Association between healthy eating index-2015 and cognitive function among the United States elderly adults: the National Health and Nutrition Examination Survey (NHANES) 2011–2012

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Abstract

Background

Diet quality plays an important role in the development of age-related chronic diseases. However, the association between dietary quality assessed by Healthy Eating Index (HEI)-2015 and cognitive function among the United States (US) elderly adults remains unclear. The present study aims to explore the association between HEI-2015 and cognitive function in elderly adults using data from National Health and Nutrition Examination Survey (NHANES) 2011-2012.

Methods

HEI-2015 scores were calculated from two days 24-hour recall interviews. The cognitive function was evaluated by Digit Symbol Substitution Test (DSST), Animal Fluency Test (AFT) and a global cognition level derived by summing the z scores of individual tests. The associations between HEI-2015 and cognitive function were explored using multiple linear regression and binary logistic regression models.

Results

A total of 1278 participants aged 60 years or older were included. Compared to the lowest HEI-2015 tertile, the elderly adults in highest tertile had a higher global cognition, DSST and AFT scores (P⊠0.05); with the lowest quartile of global cognition as cognitive impairment, those who were in the highest HEI-2015 tertile had 38% lower odds of cognitive impairment (OR: 0.62; 95%CI: 0.42-0.91). Among HEI-2015 components, the elderly adults adhering to recommended intake of whole grains and whole fruits components were more likely to have better performance on global cognition (P⊠0.05).

Conclusion

The higher HEI-2015 was positively associated the better cognitive performance on the global cognition, DSST, and AFT in the US elderly adults.

Background

With the advance of modern medical level and the increase of life expectancy, the ageing trend is accelerating. In this context, the cognitive decline, mild cognitive impairment and dementia have been worldwide public health problems and became one of the leading causes of death in the elderly population[1]. According to the most recent Global Burden of Disease study, Alzheimer's disease rose to the 6th most burdensome disease in the United States (US) in terms of disability-adjusted life years (DALYs) in 2016[2]. The costs of health care for dementia has became one of the costliest expenditures to society[3]. Although significant progress has been achieved in understanding the development of dementia, its mortality and morbidity are still rising substantially due to the lack of effective treatment[4]. Thus, there is an urgent need for discovery of efficient prevention and treatment measures.

Over the years, accumulating evidence strongly suggested that age, obesity, education, drinking, smoking, diabetes, hypertension, lipids, depression and diet were associated with cognitive function[5-13]. Among which, diet, as a modifiable factor, plays an important role for cognitive function. For instance, higher dietary intake of flavonoids was found to be associated with better cognitive health[14]. A long-term beneficial role of carotenoid consumption was demonstrated on cognitive function in women[15]. In addition, several studies suggested that the supplementation with probiotic, B12 and dairy foods improved cognitive function in the middle or/and elderly adults[16-18]. Although these studies contributed to a better understanding of the association of specific nutrient or food with cognitive function, the effect of overall diet quality is more crucial because the health outcomes of diet are generally under combined action of all diet intakes rather than a certain nutrient or food group.

Considering the cooperation and antagonism between nutrients/food groups, the evaluation of dietary patterns which embody the Dietary Guidelines with different emphasis reflects the overall intake of nutrients or foods more realistically and explains the effect of diet on public health more properly. Healthy Eating Index (HEI) is used to assess the adherence to the overall healthy dietary pattern recommendations of Dietary Guidelines for Americans (DGA)[19]. HEI-2015, the latest version of HEI, is updated every five years along with the change of DGA and has been found to be associated with the bone mineral density, coronal dental caries, arthritis, coronary heart disease and stroke[20-23]. To our knowledge, there is no study yet evaluating the association between HEI-2015 and cognitive function among the US elderly adults. Therefore, the present study aims to explore the potential association of HEI-2015 and components scores and cognitive function among elderly adults using data from the National Health and Nutrition Examination Survey (NHANES) 2011-2012, hypothesizing that the higher HEI-2015 score is, the better cognitive function performance will be.

