

Prevalence of Metabolic Syndrome in Postmenopausal Women with Non-Alcoholic Fatty Liver Disease

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ABSTRACT

Background: Menopause is accompanied by changes in body-fat distribution, insulin sensitivity and lipid metabolism that may increase susceptibility to metabolic syndrome and hepatic steatosis. **Aim:** To assess metabolic syndrome parameters and their relationship with ultrasonographic hepatic steatosis in postmenopausal women. **Methods:** This hospital-based observational study included 50 postmenopausal women evaluated in the Postgraduate Department of Physiology and Department of Gastroenterology, Government Medical College, Jammu, over one year. Anthropometry, blood pressure, fasting glucose and lipid profile were recorded. Metabolic syndrome was defined using the NCEP ATP III criteria: at least three of the following: waist circumference ≥ 88 cm, triglycerides >150 mg/dL, HDL cholesterol <50 mg/dL, blood pressure $\geq 130/85$ mmHg or antihypertensive treatment, and fasting blood glucose ≥ 110 mg/dL. Hepatic steatosis was graded by ultrasonography from grade 0 to grade 3. **Results:** Twenty-six of 50 women (52.0%) met the criteria for metabolic syndrome. Compared with women without metabolic syndrome, those with metabolic syndrome had higher weight (74.00 ± 5.43 vs 61.96 ± 4.48 kg; $P < 0.001$), BMI (29.42 ± 1.76 vs 25.09 ± 1.13 kg/m²; $P < 0.001$), waist circumference (97.42 ± 3.30 vs 89.88 ± 4.73 cm; $P < 0.001$), hip circumference (100.85 ± 3.35 vs 92.75 ± 5.34 cm; $P < 0.001$), diastolic blood pressure (84.23 ± 7.26 vs 79.17 ± 6.28 mmHg; $P = 0.012$), total cholesterol (167.46 ± 17.80 vs 149.46 ± 22.35 mg/dL; $P = 0.003$), triglycerides (213.19 ± 45.77 vs 134.08 ± 20.24 mg/dL; $P < 0.001$) and fasting glucose (130.08 ± 24.41 vs 108.29 ± 17.97 mg/dL; $P = 0.001$), while HDL cholesterol was lower (39.08 ± 5.86 vs 52.13 ± 3.96 mg/dL; $P < 0.001$). Ultrasonography showed grade 0 in 41 (82.0%), grade 1 in 2 (4.0%), grade 2 in 5 (10.0%) and grade 3 in 2 (4.0%) women. All nine women with grade 1–3 steatosis belonged to the metabolic syndrome group. **Conclusion:** Metabolic syndrome was common in this postmenopausal sample and was characterized principally by greater adiposity, hypertriglyceridemia, low HDL cholesterol and higher fasting glucose. Ultrasonographically detectable hepatic steatosis occurred only among women with metabolic syndrome, supporting a close relationship between metabolic abnormalities and fatty liver in postmenopausal women.

Keywords: postmenopause; metabolic syndrome; hepatic steatosis; NAFLD; obesity; dyslipidemia

INTRODUCTION

Metabolic syndrome describes the clustering of central obesity, dyslipidemia, elevated blood pressure and impaired glucose regulation. These abnormalities share insulin resistance and adipose-tissue dysfunction as important biological links and substantially increase cardiometabolic risk. Nonalcoholic fatty liver disease

(NAFLD) is closely connected with the same metabolic disturbances and has often been regarded as the hepatic expression of metabolic syndrome.^{1,2} Women are relatively protected from several metabolic complications during the reproductive years, but this pattern changes after menopause. Falling estrogen concentrations are accompanied by redistribution of

adipose tissue toward the abdomen, reduced insulin sensitivity and adverse changes in lipids. These shifts are biologically relevant to hepatic fat accumulation and may partly explain why the burden of NAFLD rises after menopause.^{3,4}

