

Association between type 2 diabetes mellitus and menopausal symptoms among Korean midlife women

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Abstract

Objective: Menopausal symptoms are challenging conditions with a significant impact on women's health, especially in managing type 2 diabetes mellitus (T2DM). However, few studies have explored the link between T2DM and menopausal symptoms in South Korea. Therefore, this study aims to examine the association between T2DM and the number and severity of menopausal symptoms among Korean midlife women.

Methods: A cross-sectional observational study was conducted involving 296 women aged 40–64 in South Korea. Based on their fasting blood glucose and HbA1c levels, participants were classified into the diabetic group and the nondiabetic group. The Midlife Women's Symptom Index (MSI) was used to measure menopausal symptoms, and various background and health-related characteristics were also assessed. Data analyses were conducted using independent *t* tests, Mann-Whitney *U* tests, and hierarchical multiple regression analyses.

Results: Women in the diabetic group showed a significantly greater number and higher severity of menopausal symptoms compared with those in the nondiabetic group. Subgroup analyses revealed significant differences in both the number and severity of menopausal symptoms, particularly among postmenopausal stage, with no differences observed in the premenopausal and perimenopausal stages. Furthermore, T2DM was significantly associated with both the number and the severity of menopausal symptoms after controlling for confounding variables.

Conclusion: T2DM was significantly associated with the number and severity of menopausal symptoms among Korean midlife women. Postmenopausal women with T2DM also reported a greater menopausal symptom burden than those without T2DM. Tailored interventions may help managing symptom burden and improve overall quality of life in this population.

Key Words: Menopause, Symptom, Type 2 diabetes mellitus, Women.

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Midlife women are at increased risk of complications associated with chronic illnesses such as type 2 diabetes mellitus (T2DM) as a result of hormonal changes caused by menopause, whose symptoms also lower their quality of life.¹ In South Korea, midlife women experience substantial challenges in managing blood glucose level, which contributes to an elevated risk of developing T2DM. The Korean Diabetes Association reported that the overall prevalence of T2DM in South Korea was 15.5% in 2024, surpassing the global average of 10.0%.² Among Korean women, the prevalence of T2DM was 8.6% for those aged 40–49 years, 19.1% for those aged 50–59 years, and 27.9% for those aged 60–69 years.² In addition, although the awareness and treatment rates of T2DM in Korean midlife and older women are similar to those of men, Korean women show significantly lower blood glucose control rates.²

Menopausal symptoms such as hot flashes, mood swings, and sleep disturbances are closely associated with poorer quality of life and a higher burden of chronic medical conditions.^{3,4} These menopausal symptoms, combined with the management of chronic conditions such as T2DM, can create a substantial burden that affects both physical and psychological well-being.¹ Previous studies have explored the strong reciprocal relationship between menopause and development of T2DM, identifying early menopause or postmenopausal stage as triggering factors.^{5,6} These findings underscore the importance of closely monitoring blood glucose levels and other metabolic indicators in this demographic.

In addition, a previous study revealed that T2DM exacerbates the severity and duration of vasomotor symptoms (VMS), a common menopausal symptom that increases the risk of developing T2DM.⁷ Furthermore, recent studies have reported that T2DM and other cardiometabolic risk factors such as body mass index (BMI), central obesity, and menopausal status, are associated with greater menopausal symptom severity among middle-age women.⁸ In addition, psychological symptoms increased with BMI and decreased with age in women with T2DM.⁸

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Given the increasing prevalence of T2DM during midlife and the substantial symptom burden experienced during the menopause transition, understanding the association between T2DM and menopausal symptoms is clinically important. In South Korea, studies have reported associations between menopausal symptoms and depression as well as between menopause status and increased risks of cardiovascular disease and metabolic syndrome among midlife women.⁹⁻¹¹ A recent Korean population-based study has also suggested an association between menopausal timing and the development of T2DM.¹² Furthermore, previous studies have reported that Korean women tend to underreport physical and psychological symptoms and delay seeking medical care because of sociocultural norms emphasizing self-sacrifice and emotional restraint, as well as financial burdens and time constraints.^{13,14}

Although growing evidence supports an association between T2DM and menopause-related health outcomes, most previous studies have focused on menopause status, age at menopause, or menopause timing rather than directly assessing menopausal symptom burden. Furthermore, evidence regarding the association between T2DM and menopausal symptoms among Korean midlife women remains limited. Therefore, this study aimed to assess menopausal symptoms using the Midlife Women's Symptom Index (MSI)¹⁵ and to examine whether T2DM is associated with the number and severity of menopausal symptoms among Korean midlife women.