Methods

Study population

The data currently used were obtained from NHANES (https://www.cdc.gov/nchs/nhanes/index.htm). NHANES is a programme that administers continuous 2-year-cycle cross-sectional surveys, which is conducted by the Centers for Disease Control and Prevention (CDC). This programme is designed to assess the health and nutritional status of adults and children in the United States. NHANES 2011–2012 cycle was used in the present study which included 1791 elderly adults aged 60 years or older who were eligible to complete the cognitive function testings. Among them, we further excluded participants who did not complete two 24-h dietary recalls (n=290), whose dietary data were considered unreliable defined as total energy intake less than 500 or greater than 5000 kcal/day for women and less than 500 or greater than 8000 kcal/day for men (n=9), and who had missing data on cognitive testing (n=214). As a result of exclusions, a total of 1278 elderly adults were included in the present study (Figure 1).

Estimation of Dietary quality

The dietary intake data were obtained from NHANES two 24-h recall interviews which were conducted by the trained interviewers based on the automated multiple-pass method. The first interview was arranged face-to-face in the Mobile Examination Center (MEC) and the second was carried out via phone 3-10 days later. Dietary intake was estimated using the mean value of the two 24 recall data. The energy and nutrients for each food or beverage intake were calculated using Food and Nutrient Database for Dietary Studies (FNDDS) and the food groups were determined by Food Patterns Equivalence Database (FPED) from the US Department of Agriculture (USDA).

The dietary quality was estimated using HEI-2015 which was recommended by USDA to assess the adherence to the dietary guidelines of 2015-2020 DGA. The HEI-2015 contains 13 components (food groups or nutrients), including 9 adequacy components (total vegetables, greens and beans, total fruits, whole fruits, whole grains, dairy, total protein foods, seafood and plant proteins and fatty acids) and 4 moderation components (sodium, refined grains, saturated fats and added sugars). These 13 components were expressed as amounts per 1000 kcal except for fatty acids (expressed as a ratio of unsaturated to saturated fats), saturated fats (expressed as % energy) and added sugars (expressed as % energy). For the adequacy components, the intake were encouraged and the higher score means higher intake and better dietary quality; For the moderation components, the intake were limited and the higher score means lower intake and better dietary quality. These components were scored separately and incorporated to a total score with the maximum possible score of 100.

Assessment of cognitive function

Two cognitive function testings, Digit Symbol Substitution Test (DSST) and Animal Fluency Test (AFT), were performed among elderly adults aged 60 years or older in NHANES 2011-2012 and used in the present analysis. In briefly, the DSST is used to assess the abilities of processing speed, sustained attention and working memory, which presents 9 numbers paired with symbols. Participants were asked to match symbols with corresponding numbers in 120 s, and the final scores represent the total number of correct matches[24]. The AFT is used to evaluate the categorical verbal fluency regardless of cultural context. Participants were asked to name as many animals as possible in 60 s. A point is given for each named animal, and the final score represents the total number of correct named animals[25]. Finally, the global cognition score was calculated by summing the z scores of above two individual tests to evaluate global cognitive performance.

Covariates

The potential confounding factors were collected from the interview, examination and laboratory samples in the household or MEC. As the demographic variables, age, gender (male and female), educational level (less than high school, high school and more than high school) and ethnicity (Hispanic, non-Hispanic White, non-Hispanic Black and other races) were obtained. The family monthly poverty level index was calculated according to the family monthly income and Department of Health and Human Services(HHS)' poverty guidelines and was divided into three categories (≤1.30, 1.31-1.85, >1.85).

For the lifestyle variables, participants who have smoked at least 100 cigarettes in life were defined as smoker. Participants who drunk at least 12 times in any one year were defined as drinker. In addition, the time spent sitting (sedentary time) except sleeping time in a day was used as a potential physical activity indicator.

Depressive symptoms were assessed using 9-item Patient Health Questionnaire (PHQ-9). The score of each item ranges from 0 (not at all) to 3 (nearly every day), incorporating to a total score with the maximum possible score of 27. Individuals with PHQ-9 total score of 10 or greater were categorized as depressive symptoms[26].

The blood pressure (BP) were measured in MEC after resting quietly in a seated position for 5 minute. Three consecutive BP determinations were obtained and the average of SBP and DBP were used in this study. Hypertension was defined as SBP≥140mmHg or DBP≥90mmHg or current use of prescribed medicine for hypertension. The body measures data including weight (kg) and standing height (cm) were also collected in MEC by trained health technicians. Body Mass Index (BMI) was calculated as weight in kilograms divided by height in meters squared. Total cholesterol (TC) from serum specimens was detected using enzymatic assay. Hypercholesterolaemia was defined as TC ≥ 240mg/dl or current use of prescribed medicine for hypercholesterolaemia. The quantitative measurement of % hemoglobin A1c (HbA1c) in whole blood specimens was determined using the Tosoh Automated Glycohemoglobin Analyzer HLC-723G8. Diabetes was defined as HbA1c≥6.5% or the current use of insulin or current use of diabetic pills in the present analysis.

