.4)	358 (39.0)	0.958
Prediabetes, n (%)	470 (23.0)	173 (23.5)	98 (24.7)	199 (21.7)	0.677
Central obesity, n (%)	1977 (96.5)	704 (95.6)	387 (97.7)	886 (96.6)	0.187
Regional central obesity, n (%)	1538 (75.1)	531 (72.1)	311 (78.5)	696 (75.9)	0.044

Data are means ± SD for quantitative variables and frequency (percent) for qualitative variables
[a] ANOVA for quantitative variables, chi-square for qualitative variables.

Table 3

Biochemical and anthropometric measures between menopause groups in a cross sectional study of Hoveyzeh Cohort Study

Variables	**Total (N=2049)**	**Pre-menopause (N=736)**	**Menopause (N=396)**	**Post-menopause (N=917)**	**P-value[a]**
Fasting blood sugar (mg/dl)	119.53 ± 54.27	109.01 ± 42.52 [a, b]	123.36 ± 57.19	126.31 ± 59.83	<0.001
Triglycerides (mg/dl)	155.81 ± 97.44	148.01 ± 82.25 [a, b]	160.27 ± 84.66	160.12 ± 112.39	0.025
Cholesterol (mg/dl)	197.13 ± 43.17	188.99 ± 39.91 [a, b]	200.80 ± 41.53	202.07 ± 45.41	<0.001
High-density lipoprotein (mg/dl)	53.69 ± 12.10	53.42 ± 12.37	53.68 ± 11.18	53.91 ± 12.26	0.720
Low-density lipoprotein (mg/dl)	112.49 ± 35.81	106.16 ± 32.82 [a, b]	115.05 ± 34.78	116.45 ± 37.83	<0.001
Systolic blood pressure	113.59 ± 19.81	109.21 ± 18.26 [a, b]	112.16 ± 19.12 [c]	117.72 ± 20.47	<0.001
Diastolic blood pressure	70.85 ± 11.28	70.10 ± 10.67 [b]	70.80 ± 11.22	71.48 ± 11.74	0.047
Heart rate	79.64 ± 9.53	79.47 ± 8.85	79.74 ± 9.80	79.74 ± 9.93	0.824

Table 3 (continued)

Variables	Total (N=2049)	Pre-menopause (N=736)	Menopause (N=396)	Post-menopause (N=917)	P-value[a]
Waist-To-Hip Ratio	0.97 ± 0.07	0.94 ± 0.06 [a, b]	0.98 ± 0.06 [c]	0.99 ± 0.06	<0.001
Waist-To-Height Ratio	0.65 ± 0.08	0.64 ± 0.07 [a, b]	0.66 ± 0.08	0.65 ± 0.06 [f]	<0.001
Weight adjusted waist Index	11.95 ± 0.66	11.61 ± 0.60 [a, b]	12.00 ± 0.61 [c]	12.19 ± 0.61	<0.001
Cardiometabolic index	2.07 ± 1.50	1.97 ± 1.53	2.14 ± 151	2.11 ± 1.46	0.099
Atherogenic index of plasma	0.06 ± 0.25	0.04 ± 0.26 [a, b]	0.08 ± 0.25	0.07 ± 0.25	0.016
TyG Index	8.95 ± 0.65	8.82 ± 0.63 [a, b]	9.02 ± 0.64	9.03 ± 0.65	<0.001
TyG-BMI	264.84 ± 55.28	267.06 ± 56.40 [b]	271.16 ± 55.85 [c]	260.35 ± 53.81	0.002
TyG-WC	918.47 ± 137.82	136.99 ± 5.05 [a, b]	134.87 ± 6.78	137.24 ± 3.04	<0.001
Lipid accumulation product	74.98 ± 50.74	75.83 ± 49.40	75.84 ± 52.57	73.92 ± 51.04	0.70
The lipoprotein combine index	20.08 ± 19.03	20.66 ± 18.77	20.48 ± 19.75	19.43 ± 18.93	0.385

Data are means ± SD for quantitative variables and frequency (percent) for qualitative variables
[a] ANOVA for quantitative variables, chi-square for qualitative variables.
[a] Significant difference between pre-menopause compared to menopause.
[b] Significant difference between pre-menopause compared to post-menopause.
[c] Significant difference between menopause compared to post-menopause.

