

ORIGINAL ARTICLE

Dietary patterns and depressive symptoms among Japanese men and women

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Objective: Although several studies have reported associations of depressive state with specific nutrients and foods, few studies examined the association with dietary patterns in adults. We investigated the association between major dietary patterns and depressive symptoms in Japanese.

Methods: Subjects were 521 municipal employees (309 men and 212 women), aged 21–67 years, who participated in a health survey at the time of periodic checkup. Depressive symptoms were assessed using the Center for Epidemiologic Studies Depression (CES-D) Scale. Dietary patterns were derived by using principal component analysis of the consumption of 52 food and beverage items, which was assessed by a validated brief diet history questionnaire. Logistic regression analysis was used to estimate odds ratios of depressive symptoms (CES-D ≥ 16) with adjustment for potential confounding variables.

Results: We identified three dietary patterns. A healthy Japanese dietary pattern characterized by high intakes of vegetables, fruit, mushrooms and soy products was associated with fewer depressive symptoms. The multivariate-adjusted odds ratios (95% confidence intervals) of having depressive symptoms for the lowest through highest tertiles of the healthy Japanese dietary pattern score were 1.00 (reference), 0.99 (0.62–1.59) and 0.44 (0.25–0.78), respectively (P for trend = 0.006). Other dietary patterns were not appreciably associated with depressive symptoms.

Conclusions: Our findings suggest that a healthy Japanese dietary pattern may be related to decreased prevalence of depressive status.

European Journal of Clinical Nutrition (2010) **64**, 832–839; doi:10.1038/ejcn.2010.86; published online 19 May 2010

Keywords: cross-sectional studies; depression; dietary patterns; Japanese

Introduction

Depression is an important public health issue worldwide (Doris *et al.*, 1999). Persons with severe depression have limited social life due to the symptoms and are at increased risk of suicide (Doris *et al.*, 1999). In Japan, the number of inpatient and outpatient of depression has been increasing, and suicide rate is among the highest in the world, with more than 30 000 deaths from suicide recorded over the last decade (Ministry of Health, Labor, and Welfare, 2008).

Previously, several studies have examined the association of depressive symptoms with specific nutrients and foods such as folate (Gilbody *et al.*, 2007), other vitamin B (Tolmunen *et al.*, 2004; Murakami *et al.*, 2008), vitamin C (Smith *et al.*, 1999), *n*-3 polyunsaturated fatty acids (Jacka *et al.*, 2004; Murakami *et al.*, 2008), vitamin D (Lansdowne and Provost, 1998; Jorde *et al.*, 2008), vitamin E (Shibata *et al.*, 1999; Tiemeier *et al.*, 2002), vegetables (Mikolajczyk *et al.*, 2009; Oddy *et al.*, 2009) and fish (Tanskanen *et al.*, 2001; Timonen *et al.*, 2004); however, the results have been inconsistent. The investigation of a single food factor with disease risk may be problematic, given that foods and nutrients are consumed in combination and their complex effects are likely to be interactive or synergistic (Hu, 2002). To overcome these issues, the analysis of dietary patterns has gained much interest in nutritional epidemiology. A dietary

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Received 29 October 2009; revised 9 March 2010; accepted 9 March 2010; published online 19 May 2010

pattern is a comprehensive variable that integrates consumption of several foods or food groups, and is expected to have a greater impact on disease risk than any single nutrient (Hu, 2002).

