Clinical Interventions in Aging

Dovepress
Taylor & Francis Group

Open Access Full Text Article

ORIGINAL RESEARCH

Association of Vegetable and Fruit Consumption Patterns with Cognitive Function in Older People with Different BMI Ranges: Findings from China

Liang Huang[1,*], Zixuan Hong[2,*], Ying Guo[2], Wenjin Song[2], Jiawei Huang[2], Wenwen Cao[2], Chenglin Cao[2], Ren Chen[2,3], Zhongliang Bai[2]

[1]Department of Medical Affairs Management, The First Affiliated Hospital of Wannan Medical College, Wuhu, Anhui, People's Republic of China; [2]Department of Health Services Management, School of Health Services Management, Anhui Medical University, Hefei, Anhui, People's Republic of China; [3]Department of Geriatrics, Chaohu Hospital of Anhui Medical University, Chaohu, Anhui, People's Republic of China

*These authors contributed equally to this work

Correspondence: Ren Chen; Zhongliang Bai, Department of Health Services Management, School of Health Services Management, Anhui Medical University, Hefei, Anhui, 230032, People's Republic of China, Email chenren2006@hotmail.com; baizhongliang@ahmu.edu.cn

Purpose: There is a lack of research on how vegetable and fruit consumption patterns affect cognitive function in older adults with varying BMIs. Therefore, this study aims to explore their relationship, with a special focus on gender differences.

Patients and Methods: A cross-sectional survey was conducted in Anhui Province, China, between July and September 2019, and information was collected from 6211 participants regarding socio-demographics, the frequency of vegetable and fruit consumption per week, and cognitive function. The study utilized descriptive analysis and binary logistic regression to determine the association between cognitive function and consumption patterns of vegetable and fruit.

Results: There were no statistically significant associations between vegetable and fruit consumption patterns and cognitive function in underweight and obese older adults. Among normal weight men, older adults in the V+/F- (AOR=1.65; 95% CI: 1.16–2.35) and V-/F- (AOR=3.95; 95% CI: 1.86–8.42) groups were more likely to have cognitive impairment compared with the V+/F+ group. However, no associations were observed between the two in women of normal weight. For the overweight women, a higher risk of cognitive impairment was found in the V+/F- group (AOR=1.54; 95% CI: 1.12–2.11), while older men did not.

Conclusion: The correlation between vegetable and fruit consumption patterns and cognitive function varies among older adults with different BMIs. Findings suggest the need for targeted nutritional interventions for these communities to maintain cognitive function in older adults.

Keywords: vegetable and fruit consumption, cognitive function, older people, cross-sectional, China

Introduction

China is facing population aging.[1] Under this challenging situation, cognitive impairment in older people has become a public health concern that needs to be addressed.[2,3] It has been reported that Alzheimer's disease (AD) affects over 55 million people worldwide, and this figure is anticipated to rise to a new peak by 2050.[4] Despite great efforts, there are no clinically effective means and drugs to treat Alzheimer's disease.[5] Previous studies have shown that mild cognitive impairment (MCI) is an early stage in a patient's development of AD.[6,7] Therefore, early prevention for MCI has become a new perspective and approach to addressing AD effectively.[8]

Recently, the impact of vegetable and fruit consumption on health in later life has been documented.[9–11] For example, a meta-analysis showed that vegetable and fruit consumption related to a reduced risk of cardiovascular disease and cancer mortality.[12] Besides, a prospective Australian study of older women showed that increased intake of vegetables, particularly cruciferous and allium vegetables, may prevent fractures in older women.[13] Current research has shown that the cognitive function of older adults is influenced by many factors such as lifestyle habits,[14] illnesses (depression,[15]

Received: 31 December 2024
Accepted: 6 May 2025
Published: 10 May 2025

diabetes,[16] etc.), religious beliefs,[17] and socioeconomic status.[18] Moreover, vegetable and fruit consumption has emerged as a crucial concern for preventing and delaying cognitive impairment due to the potential impact the minerals, fibre, and vitamins in vegetables and fruits may have on brain health.[19,20] As reported in a previous study, vegetable and fruit consumption has a protective role in slowing cognitive decline.[21] Another study also showed that sufficient consumption of vegetables and fruits was associated with a reduced risk of dementia.[22]

Currently, relevant studies have confirmed that older people with different weight statuses as assessed by body mass index (BMI) exhibit different cognitive function statuses.[23] Older people with a BMI defined as underweight were significantly more likely to experience a risk of cognitive impairment.[24] Another study suggested that obesity reduces the risk of dementia compared to people with a normal weight.[25] However, evidence from Poland showed that overweight and obesity in older people were not associated with cognitive decline.[26] Individuals categorized according to BMI may exhibit different cognitive capabilities,[27] and these differences could alter the impact of eating vegetables and fruits on cognitive function. For example, obesity was linked to a higher risk of cognitive decline, which may be due to the effects of obesity-related inflammation and metabolic syndrome on brain health.[28] The link between vegetable and fruit consumption and cognitive function appears multifaceted and may be influenced by various factors, including BMI. Besides, gender differences further complicate this relationship. Men and women typically exhibit different dietary patterns, nutritional needs, and physiological responses to the diet, which may impact cognitive function differently.[29,30] For instance, studies suggested that women have a higher intake of vegetables and fruits than men, potentially correlating with enhanced cognitive function.[31]

Nevertheless, evidence regarding the impact of vegetable and fruit consumption on cognitive function in older people with different BMIs, as well as gender differences, is insufficient. Therefore, this study aims to elucidate the relationship among older adults with different BMIs while focusing on gender differences. By elucidating these relationships, policymakers identify targeted dietary interventions to support cognitive function and improve older people's overall health and quality of life.

