ORIGINAL RESEARCH

The Association Between Eating Green Vegetables Every Day And Mild Cognitive Impairment: A Community-Based Cross-Sectional Study In Shanghai

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Background: Emerging evidence has suggested that green vegetables may prevent cognitive decline.

Methods: We examined the cross-sectional association between green vegetables intake and mild cognitive impairment (MCI) using data from 525 participants aged 55 years and above from the China Longitudinal Aging Study (CLAS) in Shanghai.

Results: Compared with participants who did not eat green vegetables every day, those who had consumed green vegetables every day had a significantly lower risk of mild cognitive impairment (MCI) (OR = 0.218, 95% CI, 0.116–0.411, p < 0.001), and this association was independent of age, education, having hobbies, surfing the Internet, sleep time per night (youth), long-term residency and consumption of specific red food, such as meat, bread, bean curd, and ginger.

Conclusion: In summary, using community-based data in Shanghai, we found out that subjects who eat green vegetables every day have significantly lower odds of MCI than those who do not eat every day. Based on current evidence, we propose that eating green vegetables every day might be a potential preventive measure to slow cognitive decline and neurodegeneration in the elderly.

Keywords: elderly, Chinese, dietetic association, green vegetables, cognitive impairment

Introduction

Emerging evidence has suggested that green vegetables may prevent cognitive decline.[1–3] For example, Kang et al[4] pointed out that more green vegetable intake was significantly associated with less cognitive decline, but their conclusion was only limited to aging women. Polidori et al[5] also confirmed that healthy subjects of any age with a high daily intake of vegetables, had higher antioxidant levels, lower levels of biomarkers of oxidative stress as well as better cognitive performance than those who consumed low amounts of vegetables.

Up to now, no research has been done on the relationship between green vegetables consumption and cognitive function in China. Therefore, we conducted this cross-sectional study to explore the cognitive protective effects of green vegetables among the elderly in Chinese communities.

Materials And Methods
Population Study

This cross-sectional population-based study was carried out in Xinjing, Shanghai (China), between June 1 and August 31, 2013, and the method of sampling has been described in our previous studies.[6] All 55- to 95-year-olds born between June 1, 1916,

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and August 31, 1961, and registered for census purposes in Shanghai were invited to participate in the study. The inclusion criteria involved participants who (1) were 55 years old and above; (2) had no serious physical illness, such as severe infection, acute myocardial infarction, acute cerebral infarction and tumors, or serious mental illness, such as mental retardation and schizophrenia; and (3) agreed to participate in the study.

Exclusion criteria were (1) participants who had serious physical illness or serious mental illness; (2) participants who suffered from severe visual or hearing impairment; and (3) refusal of the participants or their guardians to participate in the study. All the participants had signed an informed consent before the study was initiated and we had gotten an ethical review and approval from Shanghai Mental Health Centre. This study was conducted in accordance with the principles of Declaration of Helsinki.

Green Vegetables Consumption

By using the food frequency questionnaire (FFQ),[7] we obtained the information about participants' dietary consumption habits and frequency of consumption of green vegetables. The question "how often do you eat green vegetables?" was used in the interview. Responses were recorded as daily (for those who consumed green vegetables at least 1 time per day), weekly (for those who consumed green vegetables 1–6 times per week), or monthly (for those who consumed green vegetables less than 1 time per week).

Green vegetables intake frequencies were calculated on a weekly basis (calculated from daily, weekly and monthly recordings, e.g., green vegetables once/day, every day = 7 times/week; green vegetables once/month = 0.25 times/week, etc.). Using the same method, we have also investigated data on the consumption of meat, bread, bean curd, and ginger.

Assessments

This study consisted of two parts. Firstly, we collected general demographic data (age, sex, education, long-term residency, and living habits) of the subjects in the form of face-to-face interviews (contingent valuation study method). Then, we determined if the participant had MCI, and the diagnostic criteria for MCI[8] were as follows: (1) memory complaints; (2) objective memory impairment; (3) normal general cognitive function; (4) daily activities are well preserved; and (5) absence of dementia.