To our knowledge, only three studies have examined the association between dietary patterns and depressive status (Samieri *et al.*, 2008; Akbaraly *et al.*, 2009; Oddy *et al.*, 2009). In a study of middle-aged adults (United Kingdom), a whole food pattern (high intakes of vegetables, fruits and fish) was inversely associated with depressive symptoms, whereas a processed food pattern (high intakes of processed meat, sweetened dessert, fried food and refined grains) was positively associated (Akbaraly *et al.*, 2009). In a study of elderly women (France) (Samieri *et al.*, 2008), a healthy dietary pattern (frequent consumptions of vegetables and fruit) was associated with fewer depressive symptoms. In a study of adolescents (Australia) (Oddy *et al.*, 2009), a higher score of a Western dietary pattern (high intakes of red and processed meats, takeaway foods, confectionery and refined foods) was associated with poorer mental health. However, we are not aware of any study on this issue among Japanese populations, which have different dietary characteristics from Western populations. Here, we examined the association between major dietary patterns and depressive symptoms in Japanese employees.

Subjects and methods

Subjects

The subjects were participants in a health survey conducted in July and November 2006 among employees of two municipal offices in northeastern Kyushu, Japan. At the time of periodic health examination, all full-time workers ($n = 601$), except those on long sick leave or maternity leave, were invited. Of these, 547 subjects (323 men and 224 women aged 21–67 years) participated in the survey (response rate 91%). Participants were asked to fill in survey questionnaires beforehand, which were checked by research staff for completeness and, where necessary, clarified by asking the subject during the examination. Also obtained were data that were routinely collected in the health examination, including anthropometric measurements, biochemical data, and information about medical history, smoking and alcohol drinking. After exclusion of 17 subjects with a history of cardiovascular disease or cancer and 5 subjects with missing information on diet, 525 workers (310 men and 215 women) were included for the analysis of dietary patterns. After further exclusion of four subjects with missing information for any of the variables used in the main analysis, 521 workers (309 men and 212 women) remained for the analysis of the association between dietary patterns and depressive symptoms. The protocol of the study has been approved by the ethics committee of the National Center for Global Health and Medicine, and written informed consent was obtained from each participant.

Depressive symptoms

Depressive symptoms were assessed using a Japanese version (Shima *et al.*, 1985) of the Center for Epidemiologic Studies Depression (CES-D) scale (Radloff, 1977), which was incorporated into the lifestyle questionnaire. This scale consists of 20 questions addressing 6 symptoms of depression, including depressed mood, guilt or worthlessness, helplessness or hopelessness, psychomotor retardation, loss of appetite and sleep disturbance experienced during the preceding week. Each question is scored on a scale of 0–3 according to the frequency of the symptom, and the total CES-D score ranges from 0 to 60. The criterion validity of the CES-D scale has been well established both in Western (Radloff, 1977) and Japanese (Shima *et al.*, 1985) subjects. Depressive symptoms were defined as present when subjects had a CES-D score of ≥ 16 .

Dietary assessment

Dietary habits during the preceding month were assessed using a validated brief self-administered diet history questionnaire (BDHQ) (Sasaki, 2004), which contains queries about the consumption frequency of 56 foods and beverages and 9 dishes commonly consumed in general Japanese populations. Dietary intake for energy and selected nutrients were estimated using an *ad hoc* computer algorithm for 56 foods and beverages of the BDHQ, with reference to the Standard Tables of Food Composition in Japan (Science and Technology Agency, 2005a,b). Because few subjects took dietary supplements on weekly basis (multivitamins 3.7%, vitamin D 0.2% and multiminerals 1.1%), dietary supplement was not incorporated into the analysis. According to the validation study of the BDHQ using 16-day weighed dietary records as the gold standard, Pearson correlation coefficients for 37 nutrients in 92 men and 92 women of 31–76 years of age were 0.15–0.74 (median: 0.50) and 0.27–0.76 (median: 0.50), respectively (Sasaki, 2004).

Other variables

Marital status, job title, job position and non-job physical activity were asked in the survey questionnaire. Job title was used to create categories for occupational physical activity; sedentary work: managerial and clerical jobs; physically active work: child-care, school lunch cooking and technical jobs. Non-job physical activity was asked for daily minutes spent for walking or cycling during commute to or from work and weekly hours engaged in each of five different activities in leisure (walking, low-, moderate-, and high-intensity activities and gardening). The sum of time spent for all the non-job activities or that for leisure-time activity were expressed in hours per week.