Materials and Methods

Study Design and Sample

This cross-sectional survey is part of the Anhui Health and Longevity Survey (AHLS) conducted in China from July to September 2019.[7,32] To obtain a well-representative sample, we designed a multi-stage purposive sampling method. The sampling process of this study can be described as follows. First, four cities from Anhui Province were selected based on geographic location: Chuzhou (East), Xuancheng (South), Lu'an (West), and Fuyang (North). Second, 3 to 5 urban and rural communities were randomly selected from these four cities. Third, residents were invited to participate in the questionnaire survey in each selected urban and rural community. The following criteria were used to select the research participants: Residents aged 60 years and older, with no severe hearing or speech impairments, who were able to cooperate with the survey. The investigator conducted face-to-face interviews on-site. Prior to the interview, the investigator explained the purpose and procedures of the study to the participants, and informed consent was obtained. A total of 6211 questionnaires were collected in this survey. This study excluded participants who were unable to complete the assessment of cognitive function (N=32), had missing BMI-related data (N=381), and a final 5798 participants were eligible for data analysis (details are shown in Supplementary Figure S1). Ethical approval for this study was obtained from the Biomedical Ethics Committee of Anhui Medical University (No. 2020H011).

Cognitive Function

This study assessed the participants' cognitive function through the Chinese version of the Mini-Mental State Examination (MMSE), a validated and commonly used method for detecting cognitive impairment in clinical and research settings.[33,34] The Chinese version of MMSE consists of orientation, memory, attention and calculation, recall, and language abilities, scoring 30 points. Several questions in this scale are influenced by the participant's educational background,[35] so the criteria for assessing MCI in participants of this study are as follows: illiterate individuals scoring below 18 points; those with primary education but scoring below 21 points; those with more than six years of education but scoring below 25 points, in line with other studies.[7]

Vegetable and Fruit Consumption Patterns

To obtain the frequency of vegetable and fruit consumption of the respondents, the question "How many days a week do you usually consume vegetables/fruits?" was set in the questionnaire. The available answer choices include "every day", "4–6 days", "2–3 days", and "less than 1 day". Consistent with other studies,[32,36] respondents' vegetable and fruit consumption was categorized into the following four patterns: V+/F+: daily or often intake of both vegetables and fruits; V+/F-: daily or often intake of vegetables, but sometimes or never intake of fruits; V-/F+: daily or often intake fruits, but sometimes or never intake vegetables; V-/F-: Sometimes or never intake of either vegetables or fruits.

BMI

The investigator determined BMI (kg/m^2) by taking on-site measurements of height and weight for each participant and dividing the measured weight by the square of the height. According to the BMI standards in China,[37,38] respondents were classified as follows: underweight: BMI <18.5, normal weight: 18.5 ≤ BMI < 24, overweight: 24 ≤ BMI < 28, obese: BMI ≥ 28.

Other Variables

The following information about the respondents was collected for this study: age (years), gender, place of residence (urban, rural), living status (living alone, living with others), marital status (married, other), education level (illiterate, primary school, above primary school), annual income (<6500 CNY, ≥6500 CNY), smoking status (smoker, non-smoker), and drinking status (drinker, non-drinker). Depressive symptoms in participants were evaluated with the Patient Health Questionnaire (PHQ-9), covering nine questions out of 27 points, classifying participants with scores of five and above as depressed, otherwise not depressed.[32] The question "Do you suffer from one of the following chronic diseases (hypertension, hyperlipidemia, diabetes, chronic hepatitis, cancer, heart disease, stroke, lung disease, psychiatric disease, etc.)" was used to determine if the respondent suffered from a chronic disease. In the current study, we used the activities of daily living (ADL) scale, which includes ten dimensions, to measure disability in ADL. Respondents were classed as "No" if they scored 100, ie, indicated "self-care" on any of the items. Otherwise, they were categorized as "Yes", consistent with another study.[39]

Statistical Analysis

Data for categorical variables were described in the form of frequencies and percentages. First, we used simple descriptive analysis to describe the characteristics of the sample. Second, a binary logistic regression model was performed to explore gender differences in the correlation between vegetable and fruit consumption patterns and cognitive function. Univariate logistic regression analyses were conducted to produce Model 1, which was then adjusted for the covariates of age, place of residence, living status, marital status, education, annual income, smoking status, drinking status, chronic disease, depression status, disability in ADL, and vegetable and fruit consumption patterns to produce Model 2. The regression models yielded odds ratios (OR) and adjusted odds ratios (AOR) and the corresponding 95% confidence intervals (95% CI). This study used SPSS 23.0 software for data analysis, with statistical significance set at P<0.05.

Results

Basic Characteristics of the Sample

Participants were categorized by gender, resulting in Table 1. A total of 5798 participants, of whom more were women (3147, 54.3%), most of the participants were between 60–69 years old (2740, 47.3%), had a BMI in the normal weight range (2463, 42.5%), lived in urban areas (2864, 49.4%). Most were married (4159, 71.7%), lived with others (4733, 81.6%), and almost half were illiterate (2849, 49.2%). The majority had an annual income of less than 6,500 CNY (3469, 59.8%). Notably, 79.0% and 61.3% were non-smokers and non-drinkers, respectively. Regarding health status, the vast

Table 1 Characteristics of Participants by Gender (N=5798)

