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Association between vegetables and fruits consumption and depressive symptoms in a middle-aged Chinese population

An observational study

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Abstract

There is scarce evidence regarding the association between the consumption of vegetables and fruits and depressive symptoms in Chinese population. The purpose of this study was to ascertain the influence of vegetables and fruits consumption on depressive symptoms in a middle-aged Chinese population. This study comprised 1676 Chinese adults aged between 45 and 59 years, who participated in a Health Survey at the time of periodic checkup in the city of Linyi, Shandong Province, China. Dietary intake was assessed using a semi-quantitative food frequency questionnaire (FFQ). Depressive symptoms were assessed using the Center for Epidemiological Studies Depression (CES-D) scale. Log-binomial regression analysis was used to evaluate the association between the consumption of vegetables and fruits and depressive symptoms. A total of 53 participants (3.2%) were classified as having depressive symptoms. After adjustment for confounding variables, participants in the highest quartile of the fruits consumption and vegetables consumption had lower prevalence ratio (PR) for depressive symptoms (PR = 0.76; 95% confidence interval [CI]: 0.603–0.974, $P = .042$; PR = 0.77; 95% CI: 0.612–0.977, $P = .045$) than those in the lowest quartile. Moreover, those in the highest quartile of total vegetables and fruits consumption had also a lower PR of depressive symptoms (PR = 0.67; 95% CI: 0.503–0.806, $P = .037$) than did those in the lowest quartile.

Our findings indicate that higher consumption of vegetables and fruits is significantly associated with a lower risk of depressive symptoms. Further prospective studies are needed to confirm these findings.

Abbreviations: ANOVA = analysis of variance, BMI = body mass index, CES-D = Center for Epidemiologic Studies Depression scale, CI = confidence interval, CVD = cardiovascular disease, FFQ = food frequency questionnaire, FPG = fasting plasma glucose, IPAQ = international physical activity questionnaire, OGTT = oral glucose tolerance test, OR = odds ratio, WHO = World Health Organization.

Keywords: depressive symptoms, diet, epidemiology, middle-aged Chinese population, vegetables and fruits

1. Introduction

Depression represents a major public health concern, affecting approximately 350 million people worldwide.[1] According to the statistics from World Health Organization, it accounts for 4.3% of the global burden of disease and will be the second leading cause of disease burden by the year 2020.[2,3] A previous observational study reported that the incidence of depression in elderly Chinese was from 4% to 26.5%, and it has become a substantial burden.[4] It is well-known that depression is a multifactorial disease that may be associated with some factors, including environmental, genetic, physiological, and dietary factors.[5]

Among the dietary factors, fruits and vegetables consumption, which are rich in antioxidants and anti-inflammatory components, was hypothesized to play an important role in the development of depression.[6] A considerable number of epidemiological studies in recent years have been conducted to investigate the associations between the consumption of fruits and vegetables and risk of depressive symptoms.[6–10] However, findings from these studies have yielded controversial results. Some studies have shown an inverse association between fruits and vegetables intake and depressive symptoms,[6,10] but other studies found no significant associations.[7–9] To the best of our knowledge, only 2 studies have investigated the association between fruit and vegetables consumption and depressive symptoms in older Taiwanese,[7,8] and 1 study reported the consumption of vegetables but number of fruits was associated with lower depressive symptoms in Chinese adults aged ≥65 years.[9] Furthermore, no studies published data have

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The data and materials used in this study are available on request.

The authors declare that there have no competing interests.

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examined the association of vegetables and fruits consumption with depressive symptoms in a middle-aged Chinese population. We, therefore, conducted this study to clarify the association between the consumption of vegetables and fruits and the risk of depressive symptoms in a middle-aged Chinese population, using the data from Linyi Nutrition and Health Survey.

