Risk Management and Healthcare Policy

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ORIGINAL RESEARCH

Associations Between Consumption of Different Vegetable Types and Depressive Symptoms in Japanese Workers: A Cross-Sectional Study

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Purpose: Vegetable intake is an important part of our everyday diet and is associated with many positive health outcomes. Although previous studies have investigated the association between vegetable consumption and depressive symptoms among various populations, no study has examined this association in the adult working population. The present study investigated whether the frequency of consumption of a specific type of vegetable is associated with the prevalence of depressive symptoms in Japanese adult workers.

Participants and Methods: The final participants consisted of 1724 Japanese adults, and a cross-sectional study was conducted to analyze the results. The frequency of vegetable consumption and depressive symptoms was evaluated using a brief-type self-administered diet history questionnaire and the Zung Self-Rating Depression Scale (SDS), respectively. The association between the variables was examined using Poisson regression analysis. Age-stratified analysis was performed, and SDS cut-off values of 45 and 50 were used to perform a sensitivity analysis.

Results: After adjustment for covariates, including age, body mass index, sociodemographic and lifestyle-related variables, health condition, C-reactive protein, and other dietary variables, an inverse association was found between tomato product consumption and the prevalence of depressive symptoms among men (P for trend <0.01); however, no significant association was found for other vegetable types. For women, there was no association between the frequency of consumption of any of the vegetable types and the prevalence of depressive symptoms. The results were confirmed by the age-stratified analysis for both genders.

Conclusion: Consumption of tomato products may help alleviate depressive symptoms, regardless of differences in dietary culture among men.

Keywords: vegetables, depression, Japan, adults, workers, tomato products

Introduction

The prevalence of depressive symptoms has increased dramatically over the past few decades.[1] Previous studies have shown that depressive symptoms are associated with a higher risk of physical disability,[2] ischemic heart disease,[3] and suicide.[4] Moreover, depressive symptoms also adversely affect healthcare costs.[5] In Japan, the number of patients with depression has been increasing,[6] and approximately 20% of Japanese workers suffer from depressive symptoms.[7] Since depressive symptoms are difficult to cure or treat,[8] it is necessary to prevent the development of these symptoms among employees, during the early stages of work.

Some factors, such as physical activity[9] and sun exposure,[10] are considered as protective and alleviating factors for depressive symptoms. However, it may be difficult to obtain adequate time to exercise or receive sun exposure, especially for employees who work indoors, because they usually work more than eight hours a day (from 8 am to 5 pm). Diet, an indispensable part of daily life, is another important aspect in this regard. People gain energy and nutrition from their

Received: 30 November 2021
Accepted: 1 April 2022
Published: 18 May 2022

dietary intake. Vegetable intake is an important part of everyday diet and is directly related to many positive health outcomes, such as lowered risk of hypertension,[11] type 2 diabetes,[12] and heart failure.[13] Vegetables include nutrients such as folate, vitamins, and polyphenol, which are the most effective for reducing anti-oxidative stress.[14,15] Since previous studies have reported that oxidative stress may be associated with depressive symptoms,[16,17] vegetable consumption can be considered to have beneficial influences on depressive symptoms. A previous study on 1676 Chinese adults aged 45 to 59 years reported that higher consumption of vegetables is significantly associated with a lower risk of depressive symptoms.[18] However, this study focused on the association between total vegetable consumption and depressive symptoms and did not examine this association for particular vegetable types. Different vegetables have different nutrients, which may differently influence depressive symptoms. For example, tomato contains large amounts of lycopene, an antioxidant nutrient,[19] and green leafy vegetables are great sources of the anti-inflammatory nutrient folate.[20] Previous studies have examined the association between consumption of various vegetables, including tomatoes,[21] green leafy vegetables,[21–23] and yellow vegetables,[23–25] and depressive symptoms among various populations, including teenagers, the elderly, and the general population.[21–24] However, there is a lack of studies focusing on adult workers, who may be more prone to depressive symptoms in the face of social and family pressures compared to other populations.

Therefore, we designed a cross-sectional study to investigate whether the frequency of consumption of a specific vegetable type is associated with the prevalence of depressive symptoms, focusing on Japanese adult workers. Based on previous studies, we hypothesized that, although the consumption of all vegetables may not be inversely associated with depressive symptoms, a high frequency of consumption of vegetables that have anti-oxidative and anti-inflammatory effects may be associated with a lower prevalence of depressive symptoms in Japanese adult workers.

Methods

Participants

The data used in the present study were obtained from a prospective cohort study investigating the risk factors of non-communicable diseases among adult employees. This study was based on an annual health examination at the Sendai Oroshisho Center, Sendai city, Japan. A total of 1784 participants provided informed consent for data analysis in this study, from 2008 to 2011. The protocol of our study was approved by the Institutional Review Board of the Tohoku University Graduate School of Medicine (2019-1-394) and complies with the Declaration of Helsinki. All methods were performed in accordance with the relevant guidelines and regulations. Participants were excluded if information on dietary habits (n = 50), depressive symptoms (n = 4), or demographics (n = 6) was not available. After these exclusions, the final study sample comprised 1724 participants (men = 1333, women = 391).