At the same time, we also used the Mini-Mental State Examination (MMSE)[9] and the Montreal Cognitive

Assessment (MoCA)[10] to assess the cognitive function of those subjects. The Chinese version of the MMSE[11] diagnosed MCI patients whose MMSE scores were higher than or equal to 25, 21, or 18 if they had secondary and higher education, an elementary school education, or no education, respectively. A diagnosis of AD in the present study was characterized by MMSE scores below 25, 21, or 18 for participants who had a middle school or higher education, an elementary school education, or no education, respectively. All of our scales were assessed by experienced clinical psychology staff who have consistently trained prior to the project.

Based on the above diagnostic criteria, 530 people were enrolled in the study, while 5 were excluded (including 2 schizophrenia, 2 severe depression, and 1 acute myocardial infarction). Of the 525 participants, 14 were diagnosed with dementia, 101 were diagnosed with MCI, 406 were considered as normal elderly, and 4 diagnostic data were missing. Then, we explored the relationship between green vegetables and MCI, and the flow chart is shown in Figure 1.

Data Analysis

Categorical variables were expressed as frequencies (%) and continuous variables were expressed as mean and SD. Chi-square test and independent sample t-test were used to compare the classification variables and continuous variables of MCI group and normal elderly group, respectively. Next, we used different logistic regression models to examine the association between green vegetables intake and MCI, treating green vegetables consumption as a categorical (eat green vegetables every day, yes or no). Model (1) did not control any variables; Model (2) controlled some variables, such as age, education, having hobbies, surfing
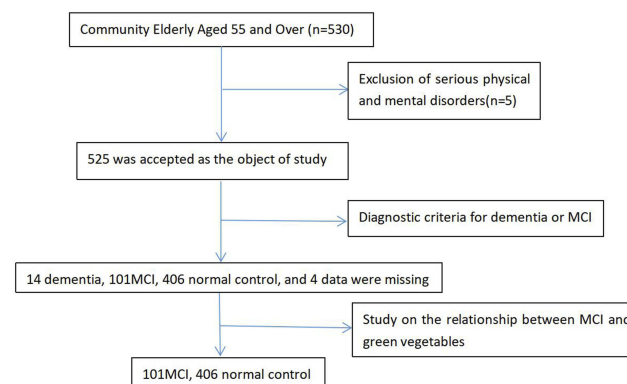

Figure 1 Research flow chart. This picture describes our research process, criteria for enrollment, and the subjects eventually included in the study.

Internet, sleep time per night (youth), and long-term residency; Model (3) furtherly controlled other variables, such as the consumption of bean curd and ginger. Then, we made an ROC curve to explore the sensitivity and specificity of the number of green vegetables eaten per week to predict MCI. Two-tailed tests were used at a significance level of p<0.05 for all analyses. The data were analyzed using SPSS 17.0 (IBM Corporation, Armonk, NY, USA).

Results

Table 1 presents the results of comparison between the normal aging and MCI groups. The normal aging participants had longer years of education and sleep time per night (youth) as well as higher proportions of surfing Internet, long-term residency in cities, meat and vegetables collocation, eating green vegetables every day, eating bean curd every day, and eating ginger every day compared to

the MCI participants. Similarly, the normal aging participants had higher scores of MMSE and MoCA. However, the MCI group was older and had a higher percentage of having hobbies (p < 0.05).

Table 2 shows the results of binary logistic regression analysis. Individuals who ate green vegetables every day had a lower risk of MCI (OR = 0.236, 95% CI, 0.126–0.439, p < 0.001); This relationship remained statistically significant after adjusting for age, education, having hobbies, surfing Internet, sleep time per night (youth), eating habits, and long-term residency in model (2) (OR = 0.219, 95% CI, 0.116–0.412, p < 0.001). Further adjustment for the consumption of bean curd and ginger in model (3) also did not change the results (OR = 0.218, 95% CI, 0.116–0.411, p < 0.001).