2. Subjects and methods

2.1. Study population

The present study was performed in the city of Linyi, Shandong Province, China from May 2016 to June 2017, as reported previously.[11] Shandong province is located in the East coast of China with a population of 99 million, and Linyi is a prefecture-level city of Shandong, with approximately 10.43 million inhabitants. The study sample was taken from 3 areas (Lanshan, Luozhuang, and Hedong) and 9 countries (Junan, Qishui, Tancheng, Pingyi, Lanling, Mengyin, Linshu, Feixian, and Yinan) by a stratified cluster random-sampling method. A total of 1865 participants (835 men and 1030 women), aged between 45 and 59 years, were recruited when attending their health examinations at the Medical Center for Physical Examination, Linyi People's Hospital, where the study participants were face-to-face interviewed by well-trained dieticians using written questionnaire. We excluded 84 participants with the missing or incomplete information on fruits and vegetables consumption in their questionnaires, 13 participants with a total energy intake of >3000 kcal/d, and 92 participants with missing information for any of the variables used in the main analysis. Ultimately, a total of 1676 participants (786 men and 890 women) were included for the analysis of the association between the consumption of vegetables and fruits and depressive symptoms. Written informed consent was provided from all participants, and the study protocol was approved by the Institutional Review and Ethics Committee of Linyi People's Hospital, and was performed in accordance with the principles described in the Declaration of Helsinki, reference DC 2016/067 in September 2016.

2.2. Assessment of fruits and vegetables intake

Diet was evaluated by well-trained dieticians using a semi-quantitative food frequency questionnaire (FFQ). For fruits and vegetables intake, participants were asked to recall their average frequency of consumption over the past 12 months and the estimated portion size, using local weight units (1 Liang = 50 g). Besides, the frequency of each food item was classified as follows: never or occasionally, 1 to 3 times/mo, 1 to 2 times/wk, 3 to 4 times/wk, 5 to 6 times/wk, 1 time/d, 2 times/d, and 3 times/d. Then, the selected frequency category for each food item was converted to g/d and used in the further analysis.

2.3. Assessment of other variables

Information on the level of physical activity was obtained by using a self-reported questionnaire and expressed as metabolic equivalents in hours per week (MET-h/wk). Detail data have been described elsewhere.[12] Moreover, information on smoking status was collected and categorized into never, former, and current smokers. The education level was classified as follows: primary school or below (<high school), middle and high school (high school), college or above (>high school). Total energy intake was estimated through the semi-quantitative FFQ, expressed in kilocalorie per day (kcal/d).

2.4. Definition of terms

The Center for Epidemiologic Studies Depression scale (CES-D) is a short self-report scale designed to measure depressive symptoms in the general population. Participants were asked to score the frequency of occurrence of specific symptoms over the last week on a 4-point scale (0, "less than 1 day"; 1, "1–2 days"; 2, "3–4 days"; and 3, "5–7 days"). Depressive symptoms were defined as a CES-D scale score ≥16.[13] Hypertension was defined as a systolic pressure of 140 mmHg or higher and/or a diastolic pressure of 90 mmHg or higher.[14] Diabete was defined by fasting plasma glucose (FPG) ≥7.0 mmol/L on at least 2 separate occasions, or an oral glucose tolerance test (OGTT) with a value ≥11.1 mmol/L, and/or use of hypoglycaemic medication (e.g., insulin or oral hypoglycaemic drug).[15] History of cardiovascular disease (CVD) was defined as previous ischemic heart disease and/or cerebrovascular accidents. Family history of premature CVD was defined as any prior diagnosis of CVD in first degree female relatives, aged <65 years, or first-degree male relatives aged <55 years.[16]

2.5. Statistical analyses

All statistical analyses were performed with the SPSS statistical software, version 23.0 (SPSS Inc, Chicago, IL). Data were checked for normality using histograms and logarithmic transformation was applied whenever appropriate. The data for continuous variables were generally reported as the mean ± SD, and the data for categorical variables were reported as sum (percentages). The chi-square test was used to assess the difference for categorical variables, while the analysis of variance (ANOVA) was used to describe mean differences for continuous variables. After adjustment for confounding variables, log-binomial regression analysis was carried-out to identify the association between the consumption of fruits and vegetables and the risk of depressive symptom. In our analyses, Model 1 was unadjusted. Model 2 was adjusted for sex (male/female), age (years), smoking status (never, former, and current), education level (<high school, high school, >high school), economic income (continuous), body mass index (BMI) (continuous), physical activity level (MET-h/wk), total energy intake (kcal/d). Model 3 was further adjusted for self-reported history of diabetes (yes/no), hypertension (yes/no), CVD (yes/no), and self-reported history of depression (yes/no). Two-tailed *P*-values <.05 were considered as statistically significant.