Assessment of Frequency of Vegetable Consumption

A dietary survey was conducted using the brief-type self-administered diet history questionnaire (BDHQ) that included questions on 75 food items.[26] The BDHQ has been validated in adult Japanese populations.[27,28] The frequency of consumption of different vegetables was evaluated using the following questions: During the past month, how frequently did you eat tomato and tomato products/cabbage and Chinese cabbage/green leafy vegetables/root vegetables (including onion, lotus root, and burdock)/turnip/carrot and pumpkin/mushroom? Participants answered by checking one out of seven frequency categories ("almost never," "<1 time/week," "1 time/week," "2−3 times/week," "4−6 times/week," "1 time/day," and "2 or more times/day"). We then divided these responses into the following four categories according to the distribution of consumption of each vegetable type, because of comparable frequency distributions among the vegetable types: "<1 time/week," "1 time/week," "2−3 times/week," and "≥4 times/week."

Assessment of Depressive Symptoms

Depressive symptoms were assessed using the Zung Self-rating Depression Scale (SDS).[29] This is a widely used scale for measuring the severity of depression. It has good internal consistency and validity[30,31] and has been used in many Japanese studies.[32,33] The SDS comprises 20 questions, and scores range from 20 to 80. Higher scores are indicative of more severe depressive symptoms. Previous studies have used cut-off values of 40,[34,35] 45,[36] and 50[37] to define depressive symptoms. In this study, we used the lowest cut-off value of 40 to define depressive symptoms, because this value was established based on the SDS[29] and has also widely been used in previous studies including our own.[34,35] Other cut-off values (45 and 50) were used for conducting a sensitivity analysis.

Assessment of Covariates

Weight (kg) and height (m) were measured, and body mass index (BMI) was calculated in kg/m^2. Physical activity (PA) was evaluated using the International Physical Activity Questionnaire (IPAQ).[38] Total daily physical activity was calculated as metabolic equivalents (METs) × hours/week. Based on the Japanese physical activity guidelines, PA was classified into two categories: <23 and ≥23 METs h/week.[39] Smoking status was categorized into non, current, and former smoker. Drinking status was classified into three categories: none, 1−6 days/week, and every day. Educational level was classified into two categories: <12 and ≥12 years. Occupation was classified into desk work and other. Living condition was classified into "living alone" and "with others." Information on age and gender was obtained using a self-reported questionnaire survey. Blood pressure was measured using a blood pressure monitor (Yamasu 605; Kenzmedico Co., Ltd., Saitama, Japan). Hypertension was defined as having a systolic blood pressure ≥140 mmHg or a diastolic blood pressure ≥90 mmHg, or taking an anti-hypertensive drug.[40] Fasting blood glucose was measured using enzymatic methods (Eerotec Co., Ltd., Tokyo, Japan). Diabetes was defined as fasting blood glucose ≥126 mg/dL or taking anti-diabetic drugs.[41] Dyslipidemia was defined as triglyceride levels ≥150 mg/dl, high-density lipoprotein levels <40 mg/dL or low-density lipoprotein levels ≥140 mg/dL, or taking anti-hyperlipidemia drugs.[42] High-sensitivity C-reactive protein concentration (hsCRP) was measured from the blood sample using an immune-technique with a Behring BN II analyzer (Dade Behring, Tokyo, Japan).

Statistical Analysis

Considering that logistic regression is used for the lower range of prevalence of an outcome, the prevalence of depressive symptoms may be overestimated.[43,44] Thus, the associations between frequency of consumption of each vegetable type and depressive symptoms were examined using Poisson regression analysis, because the prevalence of the outcome was more than 10%. We calculated prevalence ratios (PRs) with 95% confidence intervals (CIs) stratified by gender. Depressive symptoms were taken as the objective variable, and frequency of consumption of each vegetable type was used as the explanatory variable. PRs were adjusted for age (continuous variable), gender, BMI (continuous variable), educational level, occupation, living condition, smoking status, drinking status, physical activity, hypertension, diabetes, dyslipidemia, hsCRP (continuous variable), intake of total energy (continuous variable), and consumption of milk, seaweed, green tea, soy products, and other vegetables (all continuous variables) except for the explanatory variables. Age-stratified analysis was performed and the median ages (43 years for men and 40 years for women) were used to categorize the participants based on the age distribution. The SDS cut-off values of 45 and 50 were also used for sensitivity analysis. All statistical analyses were performed using the SPSS statistical software version 22.0 for Windows (SPSS, Inc., Chicago, IL). A P-value less than 0.05 was considered statistically significant.

Results

Of the 1724 participants, 1333 (77.3%) were men and 391 (22.7%) were women. Table 1 shows the basic characteristics of the participants. The participants with depressive symptoms had a lower intake of total energy, soy, and seaweed than that of those without depressive symptoms. The percentage of diabetes, nondrinker, educational level (≥ 12 years) in the participants with depressive symptoms was lower in those without depressive symptoms. Table S1 shows the characteristics of men and women according to the prevalence of depressive symptoms. Among men, the number of participants