Variables	Total (N=5798)	Male (N=2651)	Female (N=3147)
Age (years)			
60–69	2740 (47.3)	1242 (46.8)	1498 (47.6)
70–79	2283 (39.3)	1060 (40.0)	1223 (38.9)
≥80	775 (13.4)	349 (13.2)	426 (13.5)
BMI (kg/m^2)			
Underweight	274 (4.7)	134 (5.1)	140 (4.4)
Normal weight	2463 (42.5)	1177 (44.3)	1286 (40.9)
Overweight	2072 (35.7)	943 (35.6)	1129 (35.9)
Obese	989 (17.1)	397 (15.0)	592 (18.8)
Residence			
Urban	2864 (49.4)	1263 (47.6)	1601 (50.9)
Rural	2934 (50.6)	1388 (52.4)	1546 (49.1)
Living status			
Living alone	1065 (18.4)	429 (16.2)	636 (20.2)
Living with others	4733 (81.6)	2222 (83.8)	2511 (79.8)
Marital status			
Married	4159 (71.7)	2082 (78.5)	2077 (66.0)
Other	1639 (28.3)	569 (21.5)	1070 (34.0)
Education			
Illiterate	2849 (49.2)	837 (31.6)	2012 (63.9)
Primary school	1619 (27.9)	949 (35.8)	670 (21.3)
Above primary school	1330 (22.9)	865 (32.6)	465 (14.8)
Annual income			
<6500 CNY	3469 (59.8)	1398 (52.7)	2071 (65.8)
≥6500 CNY	2329 (40.2)	1253 (47.3)	1076 (34.2)
Smoking status			
Smoker	1215 (21.0)	1065 (40.2)	150 (4.8)
Non-smoker	4583 (79.0)	1586 (59.8)	2997 (95.2)
Drinking status			
Drinker	2245 (38.7)	1594 (60.1)	651 (20.7)
Non-drinker	3553 (61.3)	1057 (39.9)	2496 (79.3)
Chronic disease			
Yes	4139 (71.4)	1847 (69.7)	2292 (72.8)
No	1659 (28.6)	804 (30.3)	855 (27.2)
Depressive status			
Depression	1887 (32.5)	688 (26.0)	1199 (38.1)
No depression	3911 (67.5)	1963 (74.0)	1948 (61.9)
Disability in ADL			
No	2414 (41.6)	1180 (44.5)	1234 (39.2)
Yes	3384 (58.4)	1471 (55.5)	1913 (60.8)
Cognitive function			
Non-MCI	3976 (68.6)	1963 (74.0)	2013 (64.0)
MCI	1822 (31.4)	688 (26.0)	1134 (36.0)
Vegetable and Fruit Consumption Patterns			
V+/F+	1704 (29.4)	765 (28.9)	939 (29.8)
V+/F-	3910 (67.4)	1790 (67.5)	2120 (67.4)
V-/F+	31 (0.5)	15 (0.6)	16 (0.5)
V-/F-	153 (2.7)	81 (3.0)	72 (2.3)

majority of participants suffered from chronic diseases (4139, 71.4%), a few were depressed (1887, 32.5%), and more than half of the participants had disability in ADL (3384, 58.4%). In addition, the majority of participants' vegetable and fruit consumption patterns were classified as V+/F- (3910, 67.4%).

 https://doi.org/10.2147/CIA.S515094

Binary Logistic Regression Analysis of Vegetable and Fruit Consumption Patterns and Cognitive Function in Underweight Participants

Using binary logistic regression analysis (Table 2), we found no statistically significant relationship between vegetable and fruit consumption patterns and cognitive function among underweight men, either before or after adjustment (P>0.05). In contrast, unadjusted results among underweight women showed that the V-/F- pattern correlated with lower cognitive function (OR=11.31; 95% CI: 1.25–102.72), but no significant correlation was found after adjustment.

Binary Logistic Regression Analysis of Vegetable and Fruit Consumption Patterns and Cognitive Function in Normal Weight Participants

Table 3 illustrates the findings of the binary logistic regression model following variable adjustments. In normal weight men, cognitive impairment is more likely to be found in the V+/F- (AOR=1.65; 95% CI: 1.16–2.35) and V-/F- (AOR=3.95; 95% CI: 1.86–8.42) groups, respectively, compared to the V+/F+ group. However, in women of normal weight, vegetable and fruit consumption patterns were not statistically correlated with cognitive function after adjustment.

Binary Logistic Regression Analysis of Vegetable and Fruit Consumption Patterns and Cognitive Function in Overweight Participants

As presented in Table 4, after adjusting for confounders, only V+/F- (AOR=1.54; 95% CI: 1.12–2.11) was related to an increased probability of cognitive impairment among overweight women (Model 2). Furthermore, statistical significance did not show other vegetable and fruit consumption patterns in the overweight participants (P>0.05).

Table 2 Binary Logistic Analysis Examining Relationships Between Vegetable and Fruit Consumption Patterns and Cognitive Function in Underweight Participants (N=274)

Vegetable and Fruit Consumption Patterns	Male				Female			
	Model 1		Model 2		Model 1		Model 2	
	OR, 95% CI	*P*-value	AOR, 95% CI	*P*-value	OR, 95% CI	*P*-value	AOR, 95% CI	*P*-value
V+/F+ (REF.)								
V+/F-	1.77, (0.68–4.58)	0.241	1.70, (0.54–5.37)	0.368	1.15, (0.52–2.57)	0.727	0.92, (0.33–2.55)	0.865
V-/F+	/	/	/	/	/	/	/	/
V-/F-	0.91, (0.08–10.21)	0.935	0.35, (0.02–5.93)	0.469	11.31, (1.25–102.72)	0.031	11.75, (0.91–151.37)	0.059

Note: Model 1: unadjusted; Model 2 adjusted age, residence, living status, marital status, education, annual income, smoking status, drinking status, chronic diseases, depressive status, disability in ADL, vegetable and fruit consumption patterns.
Abbreviations: REF, reference group; /, Results could not be obtained as the actual number of participants was too small; OR, odds ratio; AOR, adjusted odds ratio; 95% CI, 95% confidence interval.