3. Results

The characteristics of the study participants according to depressive symptoms are shown in Table 1. In this population, the overall prevalence of depressive symptoms was 3.2%, with men was 1.8% and women was 4.4%. Age (54.7 ± 7.60 vs 52.1 ± 5.80, $P < .001$) and the proportion of women (73.6% vs 52.4%, $P = .002$) were significantly higher in participants with depressive symptoms than in those without depressive symptoms. Participants without depressive symptoms had significantly higher energy intake (1810.5 ± 295.2 vs 1609.3 ± 256.0, $P < .001$) and

Table 1

Characteristics of the study participants according to depressive symptoms.

Variables	Depressive symptoms		
	Yes	No	Significance*
Number of participants	53	1623	
Age, y	54.7 ± 7.60	52.1 ± 5.80	$P < .001$
BMI, kg/m^2	23.06 ± 2.91	23.75 ± 2.80	0.098
Energy intake, kcal	1609.3 ± 256.0	1810.5 ± 295.2	$P < .001$
Gender			$\chi^2 = 9.220$ $P = .002$
Male	14 (26.4)	772 (47.6)	
Female	39 (73.6)	851 (52.4)	
Smoking status (%)			$\chi^2 = 5.450$ $P = .057$
Never smoker	37 (69.8)	1318 (81.2)	
Former smoker	11 (20.8)	237 (14.6)	
Current smoker	5 (9.4)	68 (4.2)	
Education (%)			$\chi^2 = 16.394$ $P < .001$
<High school	31 (58.5)	519 (32.0)	
High school	12 (22.6)	628 (38.7)	
>High school	10 (18.9)	476 (29.3)	
Monthly income per person (%)			$\chi^2 = 0.354$ $P = .838$
≤3000 (RMB)	15 (28.3)	419 (25.8)	
3000–5000 (RMB)	26 (49.1)	782 (48.2)	
>5000 (RMB)	12 (22.6)	422 (26.0)	
Diabetes (%)	5 (9.4)	188 (11.6)	$P = .630$
Hypertension (%)	12 (22.6)	331 (20.4)	$P = .690$
CVD (%)	7 (13.2)	172 (10.6)	$P = .545$

Categorical variables are presented as sum and percentages, and continuous variables are presented as mean ± SD. CVD = cardiovascular disease, RMB = Ren min bi.

* *P* values for continuous variables (analysis of variance) and for categorical variables (chi-square test), $P < .05$ was considered statistically significant.

education level (29.3% vs 18.9%, $P < .001$) than those with depressive symptoms.

The characteristics of the study participants according to quartiles of total fruits and vegetables intake are shown in Table 2. Compared with participants in the lowest quartile, those in the highest quartile of total fruits and vegetables intake were more likely to be older ($P = .032$), women ($P < .001$), and had lower prevalence of hypertension ($P < .001$), diabetes ($P < .001$) and CVD ($P < .001$), lower BMI ($P = .011$) and fat intake ($P = .008$), and higher education level ($P < .001$), carbohydrate ($P < .001$) and protein intakes ($P = .038$), total fiber intake ($P < .001$) and energy intake ($P < .001$). Besides, there was no significant difference in the physical activity ($P = .315$).

The relations between consumption of vegetables and fruits and the risk of depressive symptoms using log-binomial regression were presented in Table 3. After adjustment for confounding variables, participants in the highest quartile of the fruits consumption and vegetables consumption had lower PR for depressive symptoms (PR = 0.76; 95% CI: 0.603–0.974, $P = .042$; PR = 0.77; 95% CI: 0.612–0.977, $P = .045$) than those in the lowest quartile. Moreover, those in the highest quartile of total vegetables and fruits consumption had also a lower PR for depressive symptoms (PR = 0.67; 95% CI: 0.503–0.806, $P = .037$) than did those in the lowest quartile.