Statistical analysis

Data were presented as mean±standard deviation (SD) for continuous variables and as frequencies and percentages for categorical variables. First, baseline characteristics were summarized according to the tertiles of HEI-2015 scores. The differences between groups were compared using F-tests for continuous variables and chi-square test for categorical variables. Secondly, the
multiple linear regression model was used to evaluate the associations of HEI-2015 with cognitive function scores. The first tertile of HEI-2015 was used as reference. The Model 1 was adjusted for age and gender; the Model 2 was additionally adjusted for energy intake, ethnicity, BMI, drinker, smoker, sedentary time, education, family monthly poverty level and depressive symptom; and the Model 3 was further adjusted for hypertension, hypercholesterolaemia and diabetes. Thirdly, the associations of HEI-2015 with cognitive impairment were assessed using binary logistic regression model. For now there has not been gold standard as the cut off score for DSST and AFT to indicate the poor cognitive performance or cognitive impairment. Consistent with methods previously used[27-29], the lowest quartile for different cognitive scores was considered as the potential cognitive impairment in the binary regression analysis. The cut off scores were 33, 12 and -1.26 for DSST, AFT and global cognition, respectively. All the covariates used in the multiple linear regression model were included in the binary logistic regression model. To test for trends, the median of HEI-2015 in each tertile was calculated and used as a continuous variable. Finally, the multiple linear regression model was further conducted to evaluate associations of the individual HEI-2015 components with global cognitive function, which was adjusted for all the covariates in Model3 plus other

components. Data management was performed using SAS version 9.4 (SAS Institute, Cary, North Carolina, USA) and all statistical analyses were performed using SPSS 24.0 (IBM, Armonk, NY, USA). The multicollinearity was evaluated by the tolerance greater than 0.1 and the variance inflation factor (VIF) less than 10. The 2-tailed $P < 0.05$ was considered statistically significant.

Results

Descriptive statistics

Participants in this analysis were 60 years old and above, of whom 639 (50.0%) are male. The characteristics of target population were shown in Table 1 by tertiles of HEI-2015. Overall, there were significant differences across HEI-2015 tertiles in the distribution of age, gender, BMI, ethnicity, education, family monthly poverty level, drinker, smoker and diabetes ($P < 0.05$). Compared with the participants in the lowest HEI-2015 tertile, those in the highest tertile were more likely to be older, female, diabetics, to have more than high school of educational level, lower BMI, higher family monthly poverty level and less likely to be drinker, smoker, non-Hispanic black race. No significant differences across HEI-2015 tertiles were observed in terms of sedentary time, energy intake, depression, hypertension and hypercholesterolaemia.

Association between HEI-2015 total score and cognitive function among elderly adults

The beta-coefficients (Bs) and 95% confidence intervals (CIs) for cognitive function according to HEI-2015 tertiles are shown in Table 2. After full adjustment for age, gender, energy intake, ethnicity, BMI, sedentary time, smoker, drinker, education, family monthly poverty level, depressive symptoms, diabetes, hypertension and hypercholesterolaemia, there were significant positive associations of HEI-2015 with DSST, AFT and global cognition. Specifically, the highest HEI-2015 tertile in fully adjusted model (Model3) were positively associated with higher DSST score (B:2.12; 95%CI: 0.43, 3.82; P⬚0.05), AFT score (B:0.76; 95%CI: 0.10, 1.43; P⬚0.05) and global cognition (B: 0.26; 95%CI: 0.08, 0.44; P⬚0.05) compared to the lowest HEI-2015 tertile. The liner trends were also observed in the associations of HEI-2015 with DSST (P_{trend}⬚0.05), AFT (P_{trend}⬚0.05) and global cognition (P_{trend}⬚0.05).