Statistical analysis

We performed principal component analysis on the basis of energy-adjusted intakes using a density method of 52 food and beverage items (excluding 4 items that overlapped with

others) to derive dietary patterns. The factors were rotated by orthogonal transformation (varimax rotation) to maintain uncorrelated factors and greater interpretability. We considered eigenvalues, the scree test and the interpretability of the factors to determine the number of factors to retain. The factors satisfied the criteria for eigenvalues greater than one, and the scree plots dropped substantially after the third factor (from 2.45 to 2.05) and remained similar after the fourth factor (2.05 for the fourth and 1.85 for the fifth factor); thus, we decided to retain three factors. Dietary patterns were named according to the food items showing high loading (absolute value) on three factors. The factor scores for each dietary pattern and for each individual were calculated by summing intakes of food items weighted by their factor loadings. Factor scores were categorized into tertiles. We performed sensitivity analysis on the method of extracting factor. When oblique rotation (promax rotation) was used, a factor loading pattern similar to that derived from orthogonal rotation was obtained. Moreover, when dietary patterns were extracted on the basis of a reduced set of food groups (40 food groups), similar dietary patterns emerged.

The confounding variables considered were age (year, continuous), sex, workplace (A or B), marital status (married or unmarried), body mass index (kg/m^2 , continuous), job position (low, middle or high), occupational physical activity (sedentary or active work), current smoking (yes or no), non-job physical activity (0, 0 to <2 or ≥ 2 h/week), history of hypertension (yes or no), history of diabetes mellitus (yes or no) and total energy intake (kcal, continuous). Difference in proportions and means of covariates according to depressive symptoms was assessed by using χ^2 -test and independent *t*-test, respectively. Trend association across tertile categories of each dietary pattern was assessed by using Mantel-Haenszel χ^2 -test for categorical variables and linear regression analysis for continuous variables, assigning ordinal numbers 0–2 to tertile categories of each dietary pattern.

Multiple logistic regression was performed to estimate the odds ratio and 95% confidence interval of depressive symptoms for the tertiles of scores for each dietary pattern, taking the lowest tertile group as the reference. The first model was adjusted for age, sex and workplace, and the second model was further adjusted for marital status, body mass index, job position, occupational physical activity, current smoking, non-job physical activity, history of hypertension, history of diabetes mellitus and total energy intake. Trend association was assessed by assigning ordinal numbers 0–2 to tertile categories of each dietary pattern. Two-side *P*-values less than 0.05 were considered as statistically significant. All analyses were performed using Statistical Analysis System (SAS) version 9.1 (SAS Institute, Cary, NC, USA).

Results

We identified three dietary patterns by principal component analysis (Table 1). The first factor was named a healthy

Table 1 Factor loading matrix for major dietary patterns identified by principal component analysis^a