Table 1 Characteristics of Participants According to Depressive Symotoms

	Depressive Symptoms	
	Yes (n = 950)	**No (n = 774)**
Men, n (%)	721 (75.9)	612 (79.1)
Age, (y)	43 (35, 53)[a]	43 (35, 55)
BMI, (kg/m^2)	22.8 (20.6, 25.3)	23.0 (20.9, 25.3)
Food and nutrition intake		
Total energy intake, (kcal/day)	1753.7 (1411.9, 2206.9)	1832.0 (1498.3, 2226.9)
Milk consumption, (g/day)	48.8 (9.0, 136.7)	61.0 (13.8, 153.8)
Soy consumption, (g/day)	47.1 (23.2, 79.5)	52.3 (29.7, 87.5)
Seaweed consumption, (g/day)	6.2 (2.8, 14.1)	11.1 (4.4, 15.4)
Green tea consumption, (g/day)	122.1 (24.7, 375.0)	150.0 (61.0, 427.2)
hsCRP, (mg/L)	0.31 (0.15, 0.67)	0.33 (0.16, 0.79)
Hypertension, n (%)	260 (27.4)	207 (26.7)
Diabetes, n (%)	67 (7.1)	42 (5.4)
Hyperlipemia, n (%)	433 (45.6)	362 (46.8)
Smoking status, n (%)		
Smoker	376 (39.6)	347 (44.8)
Drinking status, n (%)		
Drinking everyday	250 (26.3)	197 (25.5)
Drinking occasionally	462 (48.6)	428 (55.3)
Nondrinker	238 (25.1)	149 (19.3)
Living along, n (%)	137 (14.4)	106 (13.7)
Education level ≥ 12y, n (%)	260 (27.4)	285 (36.8)
Occupation (desk work; n (%))	463 (48.7)	370 (47.8)
PA (≥23METs/week; n(%))	297 (31.3)	255 (32.9)

Notes: [a]Values are expressed as median (interquartile range, IQR) for continuous variables or n (%) for categorical variables, respectively.

Abbreviations: BMI, body mass index; hsCRP, high sensitive C-reactive protein; PA, physical activity.

with a high amount of total energy, high food intake, and high educational level were higher in the no depressive symptoms category. In contrast, the proportion of participants who had diabetes was lower in the no depressive symptoms category. Among women, the amount of milk and seaweed intake and the proportion of smokers and drinkers were higher in the no depressive symptoms category.

Table 2 shows the association between frequency of consumption of each vegetable type and depressive symptoms among both men and women. An inverse association was found between tomato products consumption and prevalence of depressive symptoms in both the unadjusted and adjusted models among men. After adjusting for covariates, compared with the first category of tomato products consumption, the adjusted PRs (95% CIs) for depressive symptoms in the second, third, and fourth categories were 0.91 (0.77, 1.08), 0.83 (0.69, 0.98), and 0.77 (0.61, 0.95), respectively (P for trend <0.01). Moreover, the frequency of green leafy vegetables consumption was inversely, but not significantly, associated with the prevalence of depressive symptoms after adjusting for covariates (P for trend = 0.07). No significant association was found between the frequency of consumption of other vegetables and depressive symptoms in men. For women, the frequency of consumption of none of the vegetable types was associated with the prevalence of depressive symptoms.

Table 3 shows the results of the sensitivity analysis using other SDS cut-off points. When the cut-off value was set to ≥45, an inverse association was found between the frequency of tomato products consumption and depressive symptoms in men (P for trend = 0.01). Although this association disappeared when the cut-off value was set to ≥50, the trend was consistent with the results of the main analysis. In women, no association was found for the consumption of any of the vegetable types.

Table 4 shows age-stratified associations between the frequency of consumption of each vegetable type and depressive symptoms among men and women. The frequency of tomato products consumption was inversely associated with the

Table 2 Associations Between Frequency of Different Vegetable Types Consumption and Depressive Symptoms Among Men and Women

