Original Article

Associations between depression and unhealthy behaviours related to metabolic syndrome: a cross sectional study

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Background and Objectives: The purpose of the present study was to determine whether depression was associated with metabolic syndrome and unhealthy behaviours in community residents. **Methods and Study Design**: Using the 2009-2010 baseline data of the Saku Cohort Study, 1,225 men and women who participated in a community health screening were included in the cross-sectional analyses. Depression was assessed using the Zung Self-Rating Depression Scale. Consistent with the Japanese Society of Internal Medicine's definition, we defined metabolic syndrome as abdominal obesity plus two or more of the following: high blood pressure, hyperglycaemia, and dyslipidaemia. We defined 'pre- and metabolic syndrome' as the presence of one or more of the three criteria in addition to abdominal obesity. **Results**: There was no significant association between depression and metabolic syndrome. In women, the prevalence of pre- and metabolic syndrome was significantly higher in the depression group than that in the non-depression group (17.5% vs 9.5%, p=0.046), whereas no such significant association was observed in men. Logistic regression analysis showed that depression was associated with unhealthy behavioural factors differently in men and women. **Conclusions:** This study revealed that depression was associated with several unhealthy behavioural factors in both men and women, but depression was associated with pre- and metabolic syndrome only in women. These findings suggest that depression may be a warning sign of metabolic syndrome in women with unhealthy behavioural factors. Psychological factors should be considered in addition to the assessment of physical status.

Key Words: depression, metabolic syndrome, unhealthy behaviours, physical activity, dietary intake and habits

INTRODUCTION

Metabolic syndrome is a cluster of cardiovascular risk factors, including abdominal obesity, hypertension, dyslipidaemia, and glucose intolerance, that increases the risk of developing health problems such as type 2 diabetes, heart disease, and stroke.[1] Metabolic syndrome is thus associated with high utilization of medical care and a significant economic burden.[2] Because most of the above named risk factors are modifiable,[3] positive behaviour changes have been recommended to delay or prevent chronic health problems, including regular exercise, healthy diet, weight loss, and smoking cessation.[4]

Depression is another important global health problem due to its high lifetime prevalence in the general population.[5] Depression is independently associated with unhealthy behaviours, suggesting the difficulty of modifying behaviour in depressive populations.[6,7] Several studies have provided evidence that depression is linked to metabolic syndrome and its components, including elevated fasting glucose, hypertension, and central obesity.[8,9] In addition, metabolic syndrome has been found to be a significant predictor of depression in prospective studies[10,11] and the reverse has also been reported.[12] In contrast, some studies have reported that no such association was observed.[13] Therefore, the findings of the existing studies have been inconsistent regarding the association between depression and metabolic syndrome.

In previous studies, the relationship of depression, un-

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healthy behaviour, and metabolic syndrome has not been investigated. The purpose of the present study was to determine whether depression was associated with metabolic syndrome and unhealthy behaviours in community residents by conducting a large-scale cross-sectional study.

METHODS

Study design

We performed a cross-sectional study using the baseline data of the Saku Cohort Study for Healthy Aging at Saku Central Hospital, which is one of the core hospitals in Nagano Prefecture, Japan. The Saku Cohort Study has been described elsewhere.[14] In brief, this cohort study was designed to determine the risk factors for chronic diseases, including type 2 diabetes, cardiovascular disease, and cancer, among the community residents in Nagano Prefecture.

Participants

From January 2009 to March 2010, 1,911 residents without a history of stroke, cardiovascular disease, or chronic renal failure participated in a general health screening at Saku Central Hospital. After the exclusion of the participants with missing data (n=501) and those aged ≥75 years (n=185), 1,225 participants (521 women and 704 men) were included for analysis. The mean age was 61.5 years (SD=8.3). There were no significant differences in sociodemographic variables between the participants who were included and excluded from the analyses.

Measures

The general health screening included demographic characteristics (e.g. age and gender), medical histories, and physical tests. In addition, we assessed the participants' physical activity levels and all participants completed self-administered questionnaires regarding depression and diet.

Physical and clinical examination

The physical tests included anthropometric measurements (height, weight, and waist circumference), body mass index (BMI), visceral fat area, laboratory tests, and blood pressure measurements. Each participant underwent all of the examinations on the same morning after an overnight fast (12 h). The waist circumference was an average of two abdominal measurements at the level of the umbilicus in a standing position. BMI was calculated as weight divided by the squared height. The visceral fat area was assessed by a computed tomography scan at the level of the umbilicus, with the participants in the supine position, and it was calculated using commercially available software (Fat Scan; N2 System Corp., Osaka, Japan). Blood samples were collected for the measurement of fasting plasma glucose, insulin, HbA1c, serum total cholesterol (TC), high-density lipoprotein (HDL) cholesterol, low-density lipoprotein (LDL) cholesterol, and triglyceride (TG) levels. The participants' blood pressure was also measured twice to calculate the two values.