METHODS

Design

This study adopted a cross-sectional design to examine the association between T2DM and the number and severity of menopausal symptoms among midlife women in South Korea.

Study participants

The study participants were midlife women living in South Korea. Inclusion criteria were women aged 45-64 years who had access to the internet and provided informed consent to participate in the study. Exclusion criteria were women with communication difficulties, such as limitations in reading, writing, or hearing; serious chronic conditions that could confound symptom reporting, including diabetes complications, mental disorders (eg, depression), and sleep disorders; those who were undergoing treatments such as hormone or cancer therapy; those who had not experienced natural menopause (eg, surgical or medically induced menopause); or those who had uncontrolled glucose status.

The sample size was calculated using G*Power version 3.1.9.7,¹⁶ assuming a small effect size of 0.1, a significance level of 0.05, a statistical power of 90%, and 20 predictors. The required sample size was estimated to be 278. Considering a 15% attrition rate, a total of 320 participants were recruited. After excluding incomplete responses, 296 midlife women were included in the final analysis.

Measurement

Background and health-related characteristics

Background and health-related characteristics were assessed using structured self-administered questionnaires. Background characteristics included age, marital status, religion, educational attainment, and household income. Health-related characteristics comprised BMI, medication burden, physical activity, meal frequency, perceived general health status, and menopausal stage. Based on fasting plasma glucose and glycated hemoglobin levels, participants were classified into two groups—those with and without T2DM or prediabetes—in accordance with the criteria of the Korean Diabetes Association.² BMI (kg/m²) was categorized according to the Centers for Disease Control and Prevention (CDC) guidelines as underweight (<18.5 kg/m²), normal (18.5-24.9 kg/m²), overweight (25.0-29.9 kg/m²), or obese (≥30.0 kg/m²). Medication burden was assessed by self-report as the number of medications used, including oral hypoglycemic agents, insulin injections, antihypertensive agents, lipid-lowering agents, and anticoagulants. Physical activity level was classified as high, moderate, or low based on metabolic equivalent of task values calculated using the International Physical Activity Questionnaire, developed by the World Health Organization.¹⁷ Regarding menopausal stage, women who had menstruated within the previous three months without changes in cycle regularity were classified as premenopausal, those who had menstruated within the past 12 months but experienced irregular cycles were classified as perimenopausal, and those who had not menstruated for at least 12 consecutive months were classified as postmenopausal.

Midlife women's symptom index

The MSI was developed based on the Cornell Medical Index to assess menopausal symptoms in midlife women and has been validated in diverse populations of midlife women.^{15,18} The current version of the MSI comprises 72 items for premenopausal and perimenopausal women and 65 items for postmenopausal women. It evaluates the prevalence and severity of physical, psychological, and psychosomatic symptoms, which are rated on a five-point Likert scale ranging from 0 (not at all) to 4 (extremely). In a previous study, the Cronbach alpha coefficients for the MSI ranged from 0.94 to 0.95 for prevalence and from 0.95 to 0.96 for severity.^{19,20} In the present study, the Cronbach alpha coefficients were 0.93 for prevalence and 0.94 for severity.

Data collection

Institutional Review Board (IRB) approval was obtained from the authors' affiliation (IRB No. EUIRB2023-093). To ensure confidentiality, data were collected through a secure online survey from April to May 2024. An advertisement for the study was posted on a public online bulletin board, and individuals who expressed interest were directed to a screening survey. Eligibility was assessed through this preliminary survey, and only women aged 45-64 years who

met the inclusion and exclusion criteria were invited to participate in the main survey. After reviewing the informed consent form, participants provided electronic consent by selecting the option indicating their agreement and subsequently completed the self-administered questionnaire. Of the 330 women enrolled, 34 were excluded because of incomplete responses or withdrawal, and a final sample of 296 participants was included.