4. Discussion

In the present study, our findings demonstrated that higher consumption of vegetables and fruits was significantly associated with a decreased risk of depressive symptoms after controlling for potential confounders. Limited epidemiological studies have reported the association of vegetables and fruits consumption with depressive symptoms in Chinese population. To the authors' knowledge, this is the first study in China investigating the

Table 2

Characteristics of the study participants according to quartiles of total fruits and vegetables intake.

	Quartiles of total fruits and vegetables consumption				
	Q1 (n = 419)	Q2 (n = 419)	Q3 (n = 419)	Q4 (n = 419)	*P*-trend*
g/d (median)	223.3	348.4	403.2	447.6	
Age, y	49.5 ± 6.3	51.8 ± 6.1	50.5 ± 5.9	54.8 ± 6.7	.032
Gender (%)					$\chi^2 = 316.2$ <.001
Male	243 (58.0)	213 (50.8)	195 (46.5)	169 (40.3)	
Female	176 (42.0)	206 (49.2)	224 (53.5)	250 (59.7)	
BMI, kg/m^2	26.34 ± 5.31	25.47 ± 4.56	25.74 ± 4.91	24.52 ± 4.01	.011
Education (%)					$\chi^2 = 181.8$ <.001
<High school	89 (21.2)	92 (22.0)	123 (29.4)	92 (21.9)	
High school	180 (43.0)	159 (37.9)	134 (32.0)	139 (33.2)	
>High school	150 (35.8)	168 (40.1)	162 (38.6)	188 (44.9)	
Carbohydrate intake, g	219.3 ± 46.1	240.2 ± 45.4	245.9 ± 49.7	261.9 ± 56.4	<.001
Protein intake, g	56.8 ± 9.0	57.7 ± 10.2	58.0 ± 10.5	60.5 ± 11.4	.038
Fat intake, g	52.7 ± 12.9	48.4 ± 11.3	50.2 ± 16.5	48.6 ± 13.3	.008
Total fiber intake, g	39.8 ± 16.3	42.6 ± 15.7	40.4 ± 16.7	45.8 ± 18.4	<.001
Energy intake, kcal/d	1598.6 ± 280.2	1614.5 ± 287.0	1671.3 ± 305.8	1802.4 ± 349.5	<.001
Physical activity, MET/h/wk	489.8 ± 272.7	478.1 ± 295.5	500.3 ± 283.7	516.7 ± 337.4	.315
Hypertension (%)	77 (18.3)	71 (16.9)	72 (17.1)	56 (13.4)	<.001
Diabetes (%)	34 (8.1)	32 (7.6)	27 (6.4)	22 (5.3)	<.001
CVD (%)	39 (9.3)	38 (9.1)	35 (8.4)	25 (6.0)	<.001

Categorical variables are presented as sum and percentages, and continuous variables are presented as mean ± SD. BMI = body mass index, CVD = cardiovascular disease.

* *P* values for continuous variables (analysis of variance) and for categorical variables (chi-square test), $P < .05$ was considered statistically significant.

Table 3

Multivariate adjusted prevalence ratio (95% CI) for depressive symptoms across quartile (Q) categories of vegetables and fruits consumption.

	Fruits consumption			Vegetables consumption			Fruits and vegetables consumption		
	Q1	Q4	*P*	Q1	Q4	*P*	Q1	Q4	*P*
Model 1	1.00	0.47 (0.376,0.617)	<.001	1.00	0.62 (0.465, 0.820)	<.01	1.00	0.43 (0.361, 0.633)	<.001
Model 2	1.00	0.53 (0.419,0.730)	<.001	1.00	0.72 (0.681,0.935)	.039	1.00	0.55 (0.392, 0.719)	<.001
Model 3	1.00	0.76 (0.603,0.974)	.042	1.00	0.77 (0.612, 0.977)	.045	1.00	0.67 (0.503, 0.806)	.037

Model 1: unadjusted; Model 2: further adjusted for sex, age, educational level, economic income, smoking status, BMI, physical activity level and total energy intake; Model 3: additionally adjusted for self-reported history of diabetes (yes/no), hypertension (yes/no), CVD (yes/no), and self-reported history of depression (yes/no). Q4: the highest quartile of vegetables and fruits intake, Q1: the lowest quartile of vegetables and fruits intake (reference); CI = confidence interval.

association between the consumption of vegetables and fruits and the risk of depressive symptoms in a middle-aged population.