Physical activity

The duration and intensity of each participant's physical activity were assessed for 20 days by triaxial accelerometry (Actimarker EW4800, Panasonic Electric Works, Newark, NJ). Using the data from the triaxial accelerometry, the metabolic equivalent (MET) intensity levels of this physical activity (PA) were calculated by a simple linear regression of Km. A previous validation study had investigated the relationship between oxygen uptake ($\dot{V}O_2$) during seven types of housework and seven levels of walking/running speeds and triaxial accelerations, and the results confirmed that PA and $\dot{V}O_2$ were highly correlated (r=0.93).[15] In the present study, we used the amount of moderate to vigorous (at the intensity of 3 METs or more) physical activity (MVPA) and daily step counts as the indices of physical activity.

Dietary intake and dietary habits

Dietary intake for the previous month was assessed using a validated brief self-administered diet history questionnaire (BDHQ).[16] The BDHQ is a structured questionnaire that inquires about the consumption frequency of 58 food and beverage items; the specified serving sizes are described in terms of the natural portions or the standard weight and volume measurements of the servings commonly consumed in the general Japanese population. The dietary intake of the energy of selected nutrients was estimated using an ad hoc computer algorithm for the 58 foods and beverages described in the BDHQ, based on the Standard Tables of Food Composition in Japan.[17] The BDHQ is a short form of the comprehensive version of a validated self-administered diet history questionnaire (DHQ).[18] The validation of the DHQ and BDHQ was performed using weighed dietary records or biological markers.[16] The validity of the energy-adjusted intakes of many nutrients and food groups has been previously studied in the adult Japanese population.[19]

We previously developed a health-related behaviour questionnaire that consists of four areas: smoking, alcohol consumption, exercise, and dietary habits. The dietary habits included nine measures (meal regularity, skipping breakfast, eating a well-balanced diet, having sweetened beverages or snacks in addition to a meal, eating quickly, eating supper within 2 h before bed ≥3 times per week, eating a snack after supper ≥3 times per week, and a preference for salty food).

Depression

Symptoms of depression were assessed using the Zung Self-rating Depression Scale (SDS), a self-reporting, 20-question instrument that assesses the psychological and somatic symptoms of depression.[20] The SDS is one of the most widely used self-report measures established in several studies as a valid, reliable instrument that measures depressive symptoms.[21] The SDS has 10 positively worded and 10 negatively worded questions. Each question is scored on a four-point scale: 1 for *feeling depressed a little of the time*; 2 for *feeling depressed some of the time*; 3 for *feeling depressed a good part of the time*; and 4 for *feeling depressed most of the time*. The possible total scores range from 20 to 80 and a score of ≥50 signifies depression. The participants in the present study were categorized into two groups: less than 50 (non-depression) and ≥50 (depression). The Japanese version of the SDS [22] has good internal consistency and validity,

encompassing most DSM-IV criteria for major depression.[23] Its reliability and validity have been adequate in several studies in order to measure depressive symptoms and usefulness was reported in various clinical studies of depression in Japan.[24]

Metabolic syndrome

Metabolic syndrome was diagnosed consistent with the criteria of the Examination Committee for the Criteria for the Diagnosis of Metabolic Syndrome in Japan 2005.[25] The definition of metabolic syndrome was abdominal obesity with a waist circumference ≥85 cm for men and ≥90 cm for women and two or more of the following three risk factors: 1) high blood pressure (systolic blood pressure [SBP] ≥130 mmHg and/or diastolic blood pressure ≥85 mmHg, or treatment for previously diagnosed hypertension), 2) hyperglycaemia (fasting glucose ≥110 mg/dL or treatment for previously diagnosed type 2 diabetes), and 3) dyslipidaemia (TG levels ≥150 mg/dL and/or HDL-cholesterol <40 mg/dL, or treatment for previously diagnosed dyslipidaemia).

In addition to the Japanese criteria, we also used International Diabetes Federation criteria. After we confirmed similarity in the associations between metabolic syndrome and depression in the database, we used the Japanese criteria actually adopted in Japan.