Table 3 Binary Logistic Analysis Examining Relationships Between Vegetable and Fruit Consumption Patterns and Cognitive Function in Normal Weight Participants (N=2463)

Vegetable and Fruit Consumption Patterns	Male				Female			
	Model 1		Model 2		Model 1		Model 2	
	OR, 95% CI	*P*-value	AOR, 95% CI	*P*-value	OR, 95% CI	*P*-value	AOR, 95% CI	*P*-value
V+/F+ (REF.)								
V+/F-	1.69, (1.23–2.34)	0.001	1.65, (1.16–2.35)	0.006	1.53, (1.18–2.00)	0.002	1.18, (0.88–1.58)	0.271
V-/F+	3.42, (0.89–13.14)	0.073	2.47, (0.54–11.35)	0.246	0.61, (0.13–2.94)	0.542	0.45, (0.08–2.32)	0.339
V-/F-	4.05, (2.00–8.20)	<0.001	3.95, (1.86–8.42)	<0.001	3.07, (1.40–6.78)	0.006	1.50, (0.63–3.53)	0.364

Note: Model 1: unadjusted; Model 2 adjusted age, residence, living status, marital status, education, annual income, smoking status, drinking status, chronic diseases, depressive status, disability in ADL, vegetable and fruit consumption patterns.
Abbreviations: REF, reference group; OR, odds ratio; AOR, adjusted odds ratio; 95% CI, 95% confidence interval.

Table 4 Binary Logistic Analysis Examining Relationships Between Vegetable and Fruit Consumption Patterns and Cognitive Function in Overweight Participants (N=2072)

Vegetable and Fruit Consumption Patterns	Male				Female			
	Model 1		Model 2		Model 1		Model 2	
	OR, 95% CI	*P*-value	AOR, 95% CI	*P*-value	OR, 95% CI	*P*-value	AOR, 95% CI	*P*-value
V+/F+ (REF.)								
V+/F-	1.39, (1.00–1.94)	0.050	1.17, (0.82–1.69)	0.389	2.23, (1.67–2.99)	<0.001	1.54, (1.12–2.11)	0.007
V-/F+	7.68, (0.69–86.09)	0.098	6.14, (0.48–79.16)	0.164	/	/	/	/
V-/F-	1.44, (0.54–3.83)	0.465	0.92, (0.30–2.80)	0.885	3.03, (1.35–6.82)	0.007	2.10, (0.89–4.98)	0.091

Note: Model 1: unadjusted; Model 2 adjusted age, residence, living status, marital status, education, annual income, smoking status, drinking status, chronic diseases, depressive status, disability in ADL, vegetable and fruit consumption patterns.
Abbreviations: REF, reference group; /, Results could not be obtained as the actual number of participants was too small; OR, odds ratio; AOR, adjusted odds ratio; 95% CI, 95% confidence interval.

Binary Logistic Regression Analysis of Vegetable and Fruit Consumption Patterns and Cognitive Function in Obese Participants

Table 5 shows the results of the analyses of the obese participants. The adjusted results (Model 2) reveal that vegetable and fruit consumption patterns were not significantly correlated with cognitive function in either males or females (P>0.05).

Discussion

As far as we know, this study is the first to explore the link between vegetable and fruit consumption patterns and cognitive function in older adults with varying BMIs and to examine gender differences in this association. According to the data analysis, the association between the two varied among older people with different BMIs.

This study found that 31.4% of older individuals had MCI, surpassing the typical prevalence range of 15.2–15.9% for MCI among older people in China.[40] The present study showed no correlation between vegetable and fruit consumption patterns and cognitive function in underweight older people. One possible explanation is that older people suffering from being underweight may face overall malnutrition.[41] They may be deficient in multiple nutrients, not just those found in vegetables and fruits.[42] This deeper nutritional deficiency may have a greater impact on the brain and weaken this relationship.[43]

Conversely, among normal weight men, older people with a higher frequency of vegetable and fruit consumption reported better cognitive function, consistent with other studies.[21,36,44] In other words, individuals in the V+/F- and V-/F- groups were 1.65 and 3.95 times more likely to have poorer cognitive function than those in the V+/F+ group, respectively. Previous studies also supported this conclusion.[21,45,46] A similar association between vegetable and fruit intake and cognitive function was observed in a Brazilian cohort of older adults,[47] where higher vegetable and fruit

Table 5 Binary Logistic Analysis Examining Relationships Between Vegetable and Fruit Consumption Patterns and Cognitive Function in Obese Participants (N=989)

Vegetable and Fruit Consumption Patterns	Male				Female			
	Model 1		Model 2		Model 1		Model 2	
	OR, 95% CI	*P*-value	AOR, 95% CI	*P*-value	OR, 95% CI	*P*-value	AOR, 95% CI	*P*-value
V+/F+ (REF.)								
V+/F-	1.09, (0.65–1.83)	0.742	0.89, (0.51–1.57)	0.686	1.81, (1.25–2.63)	0.002	1.26, (0.84–1.90)	0.259
V-/F+	1.87, (0.16–21.41)	0.615	1.10, (0.08–15.47)	0.945	2.36, (0.15–38.35)	0.547	1.53, (0.09–26.81)	0.770
V/-F-	2.38, (0.84–6.72)	0.102	1.35, (0.42–4.31)	0.613	1.35, (0.38–4.79)	0.645	0.67, (0.17–2.63)	0.563