Table 4

A Comparison between menopause groups based on scores of HEI-2015 and its components

Variables	Total (N=7464)	Pre-menopause (N=736)	Menopause (N=396)	Post-menopause (N=917)	P-Value[*]
Adequacy components					
Total fruits (5)	4.43 ± 1.05	4.52 ± 0.96 [a,b]	4.33 ± 1.14	4.40 ± 1.08	0.007
Whole fruits (5)	4.86 ± 1.60	4.89 ± 1.50	4.83 ± 1.66	4.84 ± 1.64	0.161
Total vegetables (5)	4.82 ± 1.51	4.85 ± 1.44 [b]	4.86 ± 1.44 [c]	4.79 ± 1.58	0.036
Greens and beans (5)	4.75 ± 0.74	4.77 ± 0.67	4.76 ± 0.75	4.73 ± 0.79	0.453
Whole grains (10)	0.55 ± 1.68	0.54 ± 1.60	0.62 ± 1.84	0.53 ± 1.67	0.671
Dairy (10)	3.87 ± 2.42	3.74 ± 2.36	3.87 ± 2.41	3.98 ± 2.46	0.126
Total protein foods (5)	2.97 ± 1.13	2.97 ± 1.09	3.00 ± 1.13	2.95 ± 1.16	0.785
Seafood and plant proteins (5)	3.08 ± 1.38	3.20 ± 1.32 [b]	3.17 ± 1.37 [c]	2.94 ± 1.42	<0.001
Fatty acids (10)	3.55 ± 3.51	3.72 ± 3.53	3.43 ± 3.34	3.47 ± 3.55	0.244
Moderation components					-
Refined grains (10)	0.37 ± 1.73	0.37 ± 1.73	0.44 ± 1.89	0.34 ± 1.66	0.641
Sodium (10)	1.44 ± 2.18	1.56 ± 2.34	1.23 ± 1.98	1.43 ± 2.12	0.052
Added sugars (10)	3.74 ± 2.64	3.47 ± 2.50 [a, b]	3.99 ± 2.67	3.85 ± 2.72	0.002
Saturated fats (10)	9.23 ± 1.81	9.18 ± 1.87	9.35 ± 1.65	9.21 ± 1.82	0.322
Total score3	47.66 ± 6.37	47.79 ± 6.27	47.85 ± 6.18	47.47 ± 6.53	0.464

Data are means ± SD for quantitative variables
[*] ANOVA for quantitative variables
[a] Significant difference between pre-menopause compared to menopause.
[b] Significant difference between pre-menopause compared to post-menopause.
[c] Significant difference between menopause compared to post-menopause.

A multivariable logistic regression analysis was conducted to investigate anthropometric and lipid indices. Two models were investigated, with the premenopausal group serving as a control for comparison. The comparison was conducted between the menopausal and postmenopausal groups, and the results were as follows. The mean WHR significantly increased in both menopausal and premenopausal groups. In one odds ratio (OR) model, the mean WHtR showed a significant risk increase in the two groups. However, after adjusting for the variables, there was only a significant increase in the menopausal group, not the postmenopausal group. After adjusting for variables, such as age, education, and physical activity, the mean values of CMI, AIP, LCI, BMI, LAP, and HEI were not significantly different in terms of OR between the menopausal and postmenopausal groups in model 1. In models 1 and 2, the WWI index significantly increased in both groups, with the highest OR among metabolic indices in the menopausal (OR:1.93; 95% CI:1.40 to 2.66; P<0.001) and postmenopausal (OR:2.26; 95% CI::2.37 to 3.65; P<0.001) groups, respectively) (Table 5).