We defined 'pre- and metabolic syndrome' in this study as the presence of one or more of the three above criteria in addition to abdominal obesity.

Ethical considerations

The present study was reviewed and approved by the Ethical Committee of the National Center of Neurology and Psychiatry, the National Institute of Health and Nutrition, and Saku Central Hospital. Written informed consent was obtained from all participants before the study was initiated.

Statistical analysis

We used chi-square or Fisher's exact tests for categorical variables and Student's *t*-test for continuous variables. We also used multivariate logistic regression to determine which factors were independently associated with depression. After adjusting for potential confounders such as age, sex, body mass index, blood pressure, biochemical markers, physical activity, dietary intake, and dietary habits in the logistic regression analysis, the stepwise method was used for model selection. Results were presented as odds ratios (ORs) and 95% confidence intervals (CIs). All reported *p* values were two-tailed with a *p* value of 0.05 indicating statistical significance. Statistical analyses were performed using SPSS statistical software (Version 20.0 J; IBM Japan Inc., Tokyo).

RESULTS

The participants' characteristics and depression status are described in Table 1. Of all the participants, 40 women (7.7%) and 45 men (6.4%) were placed in the depression group (SDS ≥50). Although no association was observed between depression and metabolic syndrome in either men or women, the prevalence of pre- and metabolic syndrome was significantly higher in the depression group than in the non-depression group in women (17.5% vs 7.9%, p=0.046). In addition, the prevalence of high blood pressure, one of the metabolic syndrome components, was significantly higher in the depression group than in the non-depression group among the women (47.5% vs 30.6%, p=0.027) but not among the men. Among the women, SBP (p=0.037), serum insulin (p=0.013), and triglyceride levels (p=0.028) were significantly higher in the depression group than in the non-depression group, whereas HDL cholesterol level (p=0.025) was significantly lower in the depression group than in the non-depression group. Among the men, LDL (p=0.019) cholesterol level was significantly lower in the depression group than in the non-depression group.

Table 2 shows the associations of physical activity and dietary intake with depression. The amount of MVPA (METs-h/day) was significantly lower in the depression group than in the non-depression group among the women (p=0.004) but not among the men. The intake of sodium chloride equivalent (g/1,000 kcal) was significantly higher in the depression group than in the non-depression group both in men (p=0.006) and women (p=0.006). Among the men, the intakes of sucrose (g/1,000 kcal; p=0.022) and confectionery (g/1,000 kcal) products (p=0.027) were significantly lower in the depression group than in the non-depression group; in contrast, the intake of beverages was significantly higher in the depression group than in the non-depression group (p=0.033).

The dietary habits were different between the women and men. Among the women, the responses of 'skipping breakfast' (p=0.013), 'a preference for salty food' (p=0.003), and 'gained more than 10 kg weight from that at age 20' (p=0.022) were significantly higher in the depression group than in the non-depression group. In contrast, among the men, the responses of 'eating a well-balanced diet' (p=0.009) and 'having snacks in addition to a meal' (p<0.001) were significantly lower in the depression group than in the non-depression group. The responses 'eating supper within 2 h before bed ≥3 times per week' (p=0.006) and 'drinking more than approximately 60 g of an alcohol equivalent at a time' (p=0.014) were significantly higher in the depression group than in the non-depression group.

We performed multiple stepwise logistic regression analysis to examine the factors that were related to depression. Among the women, physical activity (adjusted odds ratio [AOR]=0.66, 95% CI 0.51-0.88, p=0.003), the intake of sodium chloride equivalents (AOR=1.42, 95% CI 1.08-1.86, p=0.012), the responses of 'skipping breakfast' (AOR=3.18, 95% CI 1.30-7.77, p=0.011), and 'a preference for salty food' (AOR=2.99, 95% CI 1.32-6.77, p=0.009) were significantly associated with depression. Among the men, the serum TG levels (AOR=1.00, 95% CI 1.00-1.01, p=0.034), the intake of sodium chloride equivalents (AOR=1.61, 95% CI 1.21-2.13, p=0.001), the intake of light-coloured vegetables (AOR=0.99, 95% CI 0.98-0.99, p=0.030), and the responses of 'having snacks in addition to a meal' (AOR=0.21, 95% CI 0.10-0.46, p<0.001), 'eating supper within 2 h before bed ≥3 times per week' (AOR=1.96, 95% CI 1.01-3.70, p=0.045), and 'eating snacks after supper ≥3 times per week'