Population studies have consistently reported a greater burden of metabolic syndrome among postmenopausal women. In an Indian study of 498 urban women, the prevalence of metabolic syndrome was higher after menopause, although age explained part of the association.⁵ Similar patterns have been reported in other populations using different diagnostic definitions.⁶ With respect to fatty liver, Gutierrez-Grobo and colleagues observed NAFLD in 57.9% of postmenopausal women compared with 32.2% of premenopausal women, while Hamaguchi et al. reported a prevalence of 15% in postmenopausal women in a Japanese cohort.^{7,8} The coexistence of metabolic syndrome and hepatic steatosis is especially important because abdominal obesity, dyslipidemia, glucose intolerance and hypertension may act together to increase hepatic and cardiovascular risk. Studies in postmenopausal women have found strong relationships of NAFLD with waist circumference, body mass index, insulin resistance and metabolic syndrome.^{9,10} However, data from the Jammu region are limited. The present study therefore assessed metabolic syndrome parameters in postmenopausal women and examined the distribution of ultrasonographic hepatic steatosis according to metabolic syndrome status.

MATERIALS AND METHODS

The present hospital-based observational case control study was conducted in the Postgraduate Department of Physiology and the Department of Gastroenterology, Government Medical College, Jammu. Data were collected over a period of one year.

Participants and Ethical Considerations

A total of 50 postmenopausal women were included. Postmenopausal women were diagnosed with NAFLD on the basis of hepatic steatosis on imaging or histology with absence of significant alcohol consumption, absence of competing causes of hepatic steatosis and absence of coexisting chronic liver disease. Exclusion criteria were age below 18 years, pregnancy, menstrual disorders such as polymenorrhea or menorrhagia, chronic infection, hormone-replacement therapy and refusal to consent.

The study was initiated after approval from the Institutional Ethics Committee, Government Medical College, Jammu, bearing No. IEC/ GMC/ 2022/867, dated: 10/2/2022 and written informed consent was obtained from participants

Anthropometric and blood-pressure Sssessment

Age and time since menopause were recorded in years. Height and weight were measured using standard procedures, and body mass index (BMI) was calculated as weight in kilograms divided by height in metres squared. Waist circumference was measured using a non-stretchable tape. Hip circumference and waist-to-hip ratio were also recorded. Blood pressure was measured three times and the mean value was used for analysis.

Biochemical Investigations

Fasting blood glucose was measured by the hexokinase method. Total cholesterol, triglycerides and HDL cholesterol were measured in the Department of Biochemistry using the ARCHITECT C4000 autoanalyser. LDL cholesterol was derived indirectly by using Friedewald Equation:-

$$\text{LDL Cholesterol} = \text{Total Cholesterol} - \{ \text{Triglycerides} / 5 \} + \text{HDL Cholesterol}$$

Definition of Metabolic Syndrome

Metabolic syndrome was defined according to the NCEP ATP III criteria. A participant was classified as having metabolic syndrome when at least three of the following five features were present: fasting blood glucose ≥ 110 mg/dL; systolic blood pressure ≥ 130 mmHg and/or diastolic blood pressure ≥ 85 mmHg or treatment for hypertension; triglycerides > 150 mg/dL; HDL cholesterol < 50 mg/dL in women; and waist circumference ≥ 88 cm.

Ultrasonographic Assessment

Ultrasonography was performed in the Department of Radiodiagnosis, Government Medical College, Jammu. Fatty liver was diagnosed when hepatic echogenicity exceeded that of the renal cortex and spleen, with attenuation of the ultrasound beam and loss of definition of intrahepatic architecture. Steatosis was graded as: grade 0, normal liver echogenicity and absence of steatosis; grade 1, mild steatosis with echogenicity greater than the right renal cortex but preserved portal-vein wall definition; grade 2, moderate steatosis with impaired visualization of the main portal-vein wall; and grade 3, severe steatosis with impaired visualization of the posterior hepatic parenchyma or diaphragm.