	Healthy Japanese dietary pattern	Animal food pattern	Westernized breakfast pattern
Carrots/pumpkin	0.78	—	—
Mushrooms	0.73	—	—
Green leaves vegetables	0.69	—	—
Cabbage/Chinese cabbage	0.68	0.17	—
Japanese radish/turnip	0.68	—	—
Other root vegetables	0.67	—	—
Tofu/atsuage ^b	0.50	—	–0.16
Seaweeds	0.48	0.16	–0.16
Potatoes	0.46	—	—
Other fruit	0.37	—	0.21
Persimmons/strawberries/kiwifruit	0.31	—	—
Natto ^c	0.30	—	—
Citrus fruit	0.25	—	—
Green tea	0.22	—	—
100% fruit and vegetable juice	–0.19	—	0.17
Buckwheat noodles	–0.25	0.18	—
Cola drink/soft drink	–0.29	—	0.15
Chinese noodles	–0.44	—	—
Squid/octopus/shrimp/shellfish	–0.16	0.47	–0.21
Canned tuna	—	0.44	—
Lean fish	—	0.43	—
Pork/beef	—	0.43	—
Dried fish/salted fish	—	0.41	–0.23
Ham/sausage/bacon	—	0.37	—
Chicken	—	0.37	—
Oily fish	—	0.33	–0.29
Lettuces/cabbage (raw)	0.21	0.30	0.17
Tomatoes	0.19	0.29	—
Mayonnaise/dressing	—	0.29	0.28
Small fish with bones	0.20	0.28	–0.23
Liver	—	0.27	—
Egg	—	0.21	0.21
Black tea/oolong tea	—	0.19	—
Other pickles	—	0.18	—
Rice	—	–0.67	–0.34
Bread	—	—	0.57
Western-type confectioneries	—	—	0.56
Milk and yogurt	—	—	0.36
Rice crackers/rice cake/okonomiyaki ^d	—	—	0.36
Japanese confectioneries	—	—	0.34
Ice cream	–0.19	—	0.31
Miso soup	—	—	–0.18
Pickled green leaves vegetables	0.18	0.18	–0.24
Sake	—	—	–0.26
Beer	–0.21	—	–0.41
Shochu	–0.24	—	–0.45

^aFactor loading less than ± 0.15 is represented by a dash for simplicity. Omitted in the table were food items with factor loadings less than ± 0.15 for all dietary patterns (coffee, Japanese wheat noodles, low-fat milk and yogurt, spaghetti and macaroni, whisky and wine).

^bDeep-fried tofu.

^cFermented soybeans.

^dMeat/fish and vegetables pancake.

Table 2 Characteristics according to subjects with and without depressive symptoms

	Subjects with depressive symptoms ^a	Subjects without depressive symptoms ^b	P-value ^c
Number of subjects	186	335	
Age (mean ± s.d., year)	42.6 ± 10.2	42.9 ± 11.0	0.74
BMI (mean ± s.d., kg/m ²)	22.3 ± 3.5	22.7 ± 3.4	0.23
Women (%)	41.4	40.3	0.81
Workplace A (%)	25.8	33.4	0.07
Married (%)	64.0	72.5	0.04
Current smoking (%)	29.0	27.8	0.76
Sedentary work (%)	84.9	78.5	0.07
Physical activity ^d (≥2 h/week, %)	29.0	37.0	0.07
Job position (low, %)	55.9	57.0	0.81
History of hypertension (%)	5.4	4.2	0.53
History of diabetes mellitus (%)	1.6	2.7	0.43
<i>Dietary intake (mean ± s.d.)</i>			
Energy (kcal/day)	1747 ± 537	1763 ± 497	0.73
Folate (µg/1000 kcal)	186.4 ± 62.9	199.0 ± 72.2	0.046
Vitamin C (mg/1000 kcal)	60.5 ± 27.4	63.6 ± 25.2	0.19
Vitamin D (µg/1000 kcal)	6.3 ± 3.2	6.4 ± 3.6	0.74
Vitamin E (mg/1000 kcal)	4.0 ± 1.1	4.2 ± 1.1	0.06

Abbreviation: BMI, body mass index.

^aSubjects with a Center for Epidemiologic Studies Depression scale score ≥16.

^bSubjects with a Center for Epidemiologic Studies Depression scale score <16.

^cFor continuous variables, independent *t*-test was used; for categorical variables, χ^2 -test was used.

^dPhysical activity was expressed as the sum of weekly hours spent for sport activity, as well as walking and cycling on commuting and to work.

Japanese dietary pattern because it represented high intakes of not only vegetables and fruit but also soy products, mushrooms and green tea. The second factor was characterized by high intakes of fish and shellfish, meat, processed meat, mayonnaise and egg, and thus it was named an animal food pattern. The third factor represented high intakes of bread, confectioneries, milk and yogurt, mayonnaise and egg and low intakes of rice, alcohol and fish, and the pattern was named a westernized breakfast pattern. The first to third dietary patterns accounted for 9.9, 5.0 and 4.7%, respectively, of the variance in food intakes and totally explained 19.5% of the variability.