Table 5

Multivariable logistic regression analysis on cardiometabolic and anthropometric indices between menopause groups

Variables	**Pre-menopause**	**Menopause**			**Post-menopause**		
		OR	**(95%CI)**	**P-V**	**OR**	**(95%CI)**	**P-V**
Waist-To-Hip Ratio							
Model 1	Reference	1.08	(1.06-1.11)	<0.001	1.12	(1.10-1.14)	<0.001
Model 2		1.06	(1.03-1.10)	<0.001	1.06	(1.03-1.10)	<0.001
Waist-To-Height Ratio							
Model 1	Reference	1.03	(1.02-1.05)	<0.001	1.03	(1.01-1.04)	<0.001
Model 2		1.04	(1.01-1.07)	0.010	1.03	(0.99-1.06)	0.098
Body mass index							
Model 1	Reference	1.00	(0.97-1.02)	0.706	0.95	(0.94-0.97)	<0.001
Model 2		1.01	(0.96-1.06)	0.670	0.97	(0.92-1.02)	0.260
Weight-adjusted Waist Index							
Model 1	Reference	2.94	(2.37-3.65)	<0.001	4.91	(4.06-5.94)	<0.001
Model 2		1.93	(1.40-2.66)	<0.0001	2.26	(1.57-3.26)	<0.001
Cardiometabolic index							
Model 1	Reference	1.08	(0.99-1.17)	0.07	1.07	(1.00-1.14)	0.06
Model 2		1.10	(0.97-1.26)	0.140	1.07	(0.92-1.25)	0.345
Atherogenic index of plasma							
Model 1	Reference	1.77	(1.09-2.88)	0.021	1.66	(1.12-2.44)	0.011
Model 2		1.88	(0.89-3.98)	0.099	1.57	(0.66-3.70)	0.306
TyG Index							
Model 1	Reference	1.63	(1.34-1.98)	<0.001	1.68	(1.43-1.97)	<0.001
Model 2		1.37	(1.02-1.85)	0.040	1.24	(0.88-1.74)	0.217
TyG-BMI							
Model 1	Reference	1.00	(1.00-1.01)	0.236	1.00	(1.00-1.00)	0.014
Model 2		1.00	(1.00-1.01)	0.227	1.00	(1.00-1.01)	0.616
TyG-WC							
Model 1	Reference	1.00	(1.00-1.00)	<0.001	1.00	(1.00-1.00)	<0.001
Model 2		1.00	(1.00-1.00)	0.002	1.00	(1.00-1.00)	0.142
Lipid accumulation product							
Model 1	Reference	1.00	(1.00-1.00)	0.996	1.00	(1.00-1.00)	0.447
Model 2		1.00	(0.99-1.00)	0.440	1.00	(0.99-1.00)	0.224
The lipoprotein combine index							
Model 1	Reference	1.00	(0.99-1.01)	0.885	1.00	(0.99-1.00)	0.191
Model 2		1.00	(0.99-1.00)	0.815	1.00	(0.99-1.00)	0.634
Health eating index-2015							
Model 1	Reference	1.00	(0.98-1.02)	0.871	0.99	(0.98-1.02)	0.302
Model 2		1.00	(0.97-1.03)	0.911	0.99	(0.96-1.02)	0.533

Model 1: unadjusted

Model 2: Adjusted for age, wrist circumference, physical activity, education years

DISCUSSION

In this study, we found that the prevalence of diabetes, hypertriglyceridemia, systolic blood pressure, abdominal obesity (according to Iranian guidelines), and cardiovascular disease was higher in menopausal and postmenopausal women compared to premenopausal women. According to the Tehran Lipid Study, the incidence of metabolic syndrome and its components increases during the postmenopausal period; in other words, it increases from premenopause to menopause and from menopause to postmenopause [19]. During menopause, changes in hormone secretion can lead to visceral fat accumulation in the abdomen, resulting in abdominal obesity and insulin resistance [20,21]. Studies have shown that the risk of these metabolic indicators increases during menopause.

In a study by Matti *et al.*, although physical activity could change the lipid profile of middle-aged women, it did not change or increase many metabolic indicators during menopause due to progressive changes in metabolic health that occur in this period in middle-aged women. These results suggest that physical activity at a younger age may be more effective in preventing the development of metabolic syndrome than physical activity after menopause, because the person's ability to perform effective physical activity is reduced. In this regard, a study examining anthropometric indices in China found that in women without overweight or obesity, WHR is an important factor in predicting and diagnosing metabolic syndrome. In our study, based on the HEI-2015 results, menopausal women consumed more sugar-containing foods than premenopausal women, and total fruit, vegetable, fish, and protein consumption was higher in premenopausal women than in postmenopausal women.