	Depressive Symptoms (Men)				Depressive Symptoms (Women)			
	Depression/All Subject	%	Unadjusted	Adjusted[b]	Depression/All Subject	%	Unadjusted	Adjusted[b]
Frequency of tomato product consumption (times/week)								
< 1	237/407	58.2	1	1	55/100	55.0	1	1
1	187/327	57.2	0.98 (0.87, 1.11)[a]	0.91 (0.77, 1.08)	50/75	66.7	1.21 (0.96, 1.54)	1.24 (0.89, 1.73)
2–3	190/373	50.9	0.88 (0.77, 1.00)	0.83 (0.69, 0.98)	60/104	57.7	1.05 (0.82, 1.34)	1.09 (0.80, 1.50)
≥ 4	107/226	47.3	0.81 (0.69, 0.95)	0.77 (0.61, 0.95)	64/112	57.1	1.04 (0.82, 1.32)	1.21 (0.88, 1.67)
P for trend			< 0.01	< 0.01			0.96	0.38
Frequency of mushroom consumption (times/week)								
< 1	258/439	58.8	1	1	51/85	60.0	1	1
1	245/450	54.4	0.93 (0.83, 1.04)	0.98 (0.84, 1.15)	64/104	61.5	1.03 (0.81, 1.29)	1.05 (0.76, 1.44)
2–3	159/321	49.5	0.84 (0.74, 0.97)	0.91 (0.74, 1.11)	59/111	53.2	0.89 (0.69, 1.13)	1.01 (0.71, 1.43)
≥ 4	59/123	48.0	0.82 (0.67, 1.00)	0.93 (0.69, 1.24)	55/91	60.4	1.01 (0.79, 1.28)	1.16 (0.80, 1.70)
P for trend			< 0.01	0.39			0.71	0.50
Frequency of carrot and pumpkin consumption (times/week)								
< 1	204/338	60.4	1	1	56/89	62.9	1	1
1	205/367	55.9	0.93 (0.82, 1.05)	1.17 (0.97, 1.41)	44/79	55.7	0.89 (0.69, 1.14)	0.90 (0.62, 1.30)
2–3	218/440	49.5	0.82 (0.72, 0.93)	1.12 (0.90, 1.38)	71/134	53.0	0.84 (0.67, 1.06)	1.10 (0.77, 1.57)
≥ 4	94/188	50.0	0.83 (0.70, 0.98)	1.28 (0.97, 1.69)	58/89	65.2	1.04 (0.83, 1.29)	1.34 (0.87, 2.07)
P for trend			< 0.01	0.18			0.97	0.09
Frequency of cabbage and Chinese cabbage consumption (times/week)								
< 1	126/206	61.2	1	1	54/84	64.3	1	1
1	194/337	57.6	0.94 (0.82, 1.09)	1.11 (0.89, 1.39)	45/82	54.9	0.85 (0.66, 1.10)	0.86 (0.62, 1.19)
2–3	287/557	51.5	0.84 (0.74, 0.97)	1.08 (0.86, 1.37)	68/131	51.9	0.81 (0.64, 1.02)	0.84 (0.61, 1.15)
≥ 4	114/233	48.9	0.80 (0.68, 0.95)	1.15 (0.86, 1.54)	62/94	66.0	1.03 (0.83, 1.27)	1.13 (0.78, 1.64)
P for trend			< 0.01	0.52			0.97	0.65
Frequency of turnip consumption (times/week)								
< 1	252/421	59.9	1	1	89/148	60.1	1	1
1	223/417	53.5	0.89 (0.79, 1.01)	0.97 (0.82, 1.15)	49/84	58.3	0.97 (0.78, 1.21)	1.22 (0.91, 1.64)
2–3	184/359	51.3	0.86 (0.75, 0.97)	1.01 (0.83, 1.23)	64/114	56.1	0.93 (0.76, 1.15)	1.17 (0.87, 1.56)
≥ 4	62/136	45.6	0.76 (0.62, 0.93)	0.99 (0.74, 1.31)	27/45	60.0	1.00 (0.76, 1.31)	1.19 (0.78, 1.81)
P for trend			< 0.01	0.99			0.71	0.38

(*Continued*)

https://doi.org/10.2147/RMHP.S350935

Table 2 (Continued).

	Depressive Symptoms (Men)				Depressive Symptoms (Women)			
	Depression/All Subject	%	Unadjusted	Adjusted[b]	Depression/All Subject	%	Unadjusted	Adjusted[b]
Frequency of root vegetables consumption (times/week)								
< 1	156/245	63.7	1	1	37/59	62.7	1	1
1	188/347	54.2	0.85 (0.74, 0.97)	0.96 (0.79, 1.17)	44/68	64.7	1.03 (0.79, 1.34)	1.06 (0.71, 1.57)
2–3	251/478	52.5	0.83 (0.73, 0.94)	0.95 (0.77, 1.18)	73/133	54.9	0.88 (0.68, 1.12)	0.89 (0.60, 1.31)
≥ 4	126/263	47.9	0.75 (0.64, 0.88)	0.98 (0.75, 1.28)	75/131	57.3	0.91 (0.71, 1.17)	0.91 (0.60, 1.38)
P for trend			< 0.001	0.88			0.28	0.45
Frequency of green leafy vegetables consumption (times/week)								
< 1	198/323	61.3	1	1	43/65	66.2	1	1
1	206/354	58.2	0.95 (0.84, 1.07)	1.05 (0.88, 1.25)	39/59	66.1	1.00 (0.78, 1.29)	0.98 (0.66, 1.44)
2–3	216/414	52.2	0.85 (0.75, 0.97)	0.93 (0.76, 1.14)	70/142	49.3	0.75 (0.59, 0.95)	0.78 (0.53, 1.14)
≥ 4	101/242	41.7	0.68 (0.57, 0.81)	0.80 (0.60, 1.05)	77/125	61.6	0.93 (0.75, 1.16)	0.97 (0.65, 1.45)
P for trend			< 0.001	0.07			0.29	0.90

Notes: [a]Results were obtained by poisson regression analysis. Values are expressed as prevalence ratio (95% confidence intervals). [b]Adjusted for age (continuous variable), body mass index (continuous variable), educational level (≥ 12 years or <12 years), desk work (yes or not), living condition (living along or not), smoking status (current smoker or not), drinking status (everyday, occasional, non-drinker), physical activity (< 23 or ≥ 23 MET hours/week), hypertension (yea or not), diabetes (yes or not), hyperlipemia (yes or not), hsCRP (continuous variable), intake of total energy intake (continuous variable), consumption of milk (continuous variable), seaweed (continuous variable), green tea (continuous variable), soy product (continuous variable), and other vegetables (continuous variable).

https://doi.org/10.2147/RMHP.S350935 DovePress

Table 3 Sensitive Analysis of Associations Between Frequency of Different Vegetable Types Consumption and Depressive Symptoms Among Men and Women