The characteristics of study subjects according to depressive symptoms are shown in Table 2. One hundred eighty six subjects (35.7%) were identified as having depressive symptoms (CES-D scale scores of ≥16). Compared with subjects who did not have depressive symptom, those with depressive symptoms were less likely to be married and physically active and more likely to be engaged in sedentary work, and they consumed less amount of folate and vitamin E.

Table 3 shows the characteristics according to tertile categories of dietary pattern scores. Subjects with a higher score of the healthy Japanese and westernized breakfast patterns were more likely to be women and have lower body mass index but less likely to be a current smoker and engaged in sedentary work. The healthy Japanese and animal food patterns were positively associated with intakes of folate, vitamin C, vitamin D and vitamin E. Subjects with a higher score of the westernized breakfast pattern were younger, less

likely to be married and physically active on leisure, and more likely to be in low job position, and they consumed higher amount of vitamin C and vitamin E, but less amount of vitamin D.

The odds ratio of depressive symptoms according to tertile categories of each dietary pattern score are shown in Table 4. In an age-, sex- and workplace-adjusted model, the healthy Japanese dietary pattern was significantly associated with decreased prevalence of depressive symptoms. Further adjustment for other covariates somewhat attenuated the association, but the association remained statistically significant; the multivariate-adjusted odds ratios (95% confidence interval) for the lowest through highest tertiles of the dietary pattern were 1.00 (reference), 0.99 (0.62–1.59) and 0.44 (0.25–0.78), respectively (*P* for trend=0.006). When subjects with history of mental disease (*n*=14) were excluded, the corresponding values were 1.00 (reference), 1.00 (0.62–1.62) and 0.40 (0.22–0.71), respectively (*P* for trend=0.002). All the interactions between the three dietary patterns and other covariates were not statistically significant. When other cutoff values for the definition of depressive symptoms were used (≥19 that may be suitable for Japanese (Wada *et al.*, 2007) and ≥23 indicative of severe depressive state), the values for depressive symptoms (CES-D ≥19) were 1.00 (reference), 1.07 (0.64–1.79) and 0.42 (0.22–0.80), respectively (*P* for trend=0.01) and that for severe depressive state (CES-D ≥23) were 1.00 (reference), 0.62 (0.32–1.22) and 0.31 (0.14–0.71), respectively (*P* for trend=0.006). Other dietary patterns were not appreciably associated with depressive symptoms.

Table 3 Characteristics according to tertile categories of dietary pattern scores