In our analyses, higher intake of vegetables and fruits was significantly associated with a decreased risk of depressive symptoms. Our findings are line with results from a previous study, showing an inverse relationship between consumption of fruits and/or vegetables and depressive symptoms.[17] Similarly, recent a meta-analysis conducted by Liu et al[18] also reported that consumption of vegetables and fruits are inversely related to the risk of depression. There are several possible explanations for the inverse association between the consumption of vegetables and fruits and depressive symptoms. First, the apparently protective effect of vegetables and fruits against depressive symptoms might be related to their high content of antioxidant substances, that is, vitamin C, vitamin E, and other carotenoids compounds. It is well-known that vitamin E and C, having antioxidant properties, can reduce the oxidative stress, which is thought to contribute to the incidence of depression.[19] Besides, antioxidants such as carotenoids, vitamin C, and vitamin E, which play a key role in the endothelial cell signaling cascades, could dampen the detrimental effects of oxidative stress on mental health.[20,21] Second, green vegetables contain a variety of folate and magnesium, which are important in the prevention of depression.[22,23] Chi et al[7] reported that folate is involved in the metabolism of monoamines such as serotonin in the brain. Studies also found that magnesium consumption could decrease the level of C-reactive protein, which is a marker of low-grade inflammation.[23] Third, higher intakes of vegetables and fruits can increase the amount of dietary fiber. Previous studies have found that high intake of dietary fiber may influence gut microbiota, which might also be associated with better mental and cognitive health.[24,25] Finally, most of the mentioned nutrients in fruits and vegetables may reduce inflammation, thereby reducing the risk of depression.[26,27]

4.1. Strengths and limitations

This study has some strengths and limitations. First, to the best of our knowledge, this is the first study reporting the topic of vegetables and fruits consumption and risk of depressive symptom in a middle-aged Chinese population. Second, information on the consumption of vegetables and fruits was collected by trained dieticians using a semi-quantitative FFQ. This FFQ enabled us to capture more reliable information on vegetables and fruits consumption of individuals in the last year. Third, we also have controlled for several potential known confounding factors for reliability in our analyses. However, there are also several potential limitations to this study. First, given the cross-sectional nature of this study, it could evaluate the only association and not causality. Thus, further studies are needed to confirm our findings. Second, the use of an FFQ to measure the consumption of vegetables and fruits may introduce some degree of measurement error. Third, although some confounding factors have been adjusted for in the multivariable adjusted model, we cannot eliminate the potential effect of other unmeasured factors, such as cultural factors. Fourth, in this study, we observed a significant association between higher intake of vegetables and fruits and depressive symptoms. But, the directionality of the associations was uncertain. Because participants with major depressive disease care less of their self, they may change their dietary habits and food choices, either eating less healthier food or having lower energy intake.[28] Finally, the study participants were recruited in the city of Linyi and not a random sample of the general population. Therefore, our results could not be generalizable to other populations.

5. Conclusions

In conclusion, we found that higher consumption of vegetables and fruits was significantly associated with a lower risk of depressive symptoms. Our findings reinforce the importance of diet in the progression of depressive symptoms, and also provide further evidence for the hypothesis that higher intake of vegetables and fruits was protectively associated with depressive symptoms. However, further prospective studies are urgently required to clarify whether a true causal association exists between consumption of vegetables and fruits and risk of depressive symptoms.

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Author contributions

The authors' contributions are as follow: Mei Song conceived and developed the idea for the paper and revised the manuscript; Hai-Ying Cheng contributed to data collection and wrote draft; Yun-Xia Shi and Feng-Na Yu contributed to data analysis and interpretation of the data. Huan-Zong Zhao and Jian-Hua Zhang conducted research. All authors read and approved the final manuscript.

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