Note: Model 1: unadjusted; Model 2 adjusted age, residence, living status, marital status, education, annual income, smoking status, drinking status, chronic diseases, depressive status, disability in ADL, vegetable and fruit consumption patterns.
Abbreviations: REF, reference group; OR, odds ratio; AOR, adjusted odds ratio; 95% CI, 95% confidence interval.

intake was associated with better cognitive function. Still, the effect size was not the same in Western populations.[48,49] This geographic heterogeneity may reflect differences in diet composition, food preparation methods, or lifestyle confounders across cultures. Another prospective cohort study also showed that higher vegetable and fruit consumption was positively associated with cognitive function in older people.[50] The reasons why vegetable and fruit intake can prevent cognitive decline may include the following. Vegetables and fruits are rich in various vitamins and minerals,[51,52] which are essential for brain health. For instance, folic acid can prevent hyperhomocysteinemia, reducing the risk of cognitive impairment.[53] In addition, many vegetables and fruits contain plentiful antioxidants (flavonoids, anthocyanins, carotenoids, etc.) that help reduce oxidative stress and protect brain cells from damage.[54,55] Moreover, vegetables and fruits often have anti-inflammatory properties that reduce chronic inflammation in the body, considered to be associated with AD and other cognitive impairments.[56]

Interestingly, this association was not observed in older women. There are physiological and hormonal differences between older men and women. Especially after menopause, older women's estrogen levels drop sharply, which may affect their eating habits and the utilization of nutrients from vegetables and fruits, thereby impacting their cognitive function in later life.[57,58] For overweight older people, our study found gender differences in the association between vegetable and fruit consumption patterns and cognitive function. Specifically, among overweight women, older adults with low vegetable and fruit consumption (V+/F-) have a higher likelihood of developing MCI, but not in men. This discrepancy may be attributed to differences in overweight men's and women's diets. For example, overweight women may be more inclined to improve the overall quality of their diet by increasing their vegetable and fruit intake, especially if they need to control their weight.[59] This self-regulation of diet may help them improve their overall health and cognitive function.[60] Overweight men, on the other hand, may rely more on high-protein, high-fat foods, and increased vegetable and fruit intake may not significantly improve cognitive function.[61]

Our study found no association between vegetable and fruit consumption patterns and cognitive function in obese older people. This may be attributed to the poor cognitive function of obese older people. Current research suggests that obesity negatively correlates with cognitive function.[62] Besides, obese older people commonly have chronic diseases such as diabetes, hypertension, and hyperlipidemia,[63] which may harm their cognitive function,[64] so vegetable and fruit intake, while it may improve diet quality and nutrient intake, may not counteract these adverse effects.

This study has several advantages. First, this study differs from previous research by focusing on different BMIs of older people and examining the gender differences in the association between vegetable and fruit consumption patterns and cognitive function. Second, this study employed effective and reliable tools to measure participants' cognitive function and obtained a large representative sample, reducing the impact of random factors on the results.

However, it is crucial to be aware of some research limitations. The present study was cross-sectional and could not determine the exact causal relationship, suggesting the need to explore this more fully in future cohort or intervention studies. Besides, a self-reported questionnaire on the frequency of vegetable and fruit consumption was used in this study, leading to possible misclassification of vegetables and fruits. Furthermore, China-specific evidence dominated our analysis. For example, the traditional consumption attitudes of older Chinese adults (who may be reluctant to spend money on fruits) resulted in a small sample size of vegetable and fruit consumption patterns defined as the V-/F+ group, which may limit the generalizability of the findings. The complex interplay between regional dietary habits, genetic susceptibility, and environmental factors needs to be validated by comparative studies of different ethnic populations. Finally, the variables considered in this study were limited, and some factors, such as physical activity patterns, mental health status, and medication taken by participants, were not adequately emphasized. Therefore, a longitudinal design with multidimensional assessments will be utilized in subsequent investigations to help elucidate nutritional factors' independent and synergistic effects on cognitive function.

Conclusion

This study shows how consuming vegetables and fruits is linked to cognitive function in older Chinese people with different BMIs. No correlation was found between vegetable and fruit consumption patterns and cognitive function in underweight and obese older adults. However, among normal weight and overweight older adults, those with a higher frequency of vegetable and fruit consumption reported better cognitive function, with gender differences. This study emphasizes the significance of vegetable and fruit consumption and contributes to formulating more effective policy approaches to protect cognitive function in older adults with different BMIs, aiming for healthy aging.

Abbreviations

AD, Alzheimer's Disease; MCI, Mild Cognitive Impairment; BMI, Body Mass Index; AHLS, Anhui Health and Longevity Survey; MMSE, Mini-Mental State Examination; PHQ-9, Patient Health Questionnaire; ADL, Activities of Daily Living; OR, Odds Ratios; AOR, Adjusted Odds Ratios; CI, Confidence Intervals.

Data Sharing Statement

The data that support the findings of this study are available on request from the corresponding author (Zhongliang Bai).

Ethical Approval and Informed Consent

This study adhered to the principles outlined in the Declaration of Helsinki. Ethical approval for this study was obtained from the Biomedical Ethics Committee of Anhui Medical University (No.2020H011) and informed consent was obtained from all participants. An unauthorized version of the Chinese MMSE was used by the study team without permission, however this has now been rectified with PAR. The MMSE is a copyrighted instrument and may not be used or reproduced in whole or in part, in any form or language, or by any means without written permission of PAR (www.parinc.com).