	Healthy Japanese dietary pattern			Animal food pattern			Westernized breakfast pattern					
	T1 (low)	T2	T3 (high)	Trend P ^a	T1 (low)	T2	T3 (high)	Trend P ^a	T1 (low)	T2	T3 (high)	Trend P ^a
Number of subjects	173	174	174		173	174	174		173	174	174	
Age (mean ± s.d., year)	42.2 ± 10.2	42.1 ± 11.2	44.1 ± 10.7	0.11	43.0 ± 10.9	43.4 ± 10.3	42.1 ± 11.0	0.40	46.7 ± 10.5	41.6 ± 10.5	40.1 ± 10.1	<0.01
BMI (mean ± s.d., kg/m ²)	23.2 ± 3.3	22.4 ± 3.5	22.0 ± 3.4	<0.01	22.3 ± 3.2	22.5 ± 3.5	22.8 ± 3.5	0.19	23.2 ± 3.6	22.5 ± 3.4	21.9 ± 3.2	<0.01
Women (%)	12.1	40.0	70.1	<0.01	42.2	39.7	40.2	0.88	22.0	42.0	58.0	<0.01
Workplace A (%)	38.2	31.0	23.0	<0.01	18.5	35.6	37.9	<0.01	26.0	27.0	39.1	0.01
Married (%)	64.7	70.1	73.6	0.20	66.5	75.9	66.1	0.08	76.9	67.2	64.4	0.03
Current smoking (%)	46.2	25.9	12.6	<0.01	27.7	29.9	27.0	0.83	28.2	28.2	10.9	<0.01
Sedentary work (%)	87.9	83.3	71.3	<0.01	75.7	82.8	83.9	0.11	88.4	78.7	75.3	<0.01
Physical activity ^b (≥2 h/week, %)	34.1	32.8	35.6	0.85	34.1	28.7	39.7	0.10	39.3	37.4	25.9	0.02
Job position (low, %)	57.2	59.2	53.4	0.55	52.6	57.5	59.8	0.39	41.0	58.0	70.7	<0.01
History of hypertension (%)	2.9	7.5	3.4	0.08	4.0	2.3	7.5	0.06	7.5	4.0	2.3	0.06
History of diabetes mellitus (%)	1.2	2.3	3.4	0.36	1.2	1.1	4.6	0.047	2.9	2.9	1.1	0.46
<i>Dietary intake (mean ± s.d.)</i>												
Energy (kcal/day)	1763 ± 517	1771 ± 526	1739 ± 493	0.66	1748 ± 508	1737 ± 458	1788 ± 564	0.46	1780 ± 526	1815 ± 550	1678 ± 445	0.06
Folate (µg/1000 kcal)	145.5 ± 40.0	185.4 ± 35.0	252.3 ± 75.9	<0.01	176.1 ± 64.7	191.2 ± 58.2	216.1 ± 77.8	<0.01	192.1 ± 88.1	195.3 ± 58.9	196.1 ± 56.7	0.59
Vitamin C (mg/1000 kcal)	43.5 ± 18.1	58.7 ± 15.6	85.2 ± 24.0	<0.01	57.2 ± 25.5	61.2 ± 23.8	68.9 ± 27.6	<0.01	56.4 ± 28.0	64.2 ± 25.2	66.8 ± 23.8	<0.01
Vitamin D (µg/1000 kcal)	5.4 ± 3.1	6.5 ± 2.9	7.2 ± 4.1	<0.01	4.4 ± 2.0	6.0 ± 2.4	8.6 ± 4.2	<0.01	7.3 ± 4.1	6.5 ± 3.3	5.2 ± 2.4	<0.01
Vitamin E (mg/1000 kcal)	3.4 ± 0.8	4.0 ± 0.7	5.0 ± 1.0	<0.01	3.5 ± 0.9	4.1 ± 0.9	4.7 ± 1.1	<0.01	3.8 ± 1.3	4.2 ± 0.9	4.4 ± 1.0	<0.01

Abbreviation: BMI, body mass index.

^aOn the basis of the Mantel-Haenszel χ^2 -test for categorical variables and linear regression analysis for continuous variables, assigning ordinal numbers 0–2 to tertile categories of each dietary pattern.
^bPhysical activity was expressed as the sum of weekly hours spent for sport activity, as well as walking and cycling on commuting and to work.

Discussion

In this cross-sectional study of Japanese men and women, we identified three dietary patterns. A healthy Japanese dietary pattern characterized by high intakes of vegetables, fruit, soy products and mushrooms was associated with decreased prevalence of depressive symptoms. To our knowledge, this is the first analysis in Japanese adults and replicates findings in a European population (Akbaraly *et al.*, 2009).