The HEI-2015 score is calculated out of 100 and it classifies people into three groups based on its numbers. In the first group, a score of less than 51 indicates unhealthy nutrition, a score of 51–80 indicates that nutrition needs to be improved, and a score above 80 indicates healthy and appropriate nutrition. In this study, the score in all three groups for this index was below 51, which indicates The feeder is weak and you should pay great attention to its correction. According to the abovementioned results, restricting the consumption of drinks and foods containing sugar, increasing the consumption of fish, plant proteins, and vegetables, and reducing the consumption of fruit juice in the diet of menopausal and postmenopausal women can lead to a healthy diet. In the present study, the relationship between the total HEI-2015 score and the components of metabolic syndrome was investigated in menopausal and postmenopausal women, and the results indicated a weak positive relationship between the total HEI-2015 score and HDL levels and a weak negative relationship between the total HEI-2015 score and WC. The present results revealed that the HEI-2015 score had the highest correlation with WC. In women with metabolic syndrome, the lowest scores were attributed to the consumption of dairy products, whole grains, seafood, protein substances, fatty acids, and saturated fat, while the highest scores were attributed to the total consumption of fruits, sodium, and vegetables. To reduce metabolic syndrome and insulin resistance, lifestyle changes are recommended. These changes include a healthy diet, regular physical activity, weight control, and management of blood pressure and lipids.

The researchers of the International Lipid Panel stated that the consumption of animal protein from red meat and processed materials increases the risk of heart disease, and the consumption of animal protein such as poultry and fish, dairy products, as well as animal protein from sources such as soy, nuts, reduces the risk of heart disease [21].

In Azemati *et al.*'s study, they suggested that including vegetable protein as a part of total protein in the diet has a beneficial effect on cardiometabolic factors such as waist circumference and fasting glucose level, and vegetable protein can have a protective effect in preventing overweight and obesity [22].

Studies have stated that increasing dietary fiber, especially the soluble fraction, reduces postprandial sugar and reduces cholesterol in patients with metabolic syndrome [23]. In a study conducted by Lambrinoudaki *et al.* at Athens Hospital, the TyG index was associated with arterial wall stiffness and atherosclerosis in thin postmenopausal women. However, in obese and overweight women, metabolic syndrome was a valuable marker for subclinical prediction of atherosclerosis; therefore, this index may be used as an appropriate marker of atherosclerosis in women with a normal weight [24]. In previous studies, this index showed a higher risk of diabetes in young people compared to older people.

It also served as an index for non-obese and non-overweight individuals. Overall, it appears to be more useful for predicting the risk of diabetes [25]. In our study, this index was significantly lower in the premenopausal group compared to the menopausal and postmenopausal groups, and it could indicate an increase in insulin resistance in the menopausal group compared to the premenopausal group.

In another study conducted by Jinsook Lim *et al.* in Korea, the TyG index was preferable to other tests for examining insulin resistance [26]. Jin study suggested that the TyG index could be used as a substitute method for evaluating insulin resistance in clinical conditions [27]. In our study, the AIP index was significantly higher in the menopausal and postmenopausal groups compared to the premenopausal group. Moreover, in a study by Qianyun *et al.*, AIP was introduced as a powerful and independent index to predict the risk of heart disease in Chinese postmenopausal women, and it could be superior to conventional lipid indices [28].

In our study, unlike other Iranian studies, new cardiometabolic and lipid indices were used, and the results were analyzed. Generally, these indicators are quick, convenient, and inexpensive to use for calculating the heart risk and insulin resistance. Unlike previous complex methods, simple measures, such as weight loss, exercise, diet, and control of blood pressure, lipids, and blood sugar, make it possible to identify high-risk individuals to help prevent cardiovascular disease.

In this study, the highest OR for increasing the risk of cardiometabolic indicators was related to the WWI index in menopausal and postmenopausal women. This index may be a better indicator of metabolic syndrome in menopausal women compared to other traditional lipid indices. According to a 10-year follow-up study, this index can indicate the 10-year mortality rate from all causes [29]. In this study, the comparison of cardiometabolic indices showed that the mean values of WHR, WHtR, WWI, AIP, and TyG were higher in menopausal women compared to the premenopausal group.

