



Sex-based Association between Depression and Metabolic Syndrome in Korean Middle-aged and Older Adults

Jin Suk Ra, Hye Sun Kim

College of Nursing, Chungnam National University, Daejeon, Korea

Objectives: This study aimed to identify the sex-based association between depression and the development of metabolic syndrome (Mets) among middle-aged and older Korean adults.

Methods: A cross-sectional design was used for the secondary analysis of the 2010–2014 Korean National Health and Nutrition Examination Survey. Data from 1,938 men and 2,404 women were analyzed. Mets was defined in accordance with the criteria used for clinical diagnosis. Depression was assessed with a question about having clinical depression. The association between depression and the development of Mets with or without adjustment for covariates was identified by conducting logistic regression analysis on weighted data using a complex sample procedure.

Results: More women than men had depression. Before covariate adjustment, depression was significantly associated with the development of Mets among women (odds ratio [OR], 1.586; 95% confidence interval [CI], 1.152–2.183) and with a higher triglyceride level among men (OR, 1.679; 95% CI, 1.001–2.818). After covariate adjustment; depression was significantly associated with higher waist circumference among women (adjusted OR [AOR], 1.532; 95% CI, 1.046–2.245) and higher triglyceride level (AOR, 1.511; 95% CI, 1.029–2.219) than was Mets. Conversely, depression did not have significant effects on the development of Mets among men.

Conclusion: Depression was associated with the development of Mets among middle-aged and older Korean women. Healthcare providers in communities should assess women with depression for the presence of Mets components. Interventions for relieving depressive symptoms should also be provided to women at risk for Mets.

Key Words: depression, metabolic syndrome X, sex characteristics

Corresponding author: Hye Sun Kim
E-mail: caffe815@gmail.com

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INTRODUCTION

Metabolic syndrome (Mets) is a multifactorial disease characterized by abdominal obesity, elevated glucose, and blood pressure, and altered lipid metabolism [1,2]. Development of Mets is associated with increasing age and poor lifestyle, such as inadequate physical activity, smoking, alcohol drinking, and high-fat or high-calorie diets [3,4]. Among Americans, the prevalence of Mets was 34.7% in 2011–2012 [5]. In particular, women and people aged 60 years or older had a higher prevalence of Mets than the overall prevalence [5]. Among Korean adults older than 19 years of age, the average prevalence of Mets was 18.8% in 2010, and the prevalence was higher among women and individuals older than 50 years of age [4]. The prevalence of Mets among the Korean population is expected to increase with an increasing number of older individu-



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als and adoption of a Westernized lifestyle [4]. In a longitudinal study, Mets was identified as a major risk factor for cerebral-cardiovascular disease [6]. Thus, identification of risk factors is important to decrease the prevalence of morbidity and mortality from complications due to Mets in high-risk populations such as the elderly and women in Korea [4].

Depression is a significant predictor of type 2 diabetes mellitus (T2DM) and cardiovascular disease [7–9]. Depression is also considered to be significantly associated with Mets [10]. In previous studies, depression was observed as a critical risk factor for the development of Mets in middle-aged and older people [11,12]. However, the effects of depression on Mets vary in accordance with ethnicity and sex. Depression was significantly associated with the development of Mets among American and European populations [13], but it was not a significant predictor of Mets among the Japanese population regardless of sex [14]. Allison et al [15] proposed that populations with different sociocultural backgrounds have different health risks due to genetic and socioeconomic heterogeneity. In particular, the difference in the level of psychological stress and social support, as well as lifestyle such as diet, may alter the prevalence of Mets among ethnic groups [16,17]. In these contexts, the effects of depression on the development of Mets among the Korean population may be different from that among other ethnic groups. Toker et al [18] proposed that depression may be associated with Mets among women, but not among men. According to previous studies, depression is significantly associated with the development of Mets, and it worsens the severity of Mets among African-American women but not among men [10,19,20]. In a longitudinal study, depression may also be a significant predisposing factor for the development of Mets among Finnish women but not among men [21]. Owing to these findings, the significance of the effects of depression on the development of Mets may vary by sex. In this study, we aimed to identify the association between depression and the development of Mets among middle-aged and older Korean adults on the basis of sex.