	Depressive Symptoms (Men)						Depressive Symptoms (Women)					
	SDS≧45			SDS≧50			SDS≧45			SDS≧50		
	Depression/ All Subject	%	Adjusted[b]	Depression/ All Subject	%	Adjusted[b]	Depression/ All Subject	%	Adjusted[b]	Depression/ All Subject	%	Adjusted[b]
Frequency of tomato product consumption (times/week)												
< 1	157/407	38.6	1	64/407	15.7	1	41/100	41.0	1	19/100	19.0	1
1	112/327	34.3	0.81 (0.63, 1.05)[a]	40/327	12.2	0.72 (0.43, 1.19)	23/75	30.7	0.82 (0.49, 1.38)	8/75	10.7	1.15 (0.42, 3.11)
2–3	107/373	28.7	0.68 (0.52, 0.90)	41/373	10.1	0.76 (0.47, 1.22)	32/104	30.8	0.98 (0.60, 1.59)	9/104	8.7	0.68 (0.21, 2.22)
≥ 4	68/226	30.0	0.67 (0.48, 0.93)	26/226	11.5	0.58 (0.31, 1.09)	39/112	34.8	0.18 (0.75, 1.86)	16/112	14.3	1.35 (0.49, 3.74)
P for trend			0.01			0.10			0.94			0.68
Frequency of mushroom consumption (times/week)												
< 1	165/439	37.6	1	46/245	18.8	1	33/85	38.8	1	13/85	15.2	1
1	150/450	33.3	1.03 (0.80, 1.32)	29/347	8.4	0.85 (0.53, 1.36)	38/104	36.5	1.11 (0.65, 1.88)	15/104	14.4	3.16 (0.78, 12.87)
2–3	91/321	28.3	0.97 (0.71, 1.32)	66/478	13.8	0.86 (0.49,1.50)	33/111	29.7	1.09 (0.61, 1.94)	16/111	14.4	3.95 (0.84, 18.50)
≥ 4	38/123	30.9	0.19 (0.77, 1.84)	30/263	11.4	0.95 (0.44, 2.13)	31/91	34.1	1.30 (0.68, 2.51)	8/91	8.8	2.87 (0.49, 16.86)
P for trend			0.72			0.76			0.45			0.33
Frequency of carrot and pumpkin consumption (times/ week)												
< 1	128/338	37.9	1	56/338	16.6	1	36/89	40.4	1	17/89	19.1	1
1	126/367	34.3	1.26 (0.95, 1.69)	47/367	12.8	1.26 (0.76, 2.07)	34/79	43.0	1.12 (0.63, 1.97)	11/79	13.9	1.89 (0.59, 5.98)
2–3	130/440	29.5	1.19 (0.85, 1.65)	44/440	10.0	0.95 (0.54, 1.66)	33/134	24.6	0.94 (0.51, 1.73)	11/134	8.2	1.52 (0.35, 6.60)
≥ 4	60/188	31.9	1.59 (1.04, 2.43)	24/188	12.8	1.46 (0.68, 3.14)	32/89	36.0	1.17 (0.57, 2.43)	13/89	14.6	2.28 (0.48, 10.86)
P for trend			0.09			0.67			0.84			0.46
Frequency of cabbage and Chinese cabbage consumption (times/week)												
< 1	80/206	38.8	1	40/206	19.4	1	36/84	42.9	1	15/84	17.9	1
1	118/337	35.0	1.18 (0.84, 1.67)	38/337	11.3	0.87 (0.48, 1.56)	30/82	36.6	0.91 (0.58, 1.45)	14/82	17.1	0.85 (0.35, 2.05)
2–3	147/557	26.4	1.19 (0.83, 1.71)	61/557	11.0	0.90 (0.49, 1.67)	38/131	29.0	0.65 (0.40, 1.08)	14/131	10.7	0.56 (0.20, 1.58
≥ 4	72/233	32.3	1.38 (0.88, 2.17)	32/233	14.3	1.39 (0.64, 3.01)	31/94	33.0	0.72 (0.41, 1.24)	9/94	9.6	0.37 (0.12, 1.19)
P for trend			0.22			0.42			0.13			0.08
Frequency of turnip consumption (times/week)												
< 1	163/421	38.7	1	66/421	15.7	1	59/148	39.9	1	27/148	18.2	1
1	133/417	31.9	0.95 (0.73, 1.24)	46/417	11.0	0.83 (0.52, 1.34)	27/84	32.1	1.10 (0.68, 1.77)	10/84	11.9	1.20 (0.44, 3.29)
2–3	111/359	30.9	1.05 (0.78, 1.41)	43/359	12.0	1.02 (0.60, 1.75)	35/114	30.7	1.28 (0.80, 2.03)	10/114	8.8	1.08 (0.38, 3.05)
≥ 4	37/136	27.2	1.07 (0.69, 1.64)	16/136	11.8	0.98 (0.44, 2.19)	14/45	31.1	1.19 (0.58, 2.43)	5/45	11.1	0.92 (0.21, 3.93)
P for trend			0.68			0.92			0.39			0.98

(*Continued*)

https://doi.org/10.2147/RMHP.S350935

Table 3 (Continued).