Table 1. Participants' characteristics and depression status

Participants characteristics (mean±SD)	Women			Men		
	SDS <50 (n=481)	SDS ≥50 (n=40)	p^*	SDS <50 (n=659)	SDS ≥50 (n=45)	p^*
Age (years)	57.9±8.0	59.0±7.5	0.395	57.5±8.5	57.9±7.3	0.747
Waist circumference (cm)	79.7±8.5	82.4±9.7	0.056	84.8±7.5	84.1±8.2	0.517
BMI (kg/m^2)	22.0±3.0	22.9±4.0	0.094	23.6±2.7	23.2±2.8	0.403
Visceral fat area (cm^2)	67.0±31.8	86.9±61.0	0.215	117±42.5	111±43.9	0.550
SBP (mmHg)	115±15.1	120±14.8	0.037	121±15.1	117±13.5	0.105
DBP (mmHg)	68.4±10.3	70.3±10.7	0.261	75.2±10.0	73.9±10.6	0.410
FBS (mg/dl)	98.3±15.5	99.5±11.2	0.632	104±18.1	102±11.8	0.326
HbA1c (%)	5.3±0.5	5.4±0.4	0.662	5.4±0.6	5.2±0.3	0.116
Insulin (μ/mL)	4.2±2.5	5.2±3.0	0.013	4.9±3.8	4.5±3.0	0.513
Total-C (mg/dL)	209±32.8	206±33.7	0.542	55.7±14.1	55.7±14.8	0.115
HDL-C (mg/dL)	65.8±14.6	61.0±14.7	0.025	56.4±13.9	55.7±15.7	0.762
LDL-C (mg/dL)	122±29.0	127±32.0	0.700	121±28.6	110±30.7	0.019
Triglyceride (mg/dL)	90.1±44.5	106±51.0	0.028	122±72.4	157±126	0.066
Metabolic syndrome (MetS) and its components (n, %)						
MetS (waist circumference + ≥2 MetS component)	22 (4.6)	4 (10.0)	0.130	123 (18.7)	6(13.7)	0.432
Pre- and MetS (Waist circumference + ≥1 MetS component)	38 (7.9)	7 (17.5)	0.046	252 (38.2)	12(26.7)	0.121
Abdominal obesity	57 (11.9)	8 (20.0)	0.109	324 (49.2)	17(37.8)	0.139
High blood pressure	147 (30.6)	19 (47.5)	0.027	254 (38.5)	15(33.3)	0.486
Hyperglycaemia	62 (12.9)	8 (20.0)	0.152	163 (24.7)	8(17.8)	0.193
Dyslipidaemia	130 (27.0)	14 (35.0)	0.279	233 (35.4)	20(44.4)	0.219

Values are mean±SD or number (%).
SDS: Zung Self-rating Depression Scale; BMI: body mass index; SBP: systolic blood pressure; DBP: diastolic blood pressure; FBS: fasting blood sugar; HbA1c: haemoglobin A1c; Total-C: total cholesterol; HDL-C: high density lipoprotein cholesterol; LDL-C: low density lipoprotein cholesterol; MetS: metabolic syndrome.
Abdominal obesity: waist circumference ≥85 cm for men, ≥90 cm for women.
High blood pressure: systolic blood pressure (SBP) ≥130 mmHg and/or diastolic blood pressure (DBP) ≥85 mmHg, or anti-hypertensive medication use.
Hyperglycaemia: fasting glucose ≥110 mg/dL or anti-diabetic medication use.
Dyslipidaemia: triglyceride ≥150 mg/dl and/or high density lipoprotein (HDL) cholesterol <40 mg/dL, or anti-hyperlipidemic medication use.
*Student's *t*-test for continuous variables and Pearson's chi-square test or Fisher's exact test for categorical variables.