Results from partial correlation analysis (we had controlled age, education, hobby, surfing Internet, sleep time

Table 1 Description Of The Study Sample Based On Cognitive Status

Variable	MCI (n=101)	NC (n=406)	X^2 OR t	p
Age, y	72.72±9.901	65.74±9.661	6.458	0.000*
Education,y	5.99±4.390	9.32±3.786	−6.998	0.000*
Male, N (%)	42(41.6)	191(47.0)	0.971	0.372
Cigarette smokers, N (%)	22(21.8)	103(25.4)	0.560	0.520
Alcohol consumption, N (%)	15(14.9)	66(16.3)	0.119	0.879
Drinking tea, N(%)	43(46.2)	186(45.8)	0.343	0.578
Taking exercise, N(%)	68(67.3)	276(68.0)	0.016	0.906
Have hobby, N(%)	89(88.1)	306(75.4)	7.639	0.005*
Surfing internet, N(%)	6(5.9)	72(17.7)	8.641	0.002*
Sleep time per night (youth),h	7.391±1.436	7.725±0.907	−2.230	0.028*
Eating habits				
Vegetarian diet, N(%)	37(36.6)	92(22.7)	12.647	0.002*
Meat diet, N(%)	8(7.9)	16(3.9)		
Meat and vegetable collocation, N(%)	56(55.4)	298(73.4)		
Long-term residence				
City, N(%)	85(84.2)	383(94.3)	19.205	0.000*
Town, N(%)	4(4.0)	14(3.4)		
Village, N(%)	12(11.9)	9(2.2)		
Hypertension, N(%)	62(61.4)	38(9.4)	4.613	0.125
Diabetes, N(%)	21(20.8)	10(2.5)	8.667	0.070
Hyperlipidemia, N(%)	26(25.7)	15(3.7)	8.102	0.088
MMSE	22.39±5.992	28.19±3.172	−9.408	0.000*
MoCA	16.82±6.027	27.03±4.266	16.052	0.000*
Green vegetables, N(%)	79(78.2)	381(93.8)	23.475	0.000*
Red meat, N(%)	14(13.9)	95(23.4)	5.385	0.068
Bread	5(5.0)	50(12.3)	5.129	0.077
Bean curd	2(1.98)	48(11.8)	9.194	0.010*
Ginger	3(2.97)	304(74.9)	19.679	<0.001*

Note: *p<0.05.

Table 2 Green Vegetables Consumption (As Categorical Variable) And Mild Cognitive Impairment

Green Vegetables Consumption	B	S.E	Wald	df	p	OR	95% CI	
							Upper Limits	Lower Limits
Model a	−1.446	0.317	20.742	1	0.000	0.236	0.126	0.439
Model b	−1.518	0.323	22.115	1	0.000	0.219	0.116	0.412
Model c	−1.532	0.323	22.155	1	0.000	0.218	0.116	0.411

Notes: a, basic model, no adjustment. b, adjusted for age, gender, education, hobby, surfing Internet, sleep time per night (youth), eating habits, and long-term residents. c, adjusted for all variables in model 2 + the consumption of bean curd, and ginger.

per night (youth), eating habits, and long-term residency) showed consistent results with logistic regression on the reverse relationship between eating green vegetables every day and having MCI (r=−0.237, p < 0.001). By using an ROC curve, we found out that green vegetables eaten per week could predict whether the subjects would have MCI and the area under the curve was 0.672 (Figure 2).
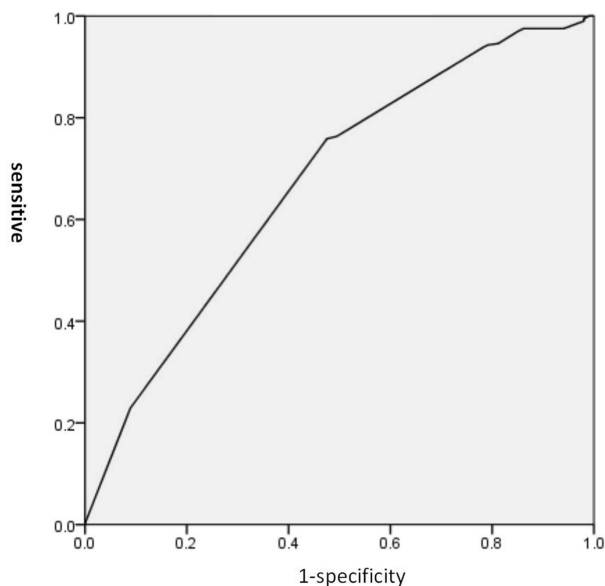
Discussion