Acknowledgments

The authors wish to express sincere appreciation to all who assisted and engaged in our study.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Funding

This work was supported by the National Natural Science Foundation of China (No. 72304003), the Outstanding Research and Innovation Team Program of Education Department of Anhui Province (No. 2023AH010036), and the Postgraduate Innovation Research and Practice Program of Anhui Medical University (No. YJS20240081).

Disclosure

The authors declare no conflicts of interest in this work.

References

1. Qi X, Li Y, Hu J, et al. Prevalence of social frailty and its associated factors in the older Chinese population: a national cross-sectional study. *BMC Geriatr*. 2023;23(1):532. doi:10.1186/s12877-023-04241-1
2. Twarowski B, Herbet M. Inflammatory processes in Alzheimer's disease-pathomechanism, diagnosis and treatment: a review. *Int J Mol Sci*. 2023;24(7):6518. doi:10.3390/ijms24076518
3. Hu X, Gu S, Zhen X, Sun X, Gu Y, Dong H. Trends in cognitive function among Chinese elderly from 1998 to 2018: an age-period-cohort analysis. *Front Public Health*. 2021;9:753671. doi:10.3389/fpubh.2021.753671
4. Nichols E, Steinmetz JD, Vollset SE. Estimation of the global prevalence of dementia in 2019 and forecasted prevalence in 2050: an analysis for the Global Burden of Disease Study 2019. *Lancet Public Health*. 2022;7(2):e105–e125. doi:10.1016/s2468-2667(21)00249-8
5. Breijyeh Z, Karaman R. Comprehensive review on Alzheimer's disease: causes and treatment. *Molecules*. 2020;25(24):5789. doi:10.3390/molecules25245789
6. Anderson ND. State of the science on mild cognitive impairment (MCI). *CNS Spectrums*. 2019;24(1):78–87. doi:10.1017/s1092852918001347
7. Fangfang H, Xiao H, Shuai Z, et al. Living environment, built environment and cognitive function among older Chinese adults: results from a cross-sectional study. *J Prev Alzheimer's Dis*. 2022;9(1):126–135. doi:10.14283/jpad.2021.59