	Depressive Symptoms (Men)						Depressive Symptoms (Women)					
	SDS≧45			SDS≧50			SDS≧45			SDS≧50		
	Depression/ All Subject	%	Adjusted[b]	Depression/ All Subject	%	Adjusted[b]	Depression/ All Subject	%	Adjusted[b]	Depression/ All Subject	%	Adjusted[b]
Frequency of root vegetables consumption (times/week)												
< 1	95/245	38.8	1	46/245	18.8	1	24/59	40.7	1	9/59	15.3	1
1	110/347	31.7	1.08 (0.79, 1.49)	29/347	8.4	0.70 (0.40, 1.22)	27/68	39.7	1.11 (0.59, 2.07)	12/68	17.6	5.60 (0.82, 38.15)
2–3	158/478	33.1	1.21 (0.87, 1.68)	66/478	13.8	1.00 (0.58, 1.71)	45/133	33.8	0.78 (0.42, 1.46)	19/133	14.3	5.24 (0.80, 34.15)
≥ 4	81/263	34.3	1.27 (0.85, 1.90)	30/263	11.4	0.93 (0.48, 1.78)	39/131	29.8	0.73 (0.38, 1.42)	12/131	9.2	3.22 (0.48, 21.43)
P for trend			0.18			0.73			0.14			0.80
Frequency of green leafy vegetables consumption (times/ week)												
< 1	127/323	39.3	1	53/323	16.4	1	31/65	47.7	1	15/65	23.1	1
1	127/354	35.9	1.11 (0.84, 1.46)	46/354	13	1.10 (0.68, 1.79)	21/59	35.6	1.08 (0.59, 1.98)	13/59	22.0	1.29 (0.45, 3.71)
2–3	122/414	29.5	0.86 (0.63, 1.18)	42/414	10.1	0.87 (0.51, 1.51)	45/142	31.7	1.10 (0.61, 1.95)	14/142	9.9	0.70 (0.25, 2.00)
≥ 4	68/242	28.1	0.98 (0.66, 1.47)	30/242	12.4	0.99 (0.50, 1.98)	38/125	30.4	0.99 (0.53, 1.85)	10/125	8.0	0.47 (0.14, 1.53)
P for trend			0.47			0.73			0.87			0.08

Notes: [a]Results were obtained by poisson regression analysis. Values are expressed as prevalence ratio (95% confidence intervals). [b]Adjusted for age (continuous variable), body mass index (continuous variable), educational level (≥ 12 years or <12 years), desk work (yes or not), living condition (living along or not), smoking status (current smoker or not), drinking status (everyday, occasional, non-drinker), physical activity (< 23 or ≥ 23 MET hours/week), hypertension (yea or not), diabetes (yes or not), hyperlipemia (yes or not), hsCRP (continuous variable), intake of total energy intake (continuous variable), consumption of milk (continuous variable), seaweed (continuous variable), green tea (continuous variable), soy product (continuous variable), and other vegetables (continuous variable).

Table 4 Age Stratified Associations Between Frequency of Different Vegetable Types Consumption and Depressive Symptoms Among Men and Women Aged

	Depressive Symptoms (Men)						Depressive Symptoms (Women)					
	Young (< 43)			Old (≥ 43)			Young (< 40)			Old (≥ 40)		
	Depression/ All Subject	%	Adjusted[b]	Depression/ All Subject	%	Adjusted[b]	Depression/ All Subject	%	Adjusted[b]	Depression/ All Subject	%	Adjusted[b]
Frequency of tomato product consumption (times/week)												
< 1	102/184	55.4	1	135/223	60.5	1	27/47	57.4	1	28/51	54.9	1
1	94/166	56.6	0.97 (0.75, 1.26)[a]	93/159	58.5	0.88 (0.71, 1.10)	32/43	74.4	1.37 (0.91, 2.08)	18/32	56.3	0.92 (0.48, 1.73)
2–3	101/197	51.3	0.86 (0.67, 1.11)	88/173	50.9	0.79 (0.62, 1.00)	32/53	60.4	1.03 (0.65, 1.63)	28/50	56.0	1.02 (0.64, 1.64)
≥ 4	41/84	48.8	0.79 (0.54, 1.14)	65/137	47.4	0.77 (0.58, 1.02)	24/43	55.8	1.16 (0.70, 1.91)	40/69	58.0	1.27 (0.80, 2.01)
P for trend			0.13			0.04			0.90			0.28
Frequency of mushroom consumption (times/week)												
< 1	76/118	64.4	1	152/245	62	1	29/38	76.3	1	22/46	47.8	1
1	93/178	52.2	1.07 (0.83, 1.37)	123/224	54.9	0.93 (0.76, 1.15)	34/56	60.7	0.70 (0.49, 1.02)	30/48	62.5	1.49 (0.88, 2.52)
2–3	112/219	51.1	0.96 (0.71, 1.30)	78/162	48.1	0.89 (0.68, 1.17)	30/56	53.6	0.64 (0.43, 0.96)	29/54	53.7	1.35 (0.75, 2.43)
≥ 4	57/116	49.1	1.01 (0.67, 1.52)	28/61	45.9	0.90 (0.59, 1.35)	22/36	61.1	0.75 (0.45, 1.24)	33/54	61.1	2.01 (1.09, 3.70)
P for trend			0.81			0.44			0.30			0.04
Frequency of carrot and pumpkin consumption (times/ week)												
< 1	83/149	55.7	1	120/187	64.2	1	30/44	68.2	1	26/45	57.8	1
1	102/183	55.7	1.30 (0.96, 1.76)	103/182	56.6	1.10 (0.87, 1.39)	25/40	62.5	0.80 (0.48, 1.32)	19/39	48.7	1.15 (0.64, 2.07)
2–3	107/206	51.9	1.20 (0.84, 1.72)	110/230	47.8	1.06 (0.81, 1.39)	37/65	56.9	1.02 (0.64, 1.64)	34/66	51.5	1.32 (0.73, 2.41)
≥ 4	46/93	49.5	1.33 (0.84, 2.12)	48/93	51.6	1.25 (0.87, 1.78)	23/37	62.2	1.18 (0.64, 2.19)	35/52	67.3	1.77 (0.86, 3.66)
P for trend			0.38			0.37			0.40			0.90
Frequency of cabbage and Chinese cabbage consumption (times/week)												
< 1	56/94	59.6	1	69/109	63.3	1	30/42	71.4	1	24/42	57.1	1
1	94/165	57.0	1.17 (0.84, 1.64)	100/172	58.1	1.09 (0.81, 1.47)	22/44	50	0.57 (0.36, 0.90)	23/37	62.2	1.13 (0.71, 1.80)
2–3	135/262	51.5	1.05 (0.73, 1.52)	151/290	52.1	1.13 (0.83, 1.54)	39/63	61.9	0.79 (0.53, 1.18)	29/66	43.9	0.65 (0.38, 1.10)
≥ 4	53/110	48.2	1.11 (0.68, 1.81)	61/121	50.4	1.24 (0.85, 1.80)	24/37	64.9	0.76 (0.44, 1.32)	38/57	66.7	1.30 (0.77, 2.22)
P for trend			0.96			0.29			0.70			0.56