As far as we know, this was the first study specifically focusing on the relationship between green vegetables consumption and MCI. In this cross-sectional study, we focused on the intrinsic relationship between green vegetables and MCI and controlled factors that might have an impact on cognitive function, such as age, education, gender, etc. And the results showed that eating green vegetables every day

ROC curve of weekly consumption of green vegetables for predicting MCI

Figure 2 ROC curve of weekly consumption of green vegetables for predicting MCI. This figure explains the sensitivity and specificity of using the number of green vegetables eaten per week to predict MCI.

might reduce the risk of MCI (OR = 0.218, 95% CI, 0.116–0.411, p < 0.001), and this result was independent of age, gender, education, hobby, surfing Internet, sleep time per night (youth), eating habits, long-term residency, and the consumption of specific food (red meat, bread, bean curd as well as ginger). Similarly, the number of vegetables eaten per week could also predict whether subjects would have MCI (the area under the curve was 0.672, 95% CI, 61.2–73.2%).

Previous studies suggested that greater adherence to Mediterranean diet (the traditional Mediterranean diet refers to a multinutrient dietary profile characterized by high intake of cereals, legumes, fruits, and vegetables; moderate consumption of fish and alcohol especially wine; low-to-moderate intake of dairy products; and low consumption of meat products and saturated fats[12]) might be associated with slower cognitive decline and reduced risk of dementia.[13–15] And some cross-sectional studies conducted in Asia also showed that the consumption of vegetables had potential benefits against dementia.[16–18] Since there were other factors in the above studies besides green vegetables, the conclusions of our study were partly consistent.

There are several explanations for why green vegetables can prevent cognitive decline. First, oxidative stress and excessive inflammatory reaction are likely to be involved in the pathogenesis of dementia.[19] Green vegetables are rich in carotenoids, vitamin C, vitamin E, and (n-3) polyunsaturated fatty acids (PUFA), which can inhibit the oxidative stress and inflammatory response effectively, so we speculate that the cognitive protective effect of green vegetables might be related with these antioxidants.[20,21] Second, inadequate folate status may result in hyperhomocysteinemia, which will increase the risk for cognitive dysfunction. As green vegetables are excellent sources of folate, increasing the intake of green vegetables will be beneficial to the cognitive function for the elderly.[22] Third, beta-amyloid (Aβ) peptides are involved in the pathogenesis of Alzheimer's disease (AD) and they trigger apoptotic cell death via the activation of caspase-dependent and caspase-

independent cell death effectors, namely caspase-3 and apoptosis-inducing factor (AIF), respectively.[23]

Accumulating evidence from epidemiological studies shows that consumption of beverages (e.g., red wine and green tea) or food (e.g., fruits and green vegetables) that are enriched in polyphenols is related to a lower risk of dementia such as AD.[24] And polyphenols are likely to achieve the role of neural protection by inhibiting the activity of caspase-3 and AIF.[25,26]

We have to admit that there are some limitations in our study. First, it is just a cross-sectional study that cannot determine the causal relationship between eating green vegetables every day and reducing the risk of MCI. Second, the results obtained may not be generalized due to the limited audience. Moreover, some confounding factors were not adjusted.

Conclusion

In summary, using community-based data in Shanghai, we found out that subjects who eat green vegetables every day have significantly lower odds of MCI than those who do not eat every day. Based on current evidence, we propose that eating green vegetables every day might be a potential preventive measure to slow cognitive decline and neurodegeneration in the elderly.

Acknowledgments

Disclosure

The authors report no conflicts of interest in this work.

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