Data analyses

Data analyses were performed using IBM SPSS Statistics for Windows, version 28.0 (IBM Corp., Armonk, NY).²¹ Differences in the prevalence and severity of menopausal symptoms between midlife women with and without T2DM or prediabetes were examined using independent *t* tests or Mann-Whitney *U* tests. Hierarchical multiple regression analyses were performed to examine the association between diabetes status (T2DM or prediabetes) and menopausal symptoms. To ensure appropriate adjustment, a stepwise selection method was applied in the initial blocks to automatically select meaningful covariates from the collected demographic and health-related variables. These covariates were thus entered into the model, followed by diabetes status in the final step to evaluate its independent association with menopausal symptoms. Multicollinearity was evaluated based on the variance inflation factor. A two-tailed significance level of $P < 0.05$ was applied for all analyses. No artificial intelligence tools were used for data collection, analysis, or interpretation of the data.

RESULTS

Background characteristics of the study participants

The background characteristics of the 296 participants, including 220 in the diabetic group (with T2DM or diabetes) and 76 women in the nondiabetic group, are presented in Table 1. The mean age of the participants was 55.02 ± 5.55 years. Those in the diabetic group had a significantly higher mean age (55.56 ± 5.50 y) than did those in the nondiabetic group (53.47 ± 5.42 y; $P = 0.005$). In addition, age group distribution differed significantly according to diabetes status ($P = 0.011$).

Overall, 75.0% of participants were married or living with a partner, 61.5% reported following a religion, and 60.5% had attained a college degree or higher. In addition, 59.8% reported a monthly household income exceeding 4,000,000 Korean won. There were no statistically significant differences between the groups for these variables.

Health-related characteristics of the participants

The health-related characteristics of the participants are also presented in Table 1. Their mean BMI was 22.97 ± 2.86 kg/m², with 18.0% of participants classified as overweight or obese. A comparison of the two groups revealed that the diabetic group had a significantly higher

mean BMI (23.38 ± 2.95 kg/m²) than did the nondiabetic group (21.78 ± 2.17 kg/m²; $P < 0.001$). In addition, the distribution of BMI categories differed significantly according to diabetes status ($P = 0.005$). Most of the participants in the diabetic group reported using one to two medications (68.6%), whereas participants in the nondiabetic group most frequently reported no medication burden (60.5%), revealing a significant difference between groups ($P < 0.001$).

Based on the International Physical Activity Questionnaire, 19.3% of participants were classified as highly active, 64.5% as moderately active, and 16.2% as having low levels of physical activity. Meal frequency was significantly higher in the diabetic group (10.54 ± 1.46) than in the nondiabetic group (9.93 ± 1.65 ; $P = 0.030$).

The mean perceived general health score was significantly lower in the diabetic group (2.80 ± 0.78) than in the nondiabetic group (3.32 ± 0.64 ; $P < 0.001$). In terms of menopausal stage, 68.6% of the participants were postmenopausal, 12.8% were perimenopausal, and 18.6% were premenopausal. In addition, a higher proportion of participants in the diabetic group were postmenopausal (72.7%) compared with the nondiabetic group (56.6%), indicating a significant group difference ($P < 0.001$).

Prevalence and severity of menopausal symptoms among participants

On average, participants reported experiencing 19.16 menopausal symptoms (SD = 12.21; range 0–65), and their mean severity score was 33.85 (SD = 28.15; range 0–152) (Table 2). Women in the diabetic group reported a significantly higher mean number of menopausal symptoms (20.30 ± 12.20) than women in the nondiabetic group (15.88 ± 11.70 , $P = 0.003$). Similarly, the mean severity score was significantly higher in the diabetic group (36.53 ± 29.27) than in the nondiabetic group (26.11 ± 23.09 ; $P = 0.005$).

Regarding symptom prevalence, significant group differences were observed in the physical and psychosomatic domains but not in the psychological domain ($P = 0.003$, 0.149, and 0.017). Regarding symptom severity, significant group differences were observed only in the physical domain, but not in the psychological and psychosomatic domains ($P < 0.001$, 0.476, and 0.277, respectively). Detailed results are presented in Table 2.