(*Continued*)

https://doi.org/10.2147/RMHP.S350935

Table 4 (Continued).

	Depressive Symptoms (Men)						Depressive Symptoms (Women)					
	Young (< 43)			Old (≥ 43)			Young (< 40)			Old (≥ 40)		
	Depression/ All Subject	%	Adjusted[b]	Depression/ All Subject	%	Adjusted[b]	Depression/ All Subject	%	Adjusted[b]	Depression/ All Subject	%	Adjusted[b]
Frequency of turnip consumption (times/week)												
< 1	122/216	56.5	1	129/203	63.5	1	51/79	64.6	1	38/69	55.1	1
1	110/209	52.6	0.97 (0.75, 1.24)	113/207	54.6	1.00 (0.79, 1.25)	19/31	61.3	1.00 (0.65, 1.54)	30/53	56.6	1.43 (0.90, 2.27)
2–3	81/153	52.9	1.02 (0.76, 1.38)	103/202	51.0	0.97 (0.75, 1.26)	34/54	63.0	1.12 (0.77, 1.63)	30/57	52.6	1.22 (0.76, 1.95)
≥ 4	25/53	47.2	1.00 (0.63, 1.59)	36/80	45.0	0.95 (0.66, 1.38)	11/22	50.0	0.93 (0.49, 1.79)	16/23	69.6	1.39 (0.76, 2.52)
P for trend			0.90			0.77			0.83			0.43
Frequency of root vegetables consumption (times/week)												
< 1	76/118	64.4	1	79/126	62.7	1	16/24	66.7	1	21/35	60.0	1
1	93/178	52.2	0.86 (0.64, 1.15)	95/169	56.2	1.09 (0.83, 1.43)	23/36	63.9	0.93 (0.49, 1.76)	21/31	67.7	1.04 (0.61, 1.77)
2–3	112/219	51.1	0.85 (0.61, 1.18)	139/257	54.1	1.07 (0.80, 1.43)	44/71	62.0	0.89 (0.49, 1.64)	29/61	47.5	0.73 (0.43, 1.24)
≥ 4	57/116	49.1	0.82 (0.54, 1.26)	68/140	48.6	1.16 (0.82, 1.66)	32/55	58.2	0.85 (0.44, 1.64)	43/75	57.3	0.82 (0.46, 1.48)
P for trend			0.46			0.49			0.59			0.32
Frequency of green leafy vegetables consumption (times/ week)												
< 1	96/159	60.4	1	101/161	62.7	1	24/35	68.6	1	19/29	65.5	1
1	97/169	57.4	0.93 (0.70, 1.24)	109/184	59.2	1.11 (0.87, 1.40)	20/29	69.0	1.08 (0.62, 1.86)	19/29	65.5	0.76 (0.43, 1.33)
2–3	103/195	52.8	0.79 (0.57, 1.11)	112/215	52.1	1.02 (0.78, 1.33)	39/69	56.5	0.91 (0.54, 1.53)	31/72	43.1	0.57 (0.32, 1.01)
≥ 4	42/108	38.9	0.56 (0.35, 0.90)	59/132	44.7	0.95 (0.67, 1.34)	32/53	60.4	1.03 (0.59, 1.79)	45/72	62.5	0.80 (0.45, 1.42)
P for trend			0.01			0.67			0.92			0.63

Notes: [a]Results were obtained by poisson regression analysis. Values are expressed as prevalence ratio (95% confidence intervals). [b]Adjusted for age (continuous variable), body mass index (continuous variable), educational level (≥ 12 years or <12 years), desk work (yes or not), living condition (living along or not), smoking status (current smoker or not), drinking status (everyday, occasional, non-drinker), physical activity (< 23 or ≥ 23 MET hours/week), hypertension (yea or not), diabetes (yes or not), hyperlipemia (yes or not), hsCRP (continuous variable), intake of total energy intake (continuous variable), consumption of milk (continuous variable), seaweed (continuous variable), green tea (continuous variable), soy product (continuous variable), and other vegetables (continuous variable).

prevalence of depressive symptoms, particularly in older men (≥43 years). For green leafy vegetable, an inverse association was obtained in younger men (<43 years). No association was found between any other vegetable type and depressive symptoms among men. In women, no association was found between any vegetable type and depressive symptoms.