Statistical Analysis

Data were compiled in Microsoft Excel and analyzed using appropriate statistical tools. Continuous variables were presented as mean $\pm$ standard deviation and categorical variables as number and percentage. Comparisons between metabolic syndrome groups used the independent t test after it fulfilled the relevant assumptions. A P value < 0.05 was considered statistically significant.

RESULTS

Among the 50 women, 27 (54.0%) were aged 50–60 years, 16 (32.0%) were younger than 50 years and 7 (14.0%) were older than 60 years. Time since menopause was 5–10 years in 23 (46.0%) participants, more than 10 years in 14 (28.0%) and less than 5 years

in 13 (26.0%). Twenty-six women (52.0%) met the criteria for metabolic syndrome and 24 (48.0%) did not. Among women with metabolic syndrome, 5 had been menopausal for <5 years, 13 for 5–10 years and 8 for >10 years.

Table 1. Demographic and anthropometric characteristics according to metabolic syndrome status

Variable	Metabolic syndrome (n=26)	No metabolic syndrome (n=24)	P value
Age (years)	53.69 ± 5.05	52.29 ± 5.68	0.360
Time since menopause (years)	9.15 ± 4.55	7.88 ± 5.22	0.359
Weight (kg)	74.00 ± 5.43	61.96 ± 4.48	<0.001
Height (cm)	158.62 ± 5.29	157.08 ± 4.83	0.291
BMI (kg/m ²)	29.42 ± 1.76	25.09 ± 1.13	<0.001
Waist circumference (cm)	97.42 ± 3.30	89.88 ± 4.73	<0.001
Hip circumference (cm)	100.85 ± 3.35	92.75 ± 5.34	<0.001
Waist-to-hip ratio	0.966 ± 0.014	0.969 ± 0.020	0.496

Women with metabolic syndrome had significantly greater weight, BMI, waist circumference and hip circumference than those without metabolic syndrome. Age, time since menopause, height and waist-to-hip ratio did not differ significantly between groups.

Table 2. Blood pressure and biochemical profile according to metabolic syndrome status

Variable	Metabolic syndrome (n=26)	No metabolic syndrome (n=24)	P value
Systolic BP (mmHg)	125.92 ± 9.07	121.88 ± 7.40	0.092
Diastolic BP (mmHg)	84.23 ± 7.26	79.17 ± 6.28	0.012
Total cholesterol (mg/dL)	167.46 ± 17.80	149.46 ± 22.35	0.003
Triglycerides (mg/dL)	213.19 ± 45.77	134.08 ± 20.24	<0.001
HDL cholesterol (mg/dL)	39.08 ± 5.86	52.13 ± 3.96	<0.001
LDL cholesterol (mg/dL)	163.85 ± 13.92	174.75 ± 21.57	0.037
Fasting blood glucose (mg/dL)	130.08 ± 24.41	108.29 ± 17.97	0.001

Diastolic blood pressure was significantly higher in the metabolic syndrome group, whereas systolic blood pressure was not significantly different. The metabolic syndrome group also had higher total cholesterol, triglycerides and fasting blood glucose and lower HDL cholesterol. LDL cholesterol was lower in the metabolic syndrome group (P=0.037)

Table 3. Distribution of individual metabolic syndrome components

Component present	Metabolic syndrome (n=26)	No metabolic syndrome (n=24)
Central obesity	26 (100.0%)	10 (41.7%)
Hypertriglyceridemia	23 (88.5%)	1 (4.2%)
Low HDL cholesterol	24 (92.3%)	5 (20.8%)
Hypertension	13 (50.0%)	3 (12.5%)
Raised fasting blood glucose	18 (69.2%)	5 (20.8%)

Central obesity was present in all women with metabolic syndrome. Low HDL cholesterol and hypertriglyceridemia were the next most frequent abnormalities, followed by raised fasting glucose and hypertension.