8. Zhang XX, Tian Y, Wang ZT, Ma YH, Tan L, Yu JT. The epidemiology of Alzheimer's disease modifiable risk factors and prevention. *J Prev Alzheimer's Dis*. 2021;8(3):313–321. doi:10.14283/jpad.2021.15
9. Tardy AL, Pouteau E, Marquez D, Yilmaz C, Scholey A. Vitamins and minerals for energy, fatigue and cognition: a narrative review of the biochemical and clinical evidence. *Nutrients*. 2020;12(1):228. doi:10.3390/nu12010228
10. Nguyen HD, Oh H, Kim MS. An increased intake of nutrients, fruits, and green vegetables was negatively related to the risk of arthritis and osteoarthritis development in the aging population. *Nutr Res*. 2022;99:51–65. doi:10.1016/j.nutres.2021.11.005
11. Fung TT, Struijk EA, Rodriguez-Artalejo F, Willett WC, Lopez-Garcia E. Fruit and vegetable intake and risk of frailty in women 60 years old or older. *Am J Clin Nutr*. 2020;112(6):1540–1546. doi:10.1093/ajcn/nqaa256
12. Aune D, Giovannucci E, Boffetta P, et al. Fruit and vegetable intake and the risk of cardiovascular disease, total cancer and all-cause mortality-a systematic review and dose-response meta-analysis of prospective studies. *Int J Epidemiol*. 2017;46(3):1029–1056. doi:10.1093/ije/dyw319
13. Blekkenhorst LC, Hodgson JM, Lewis JR, et al. Vegetable and fruit intake and fracture-related hospitalisations: a prospective study of older women. *Nutrients*. 2017;9(5):511. doi:10.3390/nu9050511
14. Dong L, Xiao R, Cai C, et al. Diet, lifestyle and cognitive function in old Chinese adults. *Arch Gerontol Geriatrics*. 2016;63:36–42. doi:10.1016/j.archger.2015.12.003
15. Wang J, Zhu A, Chen J, et al. Association between cognitive frailty and depression: a prospective cohort study of adults aged 45 years and older in China. *Clin Interventions Aging*. 2024;19:2167–2178. doi:10.2147/cia.S484352
16. Casagrande SS, Lee C, Stoeckel LE, Menke A, Cowie CC. Cognitive function among older adults with diabetes and prediabetes, NHANES 2011–2014. *Diabetes Res Clin Pract*. 2021;178:108939. doi:10.1016/j.diabres.2021.108939
17. Hosseini S, Chaurasia A, Oremus M. The effect of religion and spirituality on cognitive function: a systematic review. *Gerontologist*. 2019;59(2):e76–e85. doi:10.1093/geront/gnx024
18. Hsu HC, Bai CH. Individual and environmental factors associated with cognitive function in older people: a longitudinal multilevel analysis. *BMC Geriatr*. 2022;22(1):243. doi:10.1186/s12877-022-02940-9
19. Johnson EJ. A possible role for lutein and zeaxanthin in cognitive function in the elderly12345. *Am J Clin Nutr*. 2012;96(5):1161S–1165S. doi:10.3945/ajcn.112.034611
20. Haskell-Ramsay CF, Docherty S. Role of fruit and vegetables in sustaining healthy cognitive function: evidence and issues. *Proc Nutr Soc*. 2023;82(3):305–314. doi:10.1017/s0029665123002999
21. Huang L, Zhao C, Gao M, et al. Associations of vegetable and fruit intake with cognitive function and its decline: two longitudinal studies. *J Nutr Health Aging*. 2024;28(6):100223. doi:10.1016/j.jnha.2024.100223
22. Lee ATC, Richards M, Chan WC, Chiu HFK, Lee RSY, Lam LCW. Lower risk of incident dementia among Chinese older adults having three servings of vegetables and two servings of fruits a day. *Age Ageing*. 2017;46(5):773–779. doi:10.1093/ageing/afx018
23. Chen L, Hou Y, Sun Y, Peng D. Association of obesity indicators with cognitive function among US adults aged 60 years and older: results from NHANES. *Brain Behav*. 2024;14(9):e70006. doi:10.1002/brb3.70006
24. Ren Z, Li Y, Li X, et al. Associations of body mass index, waist circumference and waist-to-height ratio with cognitive impairment among Chinese older adults: based on the CLHLS. *J Affective Disorders*. 2021;295:463–470. doi:10.1016/j.jad.2021.08.093
25. Shinohara M, Gheni G, Hitomi J, Bu G, Sato N. APOE genotypes modify the obesity paradox in dementia. *J Neurol Neurosurg*. 2023;94(9):670–680. doi:10.1136/jnnp-2022-331034
26. Puzianowska-Kuznicka M, Kuryłowicz A, Walkiewicz D, et al. Obesity paradox in Caucasian Seniors: results of the PolSenior study. *J Nutr Health Aging*. 2019;23(9):796–804. doi:10.1007/s12603-019-1257-z
27. Grapsa I, Mamalaki E, Ntanasi E, et al. Longitudinal examination of body mass index and cognitive function in older adults: the HELIAD study. *Nutrients*. 2023;15(7):1795. doi:10.3390/nu15071795
28. Bae EM, Park SM. Association between variations in body mass index and cognitive function in older Korean adults. *J Obesity Metabolic Syndrome*. 2021;30(3):271–278. doi:10.7570/jomes21044
29. Mazza E, Troiano E, Ferro Y, et al. Obesity, dietary patterns, and hormonal balance modulation: gender-specific impacts. *Nutrients*. 2024;16(11):1629. doi:10.3390/nu16111629
30. Jacob JS, Panwar N. Effect of age and gender on dietary patterns, mindful eating, body image and confidence. *BMC Psychol*. 2023;11(1):264. doi:10.1186/s40359-023-01290-4
31. Stea TH, Nordheim O, Bere E, Stornes P, Eikemo TA. Fruit and vegetable consumption in Europe according to gender, educational attainment and regional affiliation-A cross-sectional study in 21 European countries. *PLoS One*. 2020;15(5):e0232521. doi:10.1371/journal.pone.0232521
32. Fangfang H, Qiong W, Shuai Z, et al. Vegetable and fruit intake, its patterns, and cognitive function: cross-sectional findings among older adults in Anhui, China. *J Nutr Health Aging*. 2022;26(5):529–536. doi:10.1007/s12603-022-1791-y
33. Wang Z, Zhang M. Application of the Chinese version of the Mini-Mental State Examination (MMSE). *Shanghai Arch Psychiatry*. 1989;7(3). [In Chinese].
34. Folstein MF, Folstein SE, McHugh PR. "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. *J Psychiatr Res*. 1975;12(3):189–198. doi:10.1016/0022-3956(75)90026-6
35. Bravo G, Hébert R. Age- and education-specific reference values for the Mini-Mental and modified Mini-Mental State Examinations derived from a non-demented elderly population. *Int J Geriatric Psychiatry*. 1997;12(10):1008–1018. doi:10.1002/(sici)1099-1166(199710)12:10<1008::aid-gps676>3.0.co;2-a
36. Qin A, Wang M, Xu L. Increased intake of vegetables and fruits improves cognitive function among Chinese oldest old: 10-year follow-up study. *Nutrients*. 2023;15(9):2147. doi:10.3390/nu15092147
37. Chen A, Zhou W, Hou J, et al. Impact of older age adiposity on incident diabetes: a community-based cohort study in China. *Diabet Metabol J*. 2022;46(5):733–746. doi:10.4093/dmj.2021.0215
38. Pan XF, Wang L, Pan A. Epidemiology and determinants of obesity in China. *Lancet Diabetes Endocrinol*. 2021;9(6):373–392. doi:10.1016/s2213-8587(21)00045-0
39. Shah S, Vanclay F, Cooper B. Improving the sensitivity of the Barthel index for stroke rehabilitation. *J Clin Epidemiol*. 1989;42(8):703–709. doi:10.1016/0895-4356(89)90065-6