As shown in Table 3, the associations between HEI-2015 and the cognitive impairment were explored using binary logistic regression. In Model 1, the highest HEI-2015 tertile was associated with lower odds of cognitive impairment based on DSST (OR:0.68; 95%CI: 0.50, 0.93; P⬚0.05), AFT(OR:0.55; 95%CI: 0.40, 0.78; P⬚0.05) and global cognition(OR:0.51; 95%CI: 0.37, 0.70; P⬚0.05), compared to the lowest HEI-2015 tertile. In further adjusted Model 2, the association of HEI with AFT impairment (OR:0.66; 95%CI: 0.46, 0.94; P⬚0.05) and global cognition impairment (OR:0.60; 95%CI: 0.41, 0.89; P⬚0.05) attenuated but remained significant, whereas the association with DSST impairment was no longer significant. After additionally adjusting for hypertension, hypercholesterolaemia and diabetes, the significant associations did not change for both AFT impairment (OR:0.68; 95%CI: 0.47, 0.96; P⬚0.05) and global cognition impairment (OR:0.62; 95%CI: 0.42, 0.91; P⬚0.05). We also found evidence of a linear trend in associations of HEI-2015 with AFT impairment (P_{trend}⬚0.05) and global cognition impairment (P_{trend}⬚0.05) in all models.

Association between HEI-2015 components and cognitive function among elderly adults

Given the significant association between higher HEI-2015 total score and better performance on global cognition, we further explored the relations of 13 HEI-2015 components with global cognition. With the lowest tertile as the reference, the Bs and 95% CIs of the highest tertile were shown as Figure 2 after adjusting for all covariates in Model 3 as well as other components. Compared to the participants in the lowest tertile, those with the highest intake of whole fruits were more likely to have higher global cognition (B: 0.22; 95%CI: 0.00, 0.44; $P<0.05$). Besides the whole fruits, the higher intake of whole grains was also significantly associated with better performance on global cognition (B: 0.19; 95%CI: 0.01, 0.38; $P<0.05$). We did not observe associations of the highest tertile of the other HEI-2015 components (total vegetables, greens and beans, total fruits, dairy, total protein foods, seafood, plant proteins and fatty acids, sodium, refined grains, saturated fats and added sugars) with global cognition.

Discussion

In this cross-sectional study, we found the dietary quality assessed by HEI-2015 was associated with cognitive performance based on two cognitive tests and a global cognition score in the US elderly adults. Among 13 HEI-2015 components, adherence to the recommended intake of the whole grains and whole fruits components were more likely to have better performance on global cognition level.

There have been some studies examining the associations between dietary quality and cognitive function, but most of them focused on the dietary quality assessed by the specific dietary pattern, such as Mediterranean diet pattern and Dietary Approaches to Stop Hypertension (DASH) diet pattern. NHANES 2011-2014 have revealed the cognition of US older adults may benefit from better adaptation to the Mediterranean Diet[30]. Similarly, a positive association was found between the adherence to DASH diet in midlife and better cognitive performance in late life in a Chinese sample[31]. For some previous HEI indexes, such as HEI-2010 and AHEI-2010, have been found to be associated with better cognitive performance on verbal learning and memory in African Whites or middle-aged Hispanics/Latinos rather than the general US elderly population[32,33]. HEI-2015, the latest version of HEI, involving 9 adequacy components and 4 moderation components, may have a better representation of comprehensive intake of foods and/or nutrients and was used to assess the total dietary quality in the present study. Our results support an positive association between higher HEI-2015 scores and better cognitive performance in a representative sample of US older adults, which is reasonable and is consistent to the hypothesized theoretical effects of a healthy diet. Prior to our study, we have not found a similar study on the relations between HEI-2015 and cognitive function but a relevant analysis from the Atherosclerosis Risk in Communities (ARIC) Study which reported that adherence to the HEI-2015, not the other dietary scores, during midlife was associated with lower risk of incident dementia[34]. Compared with the ARIC, our study added two important potential confounding factors, family monthly poverty level and depressive symptoms.

Some certain healthy dietary pattern may only have benefits for specific cognitive domains. In the present study, we focused on the relations of HEI-2015 with DSST and AFT which mainly evaluate processing

speed, sustained attention, working memory and categorical verbal fluency. In a community study, the positive associations were observed between higher DASH diet scores and better verbal memory assessed by Hopkins Verbal Learning Test, but were not associated with executive functioning/processing speed assessed by Stroop Test and DSST[35]. Similarly, the Mediterranean diet was observed to be associated with improvements in cognitive domains of visual memory and visual processing speed in older individuals rather than verbal fluency and executive function[5]. Thus, the cognitive performance was assessed by cognitive function testings involving different domains, possibly leading to the inconsistent results on the relationship between diet and cognitive function. As many cognitive testings as possible should be used simultaneously and the global cognitive function score should be calculated to achieve a comprehensive analysis.