Table 2. Association of physical activity and dietary intake with depression

Variables (mean±SD)	Women			Men		
	SDS <50 (n=481)	SDS ≥50 (n=40)	p^*	SDS <50 (n=659)	SDS ≥50 (n=45)	p^*
Physical activity						
Step counts (steps/day)	8803±3217	7795±3066	0.057	9042±3495	9477±3792	0.422
Amount of MVPA (METs-h/day)	3.4±1.8	2.5±1.4	0.004	3.1±2.3	3.3±2.2	0.676
Dietary intake						
Nutrient						
Energy (kcal/day)	1994±497	1858±485	0.097	2446±648	2313±655	0.183
Protein (% energy)	16.4±2.7	16.5±2.6	0.772	14.7±2.7	14.9±2.5	0.625
Fat (% energy)	29.1±4.4	28.4±4	0.305	25.1±4.8	24.7±6.2	0.679
Carbohydrate (% energy)	52.3±6.2	52.8±6.2	0.618	52.1±7.4	50.4±9.4	0.125
Sodium chloride equivalent (g/1,000 kcal)	6.3±1.1	6.8±1.3	0.006	5.8±1.1	6.3±1.2	0.006
Potassium (mg/1,000 kcal)	1717±344	1688±423	0.677	1404±328	1382±375	0.655
Calcium (mg/1,000 kcal)	351±83	360±111	0.598	288±82	294±92	0.625
Magnesium (mg/1,000 kcal)	161±27	161±33	0.890	140±26	141±27	0.903
Iron (mg/1,000 kcal)	5.0±0.9	5.0±1.0	0.776	4.3±0.9	4.3±1.1	0.927
Zinc (mg/1,000 kcal)	4.7±0.5	4.7±0.5	0.517	4.3±0.5	4.2±0.6	0.297
β-carotene equivalent (μg/1,000 kcal)	2981±1450	2831±1355	0.527	2067±1107	1941±1134	0.461
Retinol equivalent (μg/1,000 kcal)	450±191	501±292	0.290	395±205	415±226	0.576
Vitamin D (μg/1,000 kcal)	11.0±5.6	11.3±5.6	0.721	8.7±4.7	9.6±5.3	0.245
Vitamin K (μg/1,000 kcal)	234±90	223±91	0.484	187±78	174±92	0.283
Vitamin B-1 (mg/1,000 kcal)	0.47±0.08	0.46±0.07	0.417	0.40±0.07	0.39±0.09	0.417
Vitamin B (mg/1,000 kcal)	0.79±0.13	0.8±0.18	0.862	0.69±0.15	0.70±0.18	0.712
Niacin (mg/1,000 kcal)	10.4±2.3	10.5±2.1	0.926	9.2±2.2	9.6±2.2	0.366
Vitamin B-6 (mg/1,000 kcal)	0.82±0.16	0.81±0.16	0.585	0.71±0.15	0.71±0.16	0.856
Vitamin B-12 (μg/1,000 kcal)	6.6±3.0	7.0±3.0	0.372	5.7±2.6	6.3±2.5	0.132
Folate (μg/1,000 kcal)	243±64	241±74	0.906	194±57	191±67	0.706
Vitamin C (mg/1,000 kcal)	89±28	90±40	0.762	65±24	64±32	0.798
Saturated fatty acid (g/1,000 kcal)	7.64±1.45	7.39±1.42	0.287	6.59±1.55	6.48±2.26	0.755
Monounsaturated fatty acid (g/1,000 kcal)	11.5±1.95	11.2±1.6	0.225	9.97±2.02	9.79±2.57	0.649
Polyunsaturated fatty acid (g/1000 kcal)	8.95±1.62	8.9±1.69	0.840	7.75±1.62	7.61±1.72	0.592
n-6 polyunsaturated fatty acid (g/1,000 kcal)	6.95±1.31	6.88±1.36	0.762	6.06±1.28	5.89±1.39	0.405
n-3 polyunsaturated fatty acid (g/1,000 kcal)	1.97±0.47	1.98±0.47	0.900	1.66±0.46	1.69±0.5	0.666
Cholesterol (mg/1,000 kcal)	215±66	206±73	0.401	190±63	195±71	0.606
Sucrose (g/1,000 kcal)	9.1±7.2	7.6±6.5	0.214	8.4±8.2	5.5±5.8	0.022
Total dietary fiber (g/1,000 kcal)	8.4±2.1	8.4±2.5	0.904	6.7±1.8	6.4±2.2	0.298
Alcohol (g/1,000 kcal)	1.8±4.5	1.8±4.8	0.991	9.4±9.5	12.1±13.7	0.195

Table 2. Association of physical activity and dietary intake with depression (cont.)