Table 4. Ultrasonographic hepatic steatosis

Ultrasound grade	Frequency (n)	Percent
Grade 0: no steatosis	41	82.0
Grade 1: mild	2	4.0
Grade 2: moderate	5	10.0
Grade 3: severe	2	4.0
Total	50	100.0

Nine women (18.0%) had ultrasonographically detectable steatosis (grades 1–3). All nine belonged to the metabolic syndrome group, corresponding to 34.6% of the 26 women with metabolic syndrome; none of the 24 women without metabolic syndrome had fatty liver on ultrasound. Grade 2 steatosis was the most frequent abnormal grade, occurring in 5 (10.0%) participants.

DISCUSSION

In the present study, most participants were between 50 and 60 years of age, accounting for 27 (54.0%) women, while 23 (46.0%) had been menopausal for 5–10 years. Among the women with metabolic syndrome, the largest proportion had been menopausal for 5–10 years, with 13 of 26 women falling in this category. The mean age of women with metabolic syndrome was 53.69 ± 5.05 years and the mean duration since menopause was 9.15 ± 4.55 years. Although the difference in age and duration since menopause between women with and without metabolic syndrome was not statistically significant, the distribution indicates that metabolic abnormalities were particularly evident in women in the middle postmenopausal age range. This finding is broadly comparable with previous observations in women with NAFLD and metabolic abnormalities. In a study of non-obese Indian patients with NAFLD, the mean age was 42.25 ± 10.50 years, and metabolic syndrome was identified in approximately 30% of participants.¹¹ Another study involving 1423 women reported a mean age of 52.4 ± 9.4 years and found that NAFLD was more frequent in postmenopausal women than in premenopausal women.¹²

A clear difference was observed in body size between the two groups. Women with metabolic syndrome had a mean weight of 74.00 ± 5.43 kg and BMI of 29.42 ± 1.76 kg/m², compared with 61.96 ± 4.48 kg and 25.09 ± 1.13 kg/m², respectively, among women without metabolic syndrome. Both weight and BMI were significantly higher in the metabolic syndrome group ($P < 0.001$). This finding agrees with earlier evidence linking increasing adiposity and weight gain with metabolic syndrome. The CARDIA study demonstrated that higher baseline BMI and subsequent weight gain were important risk factors for development of metabolic syndrome, with the risk increasing as weight increased.¹³ Similarly, the study of women with NAFLD by Chung et al. showed that metabolic factors, particularly central obesity, were closely related to NAFLD, with postmenopausal women showing greater metabolic risk than premenopausal women.¹² These findings support the observation in the present study that excess body weight is an important

feature accompanying metabolic syndrome among postmenopausal women.

The anthropometric findings provide further support for the role of abdominal adiposity. Mean waist circumference was significantly higher in the metabolic syndrome group than in the non-metabolic syndrome group (97.42 ± 3.30 vs 89.88 ± 4.73 cm; $P < 0.001$), while mean hip circumference was also significantly greater (100.85 ± 3.35 vs 92.75 ± 5.34 cm; $P < 0.001$). In contrast, waist-to-hip ratio did not differ significantly between the groups. The importance of waist circumference in identifying metabolic risk has been emphasized in other studies. Singh et al. reported that waist circumference and triglyceride concentration were the strongest markers of metabolic syndrome in both normal-weight and overweight individuals.¹⁴ In a large Qatari population, waist circumference was found to be a better predictor of metabolic syndrome than BMI, waist-to-hip ratio or waist-to-height ratio, particularly among women.¹⁵ The stronger association of waist circumference in the present study is therefore consistent with the recognized importance of central adiposity as a marker of metabolic dysfunction. The relatively small difference in waist-to-hip ratio despite marked differences in absolute waist circumference may also indicate that absolute abdominal measurements were more informative than the ratio in this sample. The association between menopause, adiposity and metabolic abnormalities is biologically plausible. Menopause is accompanied by changes in body-fat distribution, with a tendency toward greater central and visceral adiposity. Increases in visceral fat may contribute to insulin resistance and adverse changes in lipid metabolism, thereby increasing the likelihood of metabolic syndrome. The study by Gower et al. demonstrated that postmenopausal women had greater estimated intra-abdominal adiposity and higher total cholesterol, LDL cholesterol and triglyceride concentrations than premenopausal women, and suggested that menopause-related changes in intra-abdominal fat may adversely influence the lipid profile.¹⁶ Thus, the higher BMI and waist circumference observed in the present metabolic syndrome group may represent an important component

of the broader metabolic changes occurring after menopause.