Notably, there were no longer significant association between HEI-2015 and cognitive impairment evaluated by DSST after full adjustment. It may be related to the cut off scores (the lowest 25th percentile) we selected to define the potential cognitive impairment. There is no gold standard on the cutoff scores for cognitive impairment in most cognitive function testings. In some studies, those scoring in the lowest 25th percentile of a cognitive testing was regard as cognitive impairment[28,36]; while some used the 20th percentile to indicate cognitive impairment[37,38]; even there were specific scores used as the cutoff scores[39]. The different cutoff scores may lead to the different results. Thus, we should better place emphasis on the results from the multiple linear regression model which was most widely used in studies related to various cognitive function testings[25,40,41].

Although our study focused on the overall dietary quality that represents a comprehensive intake of foods and/or nutrients, we also analyzed individual component to identify the possible components that drive the association of HEI-2015 with cognitive function. In the present study, the positive associations of the whole grains with DSST, AFT and global cognition were found among the elderly adults. Similar with our results, a cognitive study from Women's Health Study demonstrated that the greater whole grain intake was related to better averaged global cognition in older age[42]. The Bogalusa Heart Study also reported the higher whole grains were associated with increased cognitive function in a young population[43]. The mechanism of preventing cognitive decline may be related to the dietary fiber, an important component from the whole grains, which has the properties of anti-diabetes and pro-neuronal integrity[44]. As the intake of whole grain is more likely to be accepted, the intervention study on this field has great potential in the future.

There were inconsistent results to the association of the intake of vegetables and fruits with cognitive function. The CARDIA study found the intake of vegetables and fruits through young adulthood was significantly related to a better cognitive performance in midlife in the US general population[45]. However, no significant associations between the total intake of fruits and vegetables and cognitive function were observed in the middle-aged men and women from Doetinchem Cohort Study[46]. In our study, the higher intake of the whole fruits was positively associated to the better cognitive performance on global cognition, whereas the intake of vegetables was not. One possibility for this difference is that the specific fruits or vegetables may have benefits for particular cognitive function[47]. Those specific fruit and vegetable which are rich in flavonoids, carotenoids and vitamin C are responsible, in part, for the benefits of

cognitive function[48-50]. Overall, in view of the fact that diet contains nutrients from many sources, we insisted that emphasis should be placed on total dietary quality rather than specific nutrient or food, and the results of some component scores should be interpreted cautiously.

The present study has several advantages. First, NHANES has high quality for the data collection and enrolled a large nationally representative sample of the elderly people aged 60 and over. To our knowledge, this is the first study to explore the association between HEI-2015 and cognitive function in the US elderly people. Besides, we not only explored the association between the HEI-2015 total score and cognitive function, but also the HEI-2015 components with cognitive function. There are still several limitations in our present study. First, as a cross-sectional study design, we cannot ascertain a causal relationship. Second, the dietary data which was collected from the two days 24 recall, may not be able to reflect the usual intake well. Third, although two cognitive function testings and a global cognition score were used in this study, they cannot cover all the domains of cognitive function, and these testings lack a gold standard on the cutoff scores to indicate potential cognitive decline or impairment. Last but not least, we have adjusted with most potential confounders, we cannot excluded possible bias from the uncollected covariates.

Conclusion

We observed a positive association between higher HEI-2015 and better cognitive performance among the US elderly adults. Given the rational findings and several limitation in the present study, the results should be further validated in the large prospective cohort study and the assessment of overall dietary quality could be a focus of further research in the filed of cognitive function.

Abbreviations

HEI: Healthy Eating Index

NHANES: The National Health and Nutrition Examination Survey

DSST: Digit Symbol Substitution Test

AFT: Animal Fluency Test

DGA: Dietary Guidelines for Americans

CDC: Centers for Disease Control and Prevention

PHQ: Patient Health Questionnaire

BP: Blood pressure

BMI: Body Mass Index

TC: Total cholesterol

VIF: Variance inflation factor

DASH: Dietary Approaches to Stop Hypertension

Declarations

Authors' contributions

YY, LZ and YMF contributed to the study design. LZ, YMF and YYZ preformed the data analysis. YMF wrote the manuscript. JQL, YML, HC and XXT critically revised and edited the manuscript for important intellectual content. All authors reviewed and approved the final manuscript.