Variables (mean±SD)	Women			Men		
	SDS <50 (n=481)	SDS ≥50 (n=40)	p^*	SDS <50 (n=659)	SDS ≥50 (n=45)	p^*
Food group (g/1000 kcal)						
Cereals	201±51.9	214±68	0.263	232±61.6	226±75.4	0.564
Potatoes	41.5±25.2	38±24.9	0.404	34.5±23.9	29.8±19.7	0.198
Sugar and confectioneries	2.3±1.4	2.3±1.7	0.959	2.1±1.7	1.9±1.2	0.423
Bean and soybean product	43.3±19.2	45.1±26.9	0.592	37.3±18.3	36.4±16.7	0.745
Green and yellow vegetables	74.5±38.6	71.6±36.9	0.639	54.5±30.3	53.5±33.4	0.839
Light-coloured vegetables	134±54.4	135±58.7	0.963	94.4±42.1	83.3±39.4	0.086
Fruits	63±38.5	62.2±54.9	0.930	38.7±30.1	39.0±36.9	0.951
Fish and shellfish	60.9±29.2	62.9±26	0.675	50.6±25.7	53.6±24.8	0.454
Meats	30.9±15.5	30.7±13.2	0.959	29.5±13.9	29.0±15.9	0.819
Eggs	20.0±11.7	16.6±11.8	0.080	18.8±11.1	20.1±12.3	0.438
Milk and dairy product	70.4±40.7	73.0±44.6	0.698	61.3±42.5	62.3±61.1	0.912
Fat and oil	13.7±3.8	13.2±3.6	0.463	11.7±3.6	11.5±3.4	0.686
Confectionery	25.2±15.4	21.3±14.2	0.123	16.6±13.5	12.1±10.8	0.027
Preference for beverages	387±152	425±227	0.150	423±174	481±206	0.033

Values are mean±SD.
SDS: Zung Self-rating Depression Scale; MVPA: moderate to vigorous physical activity.
*Student's *t*-test

Table 3. Association between dietary habits and depression

		Women			Men		
		SDS <50 (n=481)	SDS ≥50 (n=40)	*p*	SDS <50 (n=659)	SDS ≥50 (n=45)	*p*
I have meal three times regularly	Yes	447 (92.9)	34 (85.0)	0.075	588 (89.2)	38 (84.4)	0.221
I often skipping breakfast	Yes	36 (7.5)	8 (20.0)	0.013*	62 (9.4)	5 (11.1)	0.430
I have a meal thinking about well-balanced meal	Yes	443 (92.1)	35 (87.5)	0.226	509 (77.2)	27 (60.0)	0.009*
I eat snacks in addition to a meal	Yes	442 (87.7)	35 (87.5)	0.561	336 (55.5)	12 (26.7)	<0.001**
I eat a meal quickly than others	Yes	181 (37.6)	12 (30.0)	0.337	309 (46.9)	24 (53.3)	0.402
I eat dinner 2 hours before going to sleep ≥3 times per week	Yes	76 (15.8)	9 (22.5)	0.187	181 (27.5)	21 (46.7)	0.006**
I eat a snack after dinner ≥3 times per week	Yes	61 (12.7)	4 (10.0)	0.424	76 (11.5)	7 (15.6)	0.272
I like a salty food and eat a lot	Yes	42 (8.7)	10 (25.0)	0.003*	126 (19.1)	10 (22.2)	0.365
I like a sweet food and eat a lot	Yes	160 (33.3)	12 (30.0)	0.673	155 (23.5)	11 (24.4)	0.888
I drink alcohol more than about 60 g in alcohol equivalent at a time	Yes	1 (0.2)	0 (0.0)	0.923	27 (4.1)	6 (13.3)	0.014*
I increased or decreased my weight more than 3 kg in this year	≥-3kg	24 (5.0)	5 (12.5)	0.119	64 (9.7)	8 (17.8)	0.285
	≥+3kg	27 (5.6)	4 (10.0)		57 (8.6)	3 (6.7)	
I gained weight more than 10 kg from 20 years old	Yes	104 (21.6)	15 (37.5)	0.022**	303 (46.0)	19 (42.2)	0.625

Values are number (%).
SDS: Zung Self-rating Depression Scale.
*Fisher's exact test.
**Pearson's chi-square test.

Table 4. Multiple stepwise logistic regression analysis of factors related to depression

	Women			Men		
	AOR	95%CI	*p*	AOR	95%CI	*p*
Triglyceride (mg/dL)				1.00	1.00-1.01	0.034
Physical activity (METs-h/day)	0.66	0.50-0.87	0.003			
Intake of sodium chloride equivalent (g/1000 kcal)	1.42	1.08-1.86	0.012	1.61	1.21-2.13	0.001
Intake of light-coloured vegetables (g/1000 kcal)				0.99	0.98-0.99	0.030
I often skip breakfast. (0=No, 1=Yes)	3.18	1.30-7.77	0.011			
I eat sweetened beverages and snacks other than a meal. (0=No, 1=Yes)				0.21	0.10-0.46	<0.001
I eat supper within 2 hours before bed ≥3 times per week. (0=No, 1=Yes)				1.96	1.01-3.70	0.045
I eat snacks after dinner ≥3 times per week. (0=No, 1=Yes)				2.63	1.01-7.14	0.049
I like salty food and eat a lot. (0=No, 1=Yes)	2.99	1.32-6.77	0.009			

SDS <50, 0; SDS ≥50, 1.
SDS: Zung Self-rating Depression Scale; AOR: adjusted odds ratio, CI: confidence interval.
Variables included in the model were all measured items (age, sex, body mass index, waist circumference, blood pressure, biochemical markers, physical activity, dietary intake, dietary habits).