Blood pressure findings showed that diastolic blood pressure was significantly higher in women with metabolic syndrome than in those without metabolic syndrome (84.23 ± 7.26 vs 79.17 ± 6.28 mmHg; $P=0.012$). Systolic blood pressure was also higher in the metabolic syndrome group, but the difference did not reach statistical significance. These findings are in agreement with observations from a large cross-sectional study in which individuals with metabolic syndrome had higher systolic and diastolic blood pressure measurements.¹⁵ Longitudinal evidence further supports this relationship. Jung et al. reported that increasing levels of both systolic and diastolic blood pressure were associated with a higher risk of incident metabolic syndrome during long-term follow-up, even among individuals who were not initially hypertensive.¹⁷ The higher frequency of hypertension among women with metabolic syndrome in the present study, with 13 (50.0%) women affected compared with 3 (12.5%) in the non-metabolic syndrome group, therefore fits the expected clustering of elevated blood pressure with central obesity and other metabolic abnormalities.

The lipid profile demonstrated a characteristic metabolic syndrome pattern. Women with metabolic syndrome had significantly higher total cholesterol, with a mean concentration of 167.46 mg/dL compared with 149.46 mg/dL in women without metabolic syndrome ($P=0.003$). Triglycerides were markedly higher in the metabolic syndrome group (213.19 ± 45.77 vs 134.08 ± 20.24 mg/dL; $P<0.001$), while HDL cholesterol was substantially lower (39.08 ± 5.86 vs 52.13 ± 3.96 mg/dL; $P<0.001$). Consequently, 23 (88.5%) women with metabolic syndrome had hypertriglyceridemia and 24 (92.3%) had low HDL cholesterol, compared with 1 (4.2%) and 5 (20.8%), respectively, among women without metabolic syndrome. These findings are consistent with previous work showing that hypertriglyceridemia and low HDL cholesterol are prominent components of metabolic syndrome and are closely linked to central adiposity and insulin resistance.^{14,18} The association is particularly relevant to hepatic steatosis because excess fatty-acid delivery and impaired lipid handling can promote triglyceride accumulation within hepatocytes. The higher total cholesterol and triglyceride levels observed in the metabolic syndrome group are also compatible with the metabolic changes described after menopause. Weiss reported that women who had undergone menopause had higher serum cholesterol and diastolic blood pressure than premenopausal women, while systolic blood pressure was not significantly different.¹⁹ Gower et al. similarly found that postmenopausal women had higher concentrations of total cholesterol, LDL cholesterol and

triglycerides and greater estimated intra-abdominal adiposity than premenopausal women.¹⁶ Together, these observations provide a reasonable context for the dyslipidemic pattern identified in the present study.

Fasting blood glucose was significantly higher in women with metabolic syndrome than in those without it (130.08 ± 24.41 vs 108.29 ± 17.97 mg/dL; $P=0.001$). Raised fasting glucose was present in 18 (69.2%) women with metabolic syndrome compared with 5 (20.8%) women without metabolic syndrome. This finding reinforces the clustering of glucose intolerance with obesity, dyslipidemia and hypertension. It is also consistent with the evidence that insulin resistance represents an important metabolic link between central adiposity, metabolic syndrome and hepatic steatosis. In postmenopausal women, studies of NAFLD have particularly emphasized the role of diabetes, triglyceridemia and central obesity in determining the risk of fatty liver.^{12,17}