Dietary patterns identified in this study have also been observed in previous Japanese studies. Of nine studies among Japanese populations, all have identified dietary patterns similar to the healthy Japanese dietary pattern in our study (Masaki *et al.*, 2003; Kim *et al.*, 2004; Mizoue *et al.*, 2005; Okubo *et al.*, 2006, 2007; Hirose *et al.*, 2007; Shimazu *et al.*, 2007; Nanri *et al.*, 2008; Sadakane *et al.*, 2008). In many cases, these patterns were associated with not only vegetables and fruits but also typical Japanese foods, including soy products, seaweed, mushrooms and green tea. The healthy Japanese dietary pattern in our study, however, was not characterized by high intake of fish and shellfish, which are generally considered as important components of healthy Japanese diet. Given that dietary patterns in this study were not extracted intentionally, all healthy Japanese foods were not necessarily included in the healthy pattern. Moreover, all fish and shellfish are not necessarily healthy. For example, dried or salted fish are high in salt and health effect of seafood other than fish is unclear. Nevertheless, intakes of lean fish and small fish with bones were modestly associated with the healthy Japanese dietary pattern (factor loading: lean fish, 0.145; small fish with bones, 0.197). Dietary patterns similar to the animal food pattern in our study have been documented in all the previous studies in Japan. Moreover, westernized breakfast pattern or those of the same kind have been observed in four of these studies (Masaki *et al.*, 2003; Shimazu *et al.*, 2007; Nanri *et al.*, 2008; Sadakane *et al.*, 2008). Because this dietary pattern was associated with low intakes of rice and miso soup, westernized breakfast pattern could be viewed as a mirror image of Japanese traditional pattern, which has been identified in some studies (Kim *et al.*, 2004; Okubo *et al.*, 2006, 2007; Hirose *et al.*, 2007).

In this study, we found an inverse association between the healthy Japanese dietary pattern and depressive symptoms among a middle-aged working population. Three studies have examined the association between dietary patterns and depressive state. In a study of middle-aged adults, a whole food pattern characterized by high intakes of vegetables, fruits and fish was inversely associated with depressive symptoms assessed by CES-D (Akbaraly *et al.*, 2009). In a study of the elderly, a healthy dietary pattern characterized by frequent consumptions of vegetables and fruits derived was associated with lower CES-D score in women (Samieri *et al.*, 2008). Another study among adolescents (aged 14) failed to observe an association between healthy dietary pattern and mental health (Oddy *et al.*, 2009). In that study,

Table 4 Odds ratios and 95% CIs for depressive symptoms according to tertiles of dietary pattern scores

	Tertiles of dietary pattern scores			Trend P ^a
	T1 (low)	T2	T3 (high)	
Number of subjects	173	174	174	
<i>Healthy Japanese dietary pattern</i>				
No of cases ^b	69	71	46	
Age, sex and workplace-adjusted OR (95% CI) ^c	1.00 (reference)	0.90 (0.57–1.41)	0.39 (0.23–0.67)	<0.001
Multivariate-adjusted OR (95% CI) ^{c,d}	1.00 (reference)	0.99 (0.62–1.59)	0.44 (0.25–0.78)	0.006
<i>Animal food pattern</i>				
No of cases ^b	59	71	56	
Age, sex and workplace-adjusted OR (95% CI) ^c	1.00 (reference)	1.43 (0.92–2.23)	0.99 (0.63–1.55)	0.94
Multivariate-adjusted OR (95% CI) ^{c,d}	1.00 (reference)	1.47 (0.93–2.32)	0.97 (0.61–1.55)	0.91
<i>Westernized breakfast pattern</i>				
No of cases ^b	60	60	66	
Age, sex and workplace-adjusted OR (95% CI) ^c	1.00 (reference)	0.99 (0.63–1.57)	1.21 (0.75–1.95)	0.43
Multivariate-adjusted OR (95% CI) ^{c,d}	1.00 (reference)	1.02 (0.64–1.64)	1.27 (0.77–2.10)	0.34

Abbreviations: CI, confidence interval; OR, odds ratio.

^aOn the basis of the multiple logistic regression analysis, assigning ordinal numbers 0–2 to tertile categories of each dietary pattern.

^bSubjects with a Center for Epidemiologic Studies Depression Scale score of ≥ 16 .

^cAdjusted ORs and 95% CIs were based on multiple logistic regression analysis.