LIMITATIONS AND SUGGESTIONS

One of the strengths of this study, compared to other studies, is that it simultaneously investigated and compared the amount of physical activity, HEI, and new cardiometabolic indices between the three groups. Another strength of this study is that it included a large number of sample groups and comparisons. Also, this study was conducted in the southwest of Iran, where the majority of the population is Arab and has a lifestyle that includes physical activity and a diet that is different from Persians. Overall, by using simple and inexpensive measures that are available in all regions, we can reduce the risk of cardiovascular disease and its risk factors. Another strength of this study is the use of IPAQ to assess physical activity, as well as FFQ to evaluate the participants' diets. Also, in this study, new cardiometabolic indicators were evaluated, and comparisons were made with traditional cardiovascular indicators. Finally, this study investigated metabolic syndrome and its components, physical activity levels, dietary habits (based on established indicators), and cardiometabolic indicators simultaneously.

On the other hand, a limitation of this study is the restricted age range of the participants, who were 40 to 70 years old. Additionally, the cross-sectional design of the study may not accurately demonstrate cause-and-effect relationships, and the influence of confounding factors on the results cannot be ruled out. Therefore, further case-control or cohort studies are recommended.

CONCLUSION

In this study, the prevalence of metabolic syndrome and its components, including high blood pressure, diabetes, TG levels >150 mg/dL, and abdominal obesity as defined by Iranian guidelines, increased during menopause compared to the premenopausal period. The prevalence of cardiovascular disease also increased during menopause. However, there was no significant reduction in HDL levels associated with menopause. After adjusting for other risk factors, postmenopausal women were found to have higher mean values of cardiometabolic indices, WHR, TyG index, and WHtR compared to premenopausal women; however, their mean BMI was lower. Among the metabolic indices associated with menopause, the WWI index showed the highest increase in menopausal women compared to premenopausal women, with an OR of 2.94.

Introducere: În acest studiu, ne-am propus să comparăm factorii de risc metabolic, indicii lipidici, indicele alimentației sănătoase și activitatea fizică în rândul femeilor aflate în premenopauză, menopauză și postmenopauză.

Metode: În acest studiu transversal, un total de 4.732 de femei care au participat la Hoveyzeh Cohort Study au fost plasate în trei grupuri de femei: premenopauză (n=736), menopauză (n=396) și postmenopauză (n=917), conform criteriilor de includere și excludere.

Rezultate: Prevalența sindromului metabolic a fost de 43,3%, 55,6% și 62,8% la femeile aflate în premenopauză, menopauză și, respectiv, postmenopauză. După menopauză, prevalența hipertensiunii (50,2%), a dislipidemiei (61,2%), a diabetului (37,7%) și a obezității abdominale conform ghidurilor iraniene (75,9%) a fost mai mare decât înainte de menopauză. Pe baza rezultatelor, bolile cardiovasculare au avut cea mai mare prevalență după menopauză (23%). Indicele taliei ajustat în funcție de greutate (WWI) a avut cea mai mare mărime a efectului (OR), cu valori de 2,94 și 1,93 la femeile aflate la menopauză și, respectiv, în postmenopauză (P<0,001). Conform Healthy Eating Index-2015 (HEI-2015), consumul total de fructe, legume, fructe de mare și proteine a fost mai mare la femeile aflate în premenopauză decât la femeile aflate în postmenopauză, iar consumul de alimente care conțin zahăr a fost mai mare la femeile aflate la menopauză decât la femeile aflate în premenopauză. Rezultatele au arătat că nivelul de activitate fizică a fost cel mai ridicat și cel mai scăzut la femeile aflate în premenopauză și, respectiv, în postmenopauză (P<0,001).

Concluzie: Menopauza duce la o creștere a prevalenței sindromului metabolic. Indicele aterogenic al plasmei (AIP), indicele trigliceridelor glucozei (TyG), WWI și indicele de activitate fizică au crescut la femeile aflate în postmenopauză în comparație cu femeile aflate în premenopauză. Indicele TyG, WWI și HEI-2015 nu au arătat diferențe semnificative între grupuri, pe baza analizei de regresie.

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Acknowledgements: The reported findings are extracted from a fellowship thesis presented by Maryam Sharifzadeh (D-0007). This study was supported by the Vice Chancellor for Research Affairs of Ahvaz Jundishapur University of Medical Sciences.

Declaration of interest: The authors declare no conflict of interest.

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Received 16th September 2023