Differences in menopausal symptoms by diabetes status across menopausal stages

Across all menopausal stages, women in the diabetic group reported a higher prevalence of menopausal symptoms than women in the nondiabetic group; however, this difference was statistically significant only in the postmenopausal stage ($P = 0.006$). Similarly, although symptom severity was consistently higher in the diabetic group across menopausal stages, a statistically significant difference was observed only in the postmenopausal stage ($P = 0.008$) (Table 3).

TABLE 1. Participant characteristics

Characteristic	Categories	Total		T2DM or prediabetes (n = 220)		Nondiabetes (n = 76)		P
		n/mean ± SD	%	n/mean ± SD	%	n/mean ± SD	%	
Age	45-54	146	49.3	99	45.0	47	61.8	0.011
	55-64	150	50.7	121	55.0	29	38.2	
	Total	55.02 ± 5.55		55.56 ± 5.50		53.47 ± 5.42		0.005
Marital status	Married or living with a spouse	222	75.0	163	74.1	59	77.6	0.539
	Others	74	25.0	57	25.9	17	22.4	
Religion	Yes	182	61.5	137	62.3	45	59.2	0.636
	No	114	38.5	83	37.7	31	40.8	
Educational attainment ^a	High school or lower	117	39.5	89	40.5	28	36.8	0.579
	College or higher	179	60.5	131	59.6	48	63.2	
Household income	Below 2 million KRW/month	29	9.8	23	10.5	6	7.9	0.805
	2-4 million KRW/month	90	30.4	66	30.0	24	31.6	
	Over 4 million KRW/month	177	59.8	131	59.6	46	60.5	
	National Health Insurance (Community)	89	30.1	64	29.1	25	32.9	
Body mass index		22.97 ± 2.86		23.38 ± 2.95		21.78 ± 2.17		< 0.001
	Underweight (< 18.5 kg/m ²)	11	3.7	6	2.7	5	6.6	0.005
	Normal (18.5-24.9 kg/m ²)	231	78.3	165	75.3	66	86.8	
Medication burden	Overweight or obese (≥ 25.0 kg/m ²)	53	18.0	48	21.9	5	6.6	
	0	71	24.0	25	11.3	46	60.5	< 0.001
	1-2	181	61.2	151	68.6	30	39.5	
Physical activity	≥ 3	44	14.9	44	20.0	0	0.0	
	High	57	19.3	40	18.2	17	22.4	0.369
	Moderate	191	64.5	147	66.8	44	57.9	
Meal frequency	Low	48	16.2	33	15.0	15	19.7	
				10.54 ± 1.46		9.93 ± 1.65		0.030
				2.80 ± 0.78		3.32 ± 0.64		< 0.001
Perceived general health status								< 0.001
	Menopausal stage							< 0.001
	Postmenopausal	203	68.6	160	72.7	43	56.6	
Menopausal stage	Perimenopausal	38	12.8	31	14.1	7	9.2	
	Premenopausal	55	18.6	29	13.2	26	34.2	

KRW, Korean won; T2DM, type 2 diabetes mellitus.

N = 296.

^aMissing data were excluded.

Association between diabetes status and menopausal symptoms

After adjusting for all the background and health-related characteristics, which are presented in Table 1, a significant positive association was found between T2DM and the number of menopausal symptoms, as women in the diabetic group reported a greater number of symptoms ($\beta = 0.140$, $P = 0.020$) (Table 4). In model 1, the inclusion of diabetes status explained an additional 1.4% of the variance in the number of menopausal symptoms ($P < 0.001$).

Similarly, after adjusting for background and health-related characteristics, diabetes status was positively associated with menopausal symptom severity ($\beta = 0.120$, $P = 0.040$). In model 2, the predictors accounted for an additional 1.0% of the variance in symptom severity ($P < 0.001$).