40. Jia L, Du Y, Chu L, et al. Prevalence, risk factors, and management of dementia and mild cognitive impairment in adults aged 60 years or older in China: a cross-sectional study. *Lancet Public Health*. 2020;5(12):e661–e671. doi:10.1016/S2468-2667(20)30185-7
41. Ashworth A. Sarcopenia and malnutrition: commonly occurring conditions in the older population. *Br J Nurs*. 2021;30(21):S4–s10. doi:10.12968/bjon.2021.30.21.S4
42. Fielding RA, Landi F, Smoyer KE, Tarasenko L, Groarke J. Association of anorexia/appetite loss with malnutrition and mortality in older populations: a systematic literature review. *J Cachexia Sarcopenia Muscle*. 2023;14(2):706–729. doi:10.1002/jcsm.13186
43. Fekete M, Lehoczki A, Tarantini S, et al. Improving cognitive function with nutritional supplements in aging: a comprehensive narrative review of clinical studies investigating the effects of vitamins, minerals, antioxidants, and other dietary supplements. *Nutrients*. 2023;15(24). doi:10.3390/nu15245116
44. Sheng LT, Jiang YW, Alperet DJ, Feng L, Pan A, Koh WP. Quantity and variety of fruit and vegetable intake in midlife and cognitive impairment in late life: a prospective cohort study. *Br J Nutr*. 2023;129(12):2084–2093. doi:10.1017/s0007114522000848
45. Mottaghi T, Amirabdollahian F, Haghighatdoost F. Fruit and vegetable intake and cognitive impairment: a systematic review and meta-analysis of observational studies. *Eur J Clin Nutr*. 2018;72(10):1336–1344. doi:10.1038/s41430-017-0005-x
46. Nooyens AC, Bueno-de-mesquita HB, van Boxtel MP, van Gelder BM, Verhagen H, Verschuren WM. Fruit and vegetable intake and cognitive decline in middle-aged men and women: the Doetinchem cohort study. *Br J Nutr*. 2011;106(5):752–761. doi:10.1017/s0007114511001024
47. Gonçalves NG, Bertola L, Ferri CP, Suemoto CK. Rural-urban disparities in fruit and vegetable consumption and cognitive performance in Brazil. *Rev Bras Psiquiatr*. 2023;45(6):498–505. doi:10.47626/1516-4446-2023-3316
48. Caffò AO, Spano G, Tinella L, et al. The prevalence of amnestic and non-amnestic mild cognitive impairment and its association with different lifestyle factors in a South Italian elderly population. *Int J Environ Res Public Health*. 2022;19(5):3097. doi:10.3390/ijerph19053097
49. Hughes TF, Andel R, Small BJ, et al. Midlife fruit and vegetable consumption and risk of dementia in later life in Swedish twins. *Am J Geriatric Psychiatry*. 2010;18(5):413–420. doi:10.1097/JGP.0b013e3181c65250
50. Huang Z, Guo Y, Ruan Y, et al. Associations of lifestyle factors with cognition in community-dwelling adults aged 50 and older: a longitudinal cohort study. *Front Aging Neurosci*. 2020;12:601487. doi:10.3389/fnagi.2020.601487
51. Pontifex MG, Malik M, Connell E, Müller M, Vauzour D. Citrus polyphenols in brain health and disease: current perspectives. *Front Neurosci*. 2021;15:640648. doi:10.3389/fnins.2021.640648
52. Gehlich KH, Beller J, Lange-Asschenfeldt B, Köcher W, Meinke MC, Lademann J. Fruit and vegetable consumption is associated with improved mental and cognitive health in older adults from non-Western developing countries. *Public Health Nutr*. 2019;22(4):689–696. doi:10.1017/s1368980018002525
53. Zhou H, Zhong X, Chen B, et al. Interactive effects of elevated homocysteine and late-life depression on cognitive impairment. *J Affect Disord*. 2020;277:212–217. doi:10.1016/j.jad.2020.08.022
54. Christensen K, Gleason CE, Mares JA. Dietary carotenoids and cognitive function among US adults, NHANES 2011–2014. *Nutr Neurosci*. 2020;23(7):554–562. doi:10.1080/1028415x.2018.1533199
55. Calis Z, Mogulkoc R, Baltaci AK. The roles of flavonols/flavonoids in neurodegeneration and neuroinflammation. *Mini Rev Med Chem*. 2020;20(15):1475–1488. doi:10.2174/1389557519666190617150051
56. Zhuo B, Zheng D, Cai M, et al. Mediation effect of brain volume on the relationship between peripheral inflammation and cognitive decline. *J Alzheimers Dis*. 2023;95(2):523–533. doi:10.3233/jad-230253
57. Hogervorst E, Craig J, O'Donnell E. Cognition and mental health in menopause: a review. *Best Pract Res Clin Obstet Gynaecol*. 2022;81:69–84. doi:10.1016/j.bpobgyn.2021.10.009
58. Morgan KN, Derby CA, Gleason CE. Cognitive changes with reproductive aging, perimenopause, and menopause. *Obstetr Gynecol Clin North Am*. 2018;45(4):751–763. doi:10.1016/j.ogc.2018.07.011
59. Hooshiar SH, Yazdani A, Jafarnejad S. Effect of modified alternate day fasting diet on the severity of premenstrual syndrome and health-related quality of life in women with overweight or obesity: a trial study protocol. *BMJ open*. 2023;13(5):e066740. doi:10.1136/bmjopen-2022-066740
60. Milte CM, Ball K, Crawford D, McNaughton SA. Diet quality and cognitive function in mid-aged and older men and women. *BMC Geriatr*. 2019;19(1):361. doi:10.1186/s12877-019-1326-5
61. Ruegsegger GN, Rappaport CI, Hill JJ, Jochum KA, Challeen ES, Roth MC. A meal enriched in saturated fat acutely impairs cognitive performance in obese men. *Physiol Behav*. 2022;244:113664. doi:10.1016/j.physbeh.2021.113664
62. Prickett C, Brennan L, Stolwyk R. Examining the relationship between obesity and cognitive function: a systematic literature review. *Obesity Res Clin Pract*. 2015;9(2):93–113. doi:10.1016/j.orcp.2014.05.001
63. Sattar N, McMurray JJV, McInnes IB, Aroda VR, Lean MEJ. Treating chronic diseases without tackling excess adiposity promotes multimorbidity. *Lancet Diabet Endocrinol*. 2023;11(1):58–62. doi:10.1016/s2213-8587(22)00317-5
64. Zhou H, Zhu Z, Liu C, et al. Effect of hypertension duration and blood pressure control during early adulthood on cognitive function in middle age. *J Alzheimers Dis*. 2022;85(2):779–789. doi:10.3233/jad-215070