MATERIALS AND METHODS

1. Study design and samples

We used a cross-sectional design for the secondary analysis of the 2010–2014 Korean National Health and Nutrition Examination Survey (NHANES). The NHANES is a nationwide survey that evaluates the health and nutritional status of the Korean population. In this survey, 41,102 people were selected by stratified sampling method. Samples for data analysis included adults older than 40 years of age who had completed a questionnaire

that assessed health and nutritional status and undergone a physical examination. Finally, data from 4,342 adults (1,938 men and 2,404 women) were analyzed.

2. Measurements

1) Metabolic syndrome (Mets)

In this study, Mets was defined in accordance with the clinical diagnostic criteria developed by the American Heart Association and the National Heart, Lung, and Blood Institute [2]. For waist circumference, we used the criteria suggested by the Korean Society for the Study of Obesity [22].

The subjects were diagnosed with Mets when three or more of the following five components were present: waist circumference ≥ 90 cm in men and ≥ 85 cm in women; blood pressure $\geq 130/85$ mmHg or use of medication for hypertension; high-density lipoprotein (HDL) cholesterol level < 40 mg/dL in men and < 50 mg/dL in women or use of medication for reduced HDL level; triglyceride (TG) level ≥ 150 mg/dL or use of medication for increased TG level; and fasting glucose level ≥ 100 mg/dL or use of medication for hyperglycemia.

2) Depression

Depression was assessed with the following question: “Do you currently have depression diagnosed by a psychiatrist?”

3) Covariates

To adjust for covariates related to the development of Mets, we assessed variables associated with the development of Mets such as biological factors (age, obesity, family history of hypertension, dyslipidemia, T2DM or cerebral-cardiovascular disease, and menopause [for women]), social factors (educational level, marital status, and family income), and individual health-related behavioral factors (smoking, heavy alcohol consumption, physical activity, and eating out). The covariates and their categories are presented in Table 1.

3. Statistical analysis

General characteristics of the samples, including depression, Mets, and covariates, were analyzed and shown as frequencies and percentages. The difference in the prevalence of depression and Mets by sex was analyzed using the chi-square test, which was also used to confirm significant covariates for the development of Mets based on sex. Significant covariates were incorporated into logistic regression to adjust the confounding effects of covariates. Logistic regression analysis was conducted on weighted data using a complex sample procedure to identify the association between depression and the development of Mets with or without adjustment for covariates. *p*-values of less than 0.05 were

Table 1. Characteristics of samples regarding metabolic syndrome (Mets), depression, and covariates related to the development of Mets

Variable		Men (n = 1,938)	Women (n = 2,404)
Independent variable			
Depression	Yes	88 (4.1)	312 (11.7)
	No	1,850 (95.9)	2,092 (88.3)
Dependent variable			
Metabolic syndrome	Yes	704 (37.0)	704 (25.9)
	No	1,234 (63.0)	1,700 (74.1)
Blood pressure	Yes	1,035 (51.0)	972 (36.9)
	No	903 (49.0)	1,432 (63.1)
Waist circumference	Yes	525 (27.2)	610 (23.3)
	No	1,413 (72.8)	1,794 (76.7)
High density lipoprotein	Yes	500 (26.2)	970 (38.3)
	No	1,438 (73.8)	1,434 (61.7)
Triglyceride	Yes	875 (49.0)	791 (30.1)
	No	1,063 (51.0)	1,613 (69.9)
Fasting blood glucose	Yes	931 (48.1)	744 (29.9)
	No	1,007 (51.9)	1,660 (70.1)
Covariates			
Biological factors			
Age (y)	40–64	1,338 (81.9)	1,915 (85.5)
	≥ 65	600 (18.1)	489 (14.5)
Obesity	Non-obesity	722 (34.8)	1,014 (44.1)
	obesity	1,216 (65.2)	1,390 (55.9)
Family history	Yes	921 (52.4)	1,310 (56.7)
	No	1,017 (47.6)	1,094 (43.3)
Menopause	Yes	-	1,504 (56.2)
	No	-	900 (43.8)
Social factors			
Education level	Below elementary school	407 (16.5)	769 (27.6)
	Middle school	298 (14.2)	340 (13.7)
	High school	633 (35.9)	842 (38.0)
	Above college	600 (33.4)	453 (20.7)
Marital status	Married	1,871 (95.5)	2,369 (98.6)
	Single	67 (4.5)	35 (1.4)
Family income	Low	355 (13.9)	455 (16.7)
	Mid	999 (53.8)	1,269 (53.1)
	High	584 (32.3)	680 (30.2)
Individual health-related behavioral factors			
Smoking	Never smoked	291 (14.9)	2,176 (89.8)
	At the past, not in current	880 (41.4)	96 (4.3)
	Occasionally in current	76 (4.3)	32 (1.5)
	Daily in current	691 (39.4)	100 (4.4)
Heavy alcohol consumption	Yes	483 (29.6)	80 (3.6)
	No	1,455 (70.4)	2,324 (96.4)
Physical activity	Yes	563 (29.4)	709 (29.4)
	No	1,375 (70.6)	1,695 (70.6)
Eating out	> 1 times/day	615 (36.7)	240 (10.6)
	1–6 times/week	810 (41.8)	1,188 (50.7)
	1–3 times/month	371 (16.2)	736 (29.9)
	< 1 times/month	142 (5.3)	240 (8.8)
Antidepressant medication ^a	Yes	30 (35.4)	102 (30.7)
	No	58 (64.6)	210 (69.3)