Discussion

In this study, we investigated the association between the frequency of consumption of different vegetable types and the prevalence of depressive symptoms in Japanese adult workers. As expected, not all types of vegetables were associated with the prevalence of depressive symptoms. Notable, the frequency of tomato products consumption was inversely associated with the prevalence of depressive symptoms in male workers. These results suggest that tomatoes may positively influence the prevention of depressive symptoms among Japanese male workers.

Several previous studies have examined the association between vegetable consumption and depressive symptoms. A Japanese cross-sectional study of 986 retired elderly people, aged 70 years and above, revealed that the intake of tomatoes and a tomato-rich diet was inversely associated with the prevalence of depressive symptoms.[21] Consistent with this result, our findings showed that a higher frequency of tomato products consumption was associated with a lower prevalence of depressive symptoms among male workers, particularly those aged 43 years or above. This association was confirmed when a sensitivity analysis using a higher cut-off value was conducted. Our finding is supported by a recent study showing that a higher intake of tomatoes and tomato mixture was inversely associated with depressive symptoms in Americans.[23] Therefore, consumption of tomato products may positively influence the alleviation of depressive symptoms regardless of differences in dietary culture or race.

Cross-sectional studies of New Zealanders aged 18–25 years[45] and Iranian women aged 20–49 years[25] showed that the consumption of dark leafy greens (ie, green leafy vegetables) was inversely associated with depressive symptoms. Moreover, Sun et al showed an inverse association between dark green vegetables and depressive symptoms among American adults.[23] However, no clear association was found between green leafy vegetables and the prevalence of depressive symptoms among men in the current study. One of the reasons for this could be the age difference between the study populations. The participants in the previous studies[25,45] were younger than the participants in our study (19–83 years). Interestingly, when an age-stratified analysis was performed, the frequency of green leafy vegetable consumption was found to be inversely associated with the prevalence of depressive symptoms among younger men (<43 years) in this study. It is possible that green leafy vegetables may have a beneficial impact for younger people, but not for older people. Considering the trend of older people eating in the traditional Japanese pattern, that is characterized by a larger consumption of vegetables,[46] and that consumption of vegetables in general may support anti-oxidative capacities,[47] the contribution of green leafy vegetables could have been diluted, whereas tomato and tomato products have a high enough capacity to indicate an independent association. Among the younger participants in our study, the consumption of vegetables in general was lower than that in the older population (data not shown); thus, green leafy vegetable consumption per se could have had a certain impact.

In this study, no association was found between the consumption of any vegetable type and the prevalence of depressive symptoms in women. In addition to the small sample size of women, menopausal status may have affected our findings. A previous study reported that the decline of ovarian function and decreased levels of estrogen during menopause are associated with a higher prevalence of depression.[48] However, since the number of post-menopausal women in this study was very small (n = 81), the influence of menopause status does not appear to be notable Since we are unable to provide additional explanations, further research is needed on female workers.

This study has some limitations. First, the study participants were from a single area of Sendai city, Japan. Therefore, selection bias may be present, and our results may not be representative of all Japanese workers. Second, information about food consumption was obtained using a self-reported questionnaire in which participants described their consumption over the last month. This leads to a potential recall bias, although the validity of the BDHQ was verified by comparison with 16 days' dietary record.[27] Third, we did not consider seasonal influences on the frequency of vegetable consumption. Because seasonal influences on the frequency of vegetable intake may not be particularly strong because seasonal vegetables, including tomatoes, are mostly available throughout the year in Japan. Fourth, although several confounding factors were included when analyzing the association between vegetable consumption and depressive symptoms, we cannot exclude the

possibility that other factors affected these associations. Finally, because this was a cross-sectional study, the causality of the relationship between vegetable consumption and depressive symptoms cannot be established.

In conclusion, among the selected vegetables, the frequency of tomato products consumption was inversely associated with the prevalence of depressive symptoms in Japanese male workers. Further studies are required to confirm these findings and to clarify causality.

Acknowledgments

This study was supported by a Grant-in-Aid for "Knowledge Cluster Initiative" from the Ministry of Education, Culture, Sports, Science and Technology of Japan, and was partially supported by the Center of Innovation Program from Japan Science and Technology Agency, JST. The funding sources had no role in study design, data collection, analysis and interpretation, the writing of the report, or the decision to submit the paper for publication.

Funding

This study was supported by a Grant-in-Aid for "Knowledge Cluster Initiative" from the Ministry of Education, Culture, Sports, Science and Technology of Japan, and was partially supported by the Center of Innovation Program from the Japan Science and Technology Agency, JST.

Disclosure

All the authors declare that they have no competing interests in this work.

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