(AOR=2.63, 95% CI 1.01-7.14, p=0.049) were significantly associated with depression.

DISCUSSION

The results of the present study revealed that pre- and metabolic syndrome was associated with depression in women, although depression itself was not associated with the prevalence of metabolic syndrome in men or women. Depression was associated with unhealthy behavioural factors in both men and women; however, many of these factors differed between them.

Although the results of previous studies have been inconsistent regarding the association between depression and metabolic syndrome,[10-13] a meta-analysis study showed that depression and metabolic syndrome were significantly correlated, and a bidirectional association was observed.[26] The interaction between depression and metabolic syndrome may be mediated through multiple mechanisms.

In addition, previous studies suggest that depression is involved in the development of cardiovascular disease in both men and women.[27] This is of particular importance because several studies have shown depression and its associated symptoms to be a major risk factor for both the development of cardiovascular disease and death after myocardial infarction. A meta-analysis of 11 studies concluded that depression predicts the development of coronary heart disease in initially healthy people.[28]

Gender differences in the relationship between depression and metabolic syndrome or its components are not consistent in the literature. Cross-sectional and longitudinal studies found an association only in women, not in men,[8,29] or found a stronger association in women than in men.[9] The results of our present study also suggest that the association between depression and metabolic syndrome might be more prevalent in women than in men. Conversely, other studies have shown an association with metabolic syndrome or its components in men but not in women.[30] These previous studies were also conducted with general populations, in some areas similar to that in the present study.

The variability of study outcomes is likely a consequence of the heterogeneity of the study design, sample composition, range of ages, measurement approaches, and definition of metabolic syndrome. Some authors proposed that a number of possible physiological mechanisms connecting metabolic syndrome and depressive symptoms might be increased levels of inflammatory markers, such as interleukin-6, C-reactive protein, and cortisol levels.[31,32] Another study suggested that the more profound association between depression and disturbances in physiological functioning might explain the higher risk for metabolic syndrome associated with more frequent melancholic symptoms in women.[33] The reason for this gender difference is not discussed but the health risks linked to depression may be more critical to women.

The findings of the present study suggest that depressed women have unhealthy behavioural factors that may lead to metabolic syndrome. It is well known that depressed individuals more often engage in unhealthy behavioural factors than non-depressed individuals.[34] Depressed individuals are less likely to have regular and healthy dietary habits; some people will occasionally eat to excess due to the psychological distress of depression, which can also lead to weight gain.[35] In addition, the depressed women in the present study engaged in low amounts of physical activity. Physical inactivity is a risk factor for several common chronic diseases, including type 2 diabetes, hypertension, and depression. Depressed individuals also tend to engage in less physical activity.[36] Research has also shown that long-term weight gain in adulthood has a significant impact on the incidence of type 2 diabetes.[37] The history of women in the present study likely implied this pathway; low physical activity and irregular dietary habits such as skipping breakfast may have been associated with the weight gain of more than 10 kg from their weight at age 20 in the depressed women.

Previous studies have suggested that depression is associated not only with metabolic syndrome but also with each of its components, i.e. high blood pressure, high TG levels, low HDL cholesterol levels, and insulin resistance.[8,10] We also found that depression in women was associated with high blood pressure, low HDL cholesterol, high TG levels, and high insulin levels. In addition, the depressed women had a higher dietary intake of sodium, which has been associated with increased blood pressure levels.[38] Although the difference in blood pressure between the depressed and non-depressed groups is small and may not be clinically significant in this cohort, it is worth noting from the preventive perspective. In the men, depression was associated with LDL levels. Some epidemiological studies showed an association between low serum cholesterol concentrations and depressive states in the elderly,[39] but other studies found no association between depressive disorder and low serum cholesterol levels after adjustment for confounding factors.[40] The serum cholesterol level is complexly influenced by age, gender, and hereditary factors. The direct mechanism of the association between depression and serum cholesterol levels has not been established because of inconsistent study results. A few studies reported that abnormality in the sense of taste is related to depression. Depressed patients rated high-concentration sucrose solutions as more pleasant compared to non-depressed controls.[41] Cortisol concentrations following exposure to stress were associated with perception and diminished taste intensity.[42]