Values are presented as underweighted number (weighted percentage).

^aMen=88, women=312.

considered statistically significant. Analyses were performed using IBM SPSS Statistics software (version 22.0 for Windows; IBM Co., Armonk, NY, USA).

RESULTS

1. Characteristics of samples regarding Mets, depression, and covariates related to the development of Mets

Table 1 shows the prevalence of Mets and depression as well as the biological, social, and individual health-related behavioral factors related to the development of Mets. Among the samples, 4.1% of the men and 11.7% of the women had clinical depression. In addition, 37.0% of the men and 25.9% of the women had Mets. Most of the men and women (81.9% and 85.5%, respectively) were older than 40 years and younger than 65 years. Almost half of the men and women (52.4% and 56.7%, respectively) had a family history of hypertension, dyslipidemia, T2DM, and cerebral-cardiovascular disease. More than half of the men and women (65.2% and 55.9%, respectively) were obese. About one-third of the men and women (35.4% and 30.7%, respectively) took an antidepressant medication (Table 1).

2. Difference of prevalence of depression and Mets by sex

Women had a higher prevalence of depression than did men ($\chi^2 = 86.197, p < 0.001$). Men had a higher prevalence of Mets than did women ($\chi^2 = 62.680, p < 0.001$). Regarding Mets com-

ponents, men had higher blood pressure ($\chi^2 = 88.277, p < 0.001$), TG ($\chi^2 = 161.496, p < 0.001$), fasting blood glucose ($\chi^2 = 150.872, p < 0.001$), and higher waist circumference ($\chi^2 = 8.808, p = 0.012$) than did women. However, women had lower HDL cholesterol than did men ($\chi^2 = 71.956, p < 0.001$) (Table 2).

3. Association between depression and the development of Mets

Before covariate adjustment, depression was significantly associated with the development of Mets among women (odds ratio [OR], 1.586; 95% confidence interval [CI], 1.152–2.183; $p = 0.005$). Among women, depression was associated with higher blood pressure (OR, 1.462; 95% CI, 1.102–1.940; $p = 0.008$), waist circumference (OR, 1.865; 95% CI, 1.345–2.587; $p < 0.001$), and higher TG (OR, 1.856; 95% CI, 1.366–2.522; $p < 0.001$) than the specified criteria for Mets. Among men, depression was associated with higher TG (OR, 1.679; 95% CI, 1.001–2.818; $p = 0.050$) than that specified by the criteria for Mets (Table 3).