DISCUSSION

Previous studies have reported associations between T2DM and menopause-related health outcomes among

TABLE 2. Differences in the total number and total severity scores of menopausal symptoms according to T2DM status

Categories	Subcategories	Total		T2DM or prediabetes(n = 220)		Nondiabetes(n = 76)		P
		Mean ± SD	Min/Max	Mean ± SD	Min/Max	Mean ± SD	Min/Max	
MSI prevalence	Physical	12.51 ± 8.06	0/44	13.31 ± 8.06	0/44	10.18 ± 7.62	0/30	0.003
	Psychological	5.10 ± 4.58	0/17	5.33 ± 4.49	0/17	4.45 ± 4.79	0/17	0.149
	Psychosomatic	1.54 ± 1.31	0/4	1.65 ± 1.31	0/4	1.24 ± 1.27	0/4	0.017
	Total	19.16 ± 12.21	0/65	20.30 ± 12.20	0/65	15.88 ± 11.70	0/42	0.003
MSI severity	Physical	21.84 ± 17.50	0/101	23.77 ± 18.20	0/101	16.28 ± 13.96	0/58	< 0.001
	Psychological	10.88 ± 11.26	0/54	11.15 ± 11.30	0/54	9.97 ± 11.16	0/43	0.476
	Psychosomatic	4.11 ± 3.09	0/16	4.23 ± 3.19	0/16	3.67 ± 2.65	0/12	0.277
	Total	33.85 ± 28.15	0/152	36.53 ± 29.27	0/152	26.11 ± 23.09	0/100	0.005

MSI, Menopausal Symptom Index; T2DM, type 2 diabetes mellitus.

N = 296.

TABLE 3. Differences in the total numbers and total severity scores of menopausal symptoms according to T2DM and menopausal status

	No. symptoms (N, Mean ± SD)					Severity (N, Mean ± SD)				
	T2DM or prediabetes (n = 220)		Nondiabetes (n = 76)		<i>U</i> or <i>t</i> (<i>P</i>)	T2DM or prediabetes (n = 220)		Nondiabetes (n = 76)		<i>U</i> or <i>t</i> (<i>P</i>)
Premenopausal ^a	29	20.93 ± 18.35	26	18.34 ± 11.73	337.00 (0.499)	29	36.97 ± 30.75	26	29.27 ± 22.80	333.5 (0.463)
Perimenopausal ^a	31	25.26 ± 20.43	7	20.43 ± 11.80	87.00 (0.418)	30	50.23 ± 35.36	7	40.14 ± 29.35	93.50 (0.572)
Postmenopausal ^b	160	19.21 ± 11.82	43	13.63 ± 11.40	2.770 (0.006)	160	33.79 ± 27.10	43	21.91 ± 21.49	2.660 (0.008)

T2DM, type 2 diabetes mellitus.

N = 296.

^aAnalyzed using the Mann-Whitney *U* test.^bAnalyzed using the independent *t* test.

midlife women. Building on this evidence, this study examined the association between T2DM and the number and severity of menopausal symptoms among midlife women in South Korea. Our findings, which are consistent with and extend prior studies, indicate that women with T2DM or prediabetes experience a significantly greater number and higher severity of menopausal symptoms, highlighting their burden as a salient clinical characteristic of midlife women with impaired glucose metabolism. These results underscore the importance of incorporating systematic assessment of menopausal symptoms into diabetes care for midlife women. These findings are discussed in detail below.

First, women in the diabetic group reported a significantly greater number of menopausal symptoms and higher overall symptom severity than the nondiabetic group. Significant group differences were observed in the number of symptoms in both the physical and psychosomatic domains, as well as in the severity of symptoms in the physical domain. These findings are consistent with those of previous studies conducted in other countries, indicating that T2DM contributes to an increased burden of menopausal symptoms.^{7,8} Gray et al⁷ demonstrated that T2DM exacerbates both the severity and duration of VMS, the presence of which, in turn, increases

the risk of developing T2DM. Similarly, Armeni et al⁸ reported that T2DM was associated with greater menopausal symptom severity after accounting for other cardiometabolic risk factors among midlife women in Greece. Taken together, our findings extend previous evidence to Korean midlife women and suggest that T2DM and prediabetes are associated with a greater burden of menopausal symptoms in this population. These findings underscore the need for attention to menopausal symptom burden in the clinical management of Korean midlife women with T2DM.¹²