The present study showed a marked relationship between metabolic syndrome and hepatic steatosis. Ultrasonography identified steatosis in 9 of 50 participants (18.0%), comprising 2 (4.0%) with grade 1, 5 (10.0%) with grade 2 and 2 (4.0%) with grade 3 steatosis. Importantly, all nine women with ultrasonographically detectable steatosis belonged to the metabolic syndrome group, corresponding to 34.6% of women with metabolic syndrome, whereas none of the women without metabolic syndrome had fatty liver. This finding is consistent with the recognized association between metabolic syndrome and fatty liver disease. Hamaguchi et al. reported an overall NAFLD prevalence of 15% among postmenopausal women and demonstrated that metabolic syndrome and weight gain were independent risk factors for NAFLD.²⁰ The occurrence of steatosis in 34.6% of the metabolic syndrome group in the present study is therefore of particular interest, although the overall proportion with detectable steatosis was 18.0%. The pattern of steatosis severity also supports the relationship between increasing metabolic abnormalities and hepatic involvement. Grade 2 steatosis was the most frequent abnormal finding in the present study, occurring in 5 (10.0%) participants, followed by grade 1 and grade 3 steatosis in 2 (4.0%) participants each. Previous work has similarly emphasized the close association between metabolic syndrome and the presence and severity of fatty liver disease.²¹ This relationship is clinically relevant because fatty liver may remain asymptomatic during its early stages, while its presence can serve as an indicator of underlying metabolic dysfunction. The findings are also in line with evidence from large population studies examining menopausal status and fatty liver. In a cross-sectional study of 139,170 individuals, Chen et al. reported that the prevalence of

metabolic-associated fatty liver disease among women increased progressively across reproductive stages, from 6.1% in premenopausal women to 16.8% in perimenopausal women and 30.2% in postmenopausal women.²² The same study found that metabolic abnormalities were more frequent among women with fatty liver. This progressive increase across menopausal stages provides further support for the view that the postmenopausal period represents an important setting for the clustering of obesity, dyslipidemia, glucose abnormalities and fatty liver.

Strengths and Limitations

A strength of the study is the simultaneous assessment of anthropometric, hemodynamic, biochemical and ultrasonographic variables in a clinically relevant postmenopausal group. The principal limitations are the small sample size, single-center hospital setting and observational design.

CONCLUSION

Evidently, the findings of the present study indicate that metabolic syndrome in postmenopausal women is characterized predominantly by increased body weight, higher BMI, marked central obesity, elevated triglycerides, reduced HDL cholesterol, higher diastolic blood pressure and impaired fasting glucose. The simultaneous presence of these abnormalities may create a metabolic environment favorable for hepatic fat accumulation. Ultrasonographically detectable hepatic steatosis was found only among women with metabolic syndrome. These findings support a close relationship between the postmenopausal metabolic phenotype and hepatic fat accumulation and reinforce the value of assessing abdominal obesity, lipid abnormalities and glycemic status together in postmenopausal clinical care.

DECLARATIONS

Ethics Approval and Consent to Participate

The study was conducted in accordance with the ethical principles applicable to research involving human participants. Ethical approval was obtained from the Institutional Ethics Committee, Government Medical College, Jammu (Approval No. IEC/GMC/2022/867, dated 10 February 2022). Written informed consent was obtained from all participants before their inclusion in the study.

Consent for Publication

Written informed consent was obtained from the participants for publication of the study findings. No individually identifiable information is presented in this manuscript.

Availability of Data and Materials

The data generated and/or analyzed during the present study are available from the corresponding author on reasonable request, subject to institutional and ethical restrictions.

Competing Interests

The authors declare that they have no competing interests.

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Authors' Contributions

All authors contributed to the conception and design of the study, data collection, analysis and interpretation of the findings, and preparation and critical revision of the manuscript. All authors approved the final version of the manuscript and agreed to be accountable for all aspects of the work.

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