After covariate adjustment, depression was significantly associated with higher waist circumference (adjusted OR [AOR], 1.532; 95% CI, 1.046–2.245; $p = 0.029$) and higher TG among women (AOR, 1.511; 95% CI, 1.029–2.219; $p = 0.035$) than that specified by the criteria for Mets. Among men, depression was not significantly associated with the development of Mets (Table 4).

Table 2. Sex-based difference in prevalence of depression and metabolic syndrome (component)

Outcome variable	Category	Men (n = 1,938)	Women (n = 2,404)	χ^2	p-value
Metabolic syndrome	Yes	704 (37.0)	704 (25.9)	62.680	< 0.001
	No	1,234 (63.0)	1,700 (74.1)		
Blood pressure	Yes	1,035 (51.0)	972 (36.9)	88.277	< 0.001
	No	903 (49.0)	1,432 (63.1)		
Waist circumference	Yes	525 (27.2)	610 (23.3)	8.808	0.012
	No	1,413 (72.8)	1,794 (76.7)		
High density lipoprotein	Yes	500 (26.2)	970 (38.3)	71.956	< 0.001
	No	1,438 (73.8)	1,434 (61.7)		
Triglyceride	Yes	875 (49.0)	791 (30.1)	161.496	< 0.001
	No	1,063 (51.0)	1,613 (69.9)		
Fasting blood glucose	Yes	931 (48.1)	744 (29.9)	150.872	< 0.001
	No	1,007 (51.9)	1,660 (70.1)		
Depression	Yes	88 (4.1)	312 (11.7)	86.197	< 0.001
	No	1,850 (95.9)	2,092 (88.3)		

Values are presented as underweighted number (weighted percentage).

Table 3. Sex-based association between depression and the development of metabolic syndrome (component) before covariate adjustment

Outcome variable		Depression					
		Men			Women		
		OR	95% CI	<i>p</i> -value	OR	95% CI	<i>p</i> -value
Metabolic syndrome (Ref. No)	Yes	1.162	0.653–2.068	0.608	1.586	1.152–2.183	0.005
Blood pressure (Ref. No)	Yes	1.166	0.674–2.018	0.581	1.462	1.102–1.940	0.008
Waist circumference (Ref. No)	Yes	1.008	0.546–1.862	0.979	1.865	1.345–2.587	< 0.001
High density lipoprotein (Ref. No)	Yes	0.929	0.498–1.731	0.815	1.283	0.955–1.726	0.098
Triglyceride (Ref. No)	Yes	1.679	1.001–2.818	0.050	1.856	1.366–2.522	< 0.001
Fasting blood glucose (Ref. No)	Yes	0.906	0.521–1.574	0.725	1.260	0.923–1.720	0.145

OR, odds ratio; CI, confidence interval; Ref., reference.

Table 4. Sex-based association between depression and the development of metabolic syndrome (component) after covariate adjustment

Outcome variable		Depression					
		Men			Women		
		AOR	95% CI	<i>p</i> -value	AOR	95% CI	<i>p</i> -value
Metabolic syndrome (Ref. No)	Yes	1.227 ^a	0.660–2.280	0.517	1.253 ^e	0.880–1.785	0.210
Blood pressure (Ref. No)	Yes	1.186 ^b	0.681–2.068	0.546	1.142 ^e	0.835–1.562	0.407
Waist circumference (Ref. No)	Yes	1.039 ^c	0.512–2.105	0.916	1.532 ^h	1.046–2.245	0.029
High density lipoprotein (Ref. No)	Yes	0.923 ^d	0.482–1.765	0.808	1.139 ^e	0.843–1.540	0.395
Triglyceride (Ref. No)	Yes	1.488 ^e	0.779–2.840	0.228	1.511 ^h	1.029–2.219	0.035
Fasting blood glucose (Ref. No)	Yes	0.861 ^f	0.483–1.533	0.610	1.061 ^g	0.766–1.470	0.720

AOR, adjusted odds ratio; CI, confidence interval; Ref., reference.

Adjusted for ^asmoking, heavy alcohol consumption, obesity; ^bage, family income, smoking, heavy alcohol consumption, family history, obesity; ^cheavy alcohol consumption, physical activity, obesity; ^deducation level, obesity; ^eage, education level, smoking, heavy alcohol consumption, family history, eating out, obesity, antidepressant medication; ^feducation level, heavy alcohol consumption, obesity; ^gage, education level, family income, eating out, obesity, menopause; ^heducation level, family income, heavy alcohol consumption, eating out, obesity, menopause, antidepressant medication.