We found that the unhealthy behavioural factors associated with depression were different between the men and women in the present study. Among the men, preferences for beverages and alcohol were prevalent in the depression group. Depression may strengthen the taste and desire for beverages and alcohol as well as abate the taste and desire for sweet and confectionery items in men. The depressed men also had a low intake of light-coloured vegetables and were unlikely to eat a well-balanced diet but were more likely to eat a late supper or snack before bedtime; in contrast, the depressed women were more likely to skip breakfast and to prefer salty foods. A previous study suggests that depression is negatively associated with health-promoting behaviours.[7] It was not clear in our present study whether the depressed men developed metabolic syndrome through different unhealthy behavioural factors or depression. Unhealthy

behavioural factors may not be related to metabolic syndrome in men. The reason for this discrepancy has not been clearly resolved, but it may be attributable to the heterogeneity in hereditary factors, hormonal factors, socioeconomic factors, and the social roles between men and women. Any gender differences should be interpreted with caution given the absence of an interaction between depression and gender in predicting metabolic syndrome.

There were numerous limitations in the present study. First, the subjects of this study were healthy community residents seen for general health check-ups and those with cardiovascular diseases were excluded. Assuming many people with metabolic syndrome were excluded because of their comorbidities, the prevalence of metabolic syndrome, particularly in women, was very low; thus, the statistical power was insufficient to show a correlation between depression and metabolic syndrome. Moreover, there is the possibility that the association of metabolic syndrome and depression has been underestimated. Second, we performed neither psychiatric structured interviews nor assessments using other instruments to screen for depression. Although the SDS is one of the most widely used self-report measures for depression and depressive symptoms,[21] the SDS alone is not sufficient for the diagnosis of depression. Third, because the presence of bipolar disorder or other comorbid mental disorders cannot be ruled out in depressed participants, these comorbidities and their treatments might also have affected the prevalence of metabolic syndrome. Fourth, it was found that the use of a pedometer is associated with significant increases in physical activity. Because all participants in the present study were examined by accelerometry, there may not be a significant impact on their physical activity. However, it is necessary to consider the possible impact of monitoring on physical activity in future studies. Fifth, because of the cross-sectional nature of the study, the results cannot be used to conclude that there is a causal inference between depression and metabolic syndrome. It was not clear from the results of the present study whether depression caused unhealthy behavioural factors such as physical inactivity or unhealthy dietary habits. Sixth, the participants were those who had a voluntary general health screening; these individuals may be more health conscious than those who did not come in for a screening. In fact, obesity and metabolic syndrome were less prevalent in the study population than in the general population. We cannot rule out the possibility of selection bias. Finally, the generality of the present study is limited because the participants came from the same community of residents; their diet and unhealthy behavioural factors may have similar geographic characteristics.

In conclusion, despite these limitations, our findings provided insights for a better understanding of the relationships among depression, metabolic syndrome, and unhealthy behavioural factors. Although it remains unclear whether depression leads to unhealthy behavioural factors or vice versa, these findings highlight the importance of a better understanding of the role of depression and unhealthy behavioural factors in metabolic syndrome, particularly among women. Our findings suggest that clinicians and health care professionals should consider psychological factors in addition to the assessment of physical status when caring for these patients.

Although depression is common in medical patients, it often goes untreated or undertreated.

Previous studies have suggested that patients with depression comorbid with chronic physical disorder have significant difficulty overcoming both diseases and are likely to have a poor prognosis.[43]

The association of depression with metabolic syndrome is important regarding early interventions for both diseases. The treatment of depression improves life expectancy in people with physical health problems and collaborative care for patients with depression and chronic disease has been effective for the control of both depression and comorbidities.[44]

Careful monitoring of unhealthy behavioural factors and psychological states by a team of care providers including dieticians and mental health professionals may enhance self-care with unhealthy behaviour modifications (appropriate diet and physical activity) and improve mental health; this may lead to the prevention of metabolic syndrome.

In the future, a larger-scale epidemiological study is needed to re-examine the association between metabolic syndrome and depression, to assess the severity of depression, and to focus on modifiable unhealthy behaviours.

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AUTHOR DISCLOSURES

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