Second, significant differences in the number and severity of menopausal symptoms between the diabetic and nondiabetic groups were observed primarily during the postmenopausal stage. These findings align with those of prior studies, suggesting that the postmenopausal stage is a period of heightened metabolic vulnerability, with postmenopausal women exhibiting a greater risk of T2DM than premenopausal women.²²⁻²⁴ A large prospective study reported that short sleep duration and sleep-disordered breathing were associated with a significantly higher risk of treated T2DM among postmenopausal women.²⁵ In addition, poor sleep quality in this population has been linked to increased insulin resistance—a key precursor of impaired glycemic control.²⁶ Therefore, our findings suggest that

TABLE 4. Associations between multiple factors and the total number and severity scores of menopausal symptoms

Predictors	Model 1 (no. symptoms)			Model 2 (severity)		
	β 1	β 2	β 3	β 1	β 2	β 3
Step 1						
Age	-0.165 ^b	-0.197 ^c	-0.200 ^c	-0.177 ^b	-0.245 ^c	-0.247 ^c
Step 2						
Meal frequency	—	-0.123 ^a	-0.142 ^a	—	-0.124 ^a	-0.14
Subjective health status	—	-0.228 ^c	-0.194 ^b	—	-0.229 ^c	-0.200 ^c
Overweight or obesity	—	0.107	0.086	—	0.160 ^b	0.141 ^a
Postmenopausal or perimenopausal	—	0.075	0.049	—	0.133 ^a	0.110
IPAQ Low	—	0.109	0.116 ^a	—	0.036	0.042
Step 3						
T2DM or prediabetes	—	—	0.140 ^a	—	—	0.121 ^a
Adjusted R ² (%)	0.024 ^b	0.116 ^c	0.130 ^c	0.028	0.133	0.143
Δ R ² (%)	—	0.092	0.014	—	0.105	0.010
<i>F</i>	8.249 ^b	7.442 ^c	7.270 ^c	9.546 ^b	8.554 ^c	8.014 ^c

IPAQ, International Physical Activity Questionnaire; T2DM, type 2 diabetes mellitus.

N = 296.

^a*P* < 0.05.^b*P* < 0.01.^c*P* < 0.001.

menopausal symptoms, particularly during the postmenopausal stage, may serve as a critical factor with direct and/or indirect associations with diabetes care.

Finally, after adjusting for background and health-related characteristics, diabetes status remained significantly associated with both the number and severity of menopausal symptoms. Recent Korean studies on menopause-related metabolic health and hormone therapy further support the close relationship between menopause and glucose metabolism in Korean women.¹² These findings are consistent with previous international studies reporting an association between diabetes-related metabolic factors and menopausal symptom burden.^{27,28} Future longitudinal studies should further examine the temporal relationships between T2DM and menopause symptom progression, as well as the potential mediating factors, including obesity, physical activity, and psychosocial stress. In accordance with the literature, postmenopausal women with T2DM have been shown to exhibit worse glucose control in conjunction with higher menopausal symptom severity, including somatic symptoms (eg, joint pain, VMS), than those with better glycemic management.^{8,29} In addition, higher intensity of menopausal symptoms has been associated with poorer quality of life among menopausal women with diabetes.³⁰ Taken together, these findings support the consideration of assessing menopausal symptoms as part of comprehensive diabetes care for Korean midlife women.

This study has some limitations. First, we included only midlife women from South Korea, potentially limiting the generalizability of the findings to other populations. Second, data were collected using self-administered online surveys, which may have caused selection bias. Third, subgroup sample size imbalance and the lack of direct assessment of central obesity should be considered when interpreting the findings. Finally, because this study employed a cross-sectional design, the causal relationships among variables could not be examined.

CONCLUSION

This study demonstrated that Korean midlife women with T2DM or prediabetes experience a greater number and severity of menopausal symptoms than nondiabetic midlife women, particularly in the postmenopausal stage. Also, diabetes status was significantly associated with menopausal symptom burden in Korean midlife women. These findings suggest the importance of integrating menopausal symptom assessment and management into diabetes care for Korean midlife women to improve quality of life. Future longitudinal studies are recommended to further clarify the biological and psychosocial mechanisms linking glucose metabolism and menopausal symptom burden in this population.

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