DISCUSSION

This study identified a sex-specific association between depression and the development of Mets among Korean population older than 40 years of age. Almost one-third of the Korean adults older than 40 years of age had Mets. According to the Korean NHANES for 1998–2007, the prevalence of Mets among Korean adults over 20 years of age was 24.9% in 1998, 31.3% in 2007, and 21.7% in 2012 after age adjustment [23,24]. Specifically, the prevalence of Mets was over 50% after the age of 50 years in both men and women in 2007 and 2012 [23,24]. When the age-adjusted prevalence of Mets in the United States was 34.2% in 2006 [25], the Korean population showed almost a similar risk for the development of Mets. Thus, an active identification of risk factors for the development of Mets and early intervention are required to prevent Mets-related complication.

In this study, with unadjusted covariates, depression was significantly associated with the development of Mets, and most of the Mets components were among women. Among men, depression was associated with TG level only. After covariate adjustment, depression was associated with higher waist circumference and higher TG level among women. However, depression was not associated with the development of Mets among men. In a prospective cohort study among Dutch population, depression was considerably associated with higher waist circumference and TG level during a 6-year follow-up [13]. In particular, Toker et al [18] proposed that depression may be positively associated with higher waist circumference and TG level among women. Similarly, depressive symptoms are associated with higher risk for abdominal obesity among women, but not among men, after controlling the covariates [19,26]. Among German population, depressive symptoms are significantly associated with higher

waist circumference and dyslipidemia (lower HDL cholesterol) among women, but not among men, after covariate adjustment [27]. Depressive symptoms also exhibit effects on visceral adiposity in middle-aged American women, but not in men [28]. Thus, depression was considered to have more detrimental effects on the development of Mets among women than among men [29].

Schulz et al [30] reported that women show higher increased cortisol level than men in chronic stress. In the same vein, depressive symptoms significantly affect cortisol secretion among women, but not among men [31,32]. Furthermore, an elevated cortisol level may be considered a mediator between depression and Mets components among women [24]. In these contexts, depressive symptoms negatively affect Mets components such as higher waist circumference, higher blood pressure, and blood, and lower HDL cholesterol after covariate adjustment among women [27]. Björntorp [33] proposed that cortisol binds to glucocorticoid receptors with a high density in the visceral fat deposit. This activity enhances lipoprotein lipase and inhibits lipid mobilization, which results in increased visceral fat. These effects are more elevated with low levels of sex steroid hormone [33], which tends to be low in depression [34]. Thus, low levels of sex steroids may show a more evident effect on the accumulation of visceral fat among depressed women than among men [27]. In particular, older age may be associated with an increase in the stress response and cortisol level more often among women than among men [35]. Thus, middle-aged and older women with depression may be more vulnerable to Mets development than are men.

In conclusion, depression was an associated factor for the development of Mets among middle-aged and older Korean women. In the present and in a previous study [36], Korean women tended to have a higher prevalence of depression than did men. Thus, screening and early management of depression are essential to prevent Mets and reduce the severity of Mets. In

particular, health care providers in communities should focus on the association between depression and Mets in women with depressive symptoms and evaluate Mets components. Furthermore, interventions for relieving the depressive symptoms should be provided for women at risk for Mets.

Our study had several limitations. First, we did not control each covariate owing to the limitation of the secondary data analysis. Original studies that control covariates are suggested to confirm the association between depression and the development of Mets among Korean population. Second, our study focused only on the sex-specific association between depression and Mets. However, the association between depression and Mets may be different by other socio-demographic factors (e.g., age, residence, and socioeconomic level). Thus, further examinations based on various socio-demographic factors are required. Finally, we did not explain the specificity of the development of Mets in Korean population in this study. Multi-ethnic studies, including the Korean population, are recommended to verify the association between depression and Mets with genetic and sociocultural factors on the basis of ethnicity.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

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