^dAdjusted for age (year, continuous), sex, workplace (A or B), marital status (married or unmarried), body mass index (kg/m², continuous), job position (low, middle or high), occupational physical activity (sedentary or active work), current smoking (yes or no), non-job physical activity (0, 0 to <2 or ≥ 2 h/week), history of hypertension (yes or no), history of diabetes mellitus (yes or no) and total energy intake (kcal/day).

however, higher intakes of leafy green vegetables and fruits were associated with good mental health in food group-based analysis (Oddy *et al.*, 2009). In a Spanish study, Mediterranean dietary pattern, which is similar to the healthy Japanese pattern in terms of high intakes of vegetables, fruit and legumes, was associated with lower incidence of depression (Sanchez-Villegas *et al.*, 2009).

Previously, specific nutrients such as folate (Gilbody *et al.*, 2007), vitamin C (Smith *et al.*, 1999) and vitamin E (Shibata *et al.*, 1999; Tiemeier *et al.*, 2002) have been shown to be associated with decreased risk of depressive symptoms. In this study, subjects in the highest tertile of the healthy Japanese dietary pattern score consumed much greater amount of these vitamins than those in the lowest tertile. Folate is involved in the metabolism of monoamines such as serotonin in the brain and hypothesized to protect brain function by decreasing homocysteine, which has a neurotoxic effect through several mechanisms, including impaired methylation, excitotoxicity, oxidative stress and hypoxia in the central nervous system (Bottiglieri, 2005). In addition, it is hypothesized that oxidative stress caused by reactive oxygen species and defective antioxidant defenses may be involved in the pathophysiology of neuropsychiatric disorders (Bilici *et al.*, 2001). In this context, antioxidant vitamins such as vitamin C and vitamin E may have a role in decreasing risk of mood disorders. The clear inverse association with the healthy Japanese dietary pattern in this study may be ascribed to the combined effect of these nutrients on mood.

Major strengths of this study include high study participation rate and adjustment of known and suspected risk factor of depression symptoms. Because this study was conducted in selected municipal offices at the time of the nonselective recruitment for the annual health checkup and high study participation rate (91%), the possibility of selection bias is low. Our study had some limitations. First, an association derived from cross-sectional study does not necessarily indicate causality. Specifically, lower food intake among persons with depressive symptoms than those without could be ascribed to the difference in appetite, which is decreased in depressive state. However, this is not plausible in our study because total energy intake was similar between subjects with and without depressive symptoms. Nevertheless, we could not exclude a possibility that the choice of foods that determines dietary pattern has been changed due to depressive symptoms. Second, statistical power might not be sufficient to detect a moderate association. However, we also analyzed data for men and women combined and found a statistically significant inverse association for the healthy Japanese dietary pattern. Third, because study subjects were Japanese municipal employees, the present findings may not be generalized to the population with a different background. Finally, principal component analysis requires subjective decisions in determining the number of factors to retain, in choosing the method of rotation of the initial factors and in labeling the dietary patterns (Martinez *et al.*, 1998; Hu, 2002).

In conclusion, a healthy Japanese dietary pattern characterized by high intake of vegetables, fruit, mushrooms and soy products was associated with a decreased prevalence of depressive symptoms. The protective association obtained from this cross-sectional observation requires confirmation in prospective studies.

Conflict of interest

The authors declare no conflict of interest.

Acknowledgements

We thank Tamami Hatano, Akihiko Tanaka and Yuko Ejima (Kyushu University); Mio Ozawa (Fukuoka Women's University); and Akiko Hayashi and Kie Nagao (International Medical Center of Japan) for their help in data collection. This study was supported by Grant-in-Aid for Young Scientists (B)(21790598) from the Ministry of Education, Culture, Sports, Science and Technology (to Dr Nanri) and Grant-in-Aid for Scientific Research (C)(18590601) and (B)(21390213) from Japan Society for the Promotion of Science (to Dr Mizoue).

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