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Consent for publication

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Competing interests

The authors declare that they have no competing interests.

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Tables

Table 1. Characteristics of the overall target population and according to HEI-2015 tertiles[1] (n = 1278)

		Tertiles of HEI-2015			
Characteristics	All	T1(16.93-52.24)[2]	T2(52.25-63.95)	T3(63.96-94.38)	
n	1278	425	427	426	P^3
Age (years)	69.3 ± 6.9	68.7 ± 6.7	69.2 ± 6.9	70.0 ± 7.0	0.031
Gender, n(%)					⬚0.001
Male	639(50.0)	248(58.4)	207(48.5)	184(43.2)	
Female	639(50.0)	177(41.6)	220(51.5)	242(56.8)	
Body mass index (kg/m^2)	29.1±6.4	29.9±6.8	29.2±6.4	28.4±5.8	0.004
Ethnicity, n(%)					0.008
Hispanic	228(17.8)	68(16.0)	73(17.1)	87(20.4)	
Non-Hispanic white	586(45.9)	183(43.1)	209(48.9)	194(45.5)	
Non-Hispanic black	351(27.5)	143(33.6)	110(25.8)	98(23.0)	
Asian or other race	113(8.8)	31(7.3)	35(8.2)	47(11.0)	
Education, n(%)					⬚0.001
less than high school	350(27.4)	137(32.2)	120(28.1)	93(21.8)	
high school	291(22.8)	105(24.7)	107(25.1)	79(18.5)	
more than high school	637(49.8)	183(43.1)	200(46.8)	254(59.6)	
Family monthly poverty level,n(%)					⬚0.001
≤1.30	387(30.3)	149(35.1)	135(31.6)	103(24.2)	
1.31 ~ 1.85	234(18.3)	91(21.4)	69(16.2)	74(17.4)	
⬚1.85	657(51.4)	185(43.5)	223(52.2)	249(58.5)	
Energy intake (kcal/d)	1802.3±659.0	1826.2±719.3	1811.23±631.8	1769.7±621.8	0.432
Sedentary time (h/d)	6.0±3.1	6.1±3.1	6.0±3.2	5.9±3.0	0.728
Drinker, n(%)					0.016
Yes	871(68.2)	312(73.4)	283(66.3)	276(64.8)	
No	407(31.8)	113(26.6)	144(33.7)	150(35.2)	
Smoker, n(%)					⬚

					0.001
Yes	657(51.4)	243(57.2)	226(52.9)	188(44.1)	
No	621(48.6)	182(42.8)	201(47.1)	238(55.9)	
Depression, n(%)					0.211
Yes	92(7.2)	34(8.0)	35(8.2)	23(5.4)	
No	1186(92.8)	391(92.0)	392(91.8)	403(94.6)	
Hypertension, n(%)					0.631
Yes	859(67.2)	291(68.5)	289(67.7)	279(65.5)	
No	419(32.8)	134(31.5)	138(32.3)	147(34.5)	
Diabetes, n(%)					0.034
Yes	346(27.1)	134(31.5)	110(25.8)	102(23.9)	
No	932(72.9)	291(68.5)	317(74.2)	324(76.1)	
Hypercholesterolaemia, n(%)					0.193
Yes	673(52.7)	213(50.1)	221(51.8)	239(56.1)	
No	605(47.3)	212(49.9)	206(48.2)	187(43.9)	

[1]Values are percentages (%) or means±SD; HEI-2015: Healthy Eating Index; T, tertile.

[2]*P*-values refer to differences across tertiles and were calculated using chi-square tests for categorical variables and F-tests for continuous variables.

[3]T1 represents the unhealthiest diet quality, T3 represents the healthiest diet quality.

Table 2. Regression cofficients and 95% confidence intervals of HEI-2015 for cognitive function scores (n =1278)[1]

		Cognitive function		
		DSST[2]	AFT	Global cognition[2]
Tertiles of HEI-2015	n	B (95%CI)	B (95%CI)	B (95%CI)
Model1[3]				
T1[4]	423	0 (Reference)	0 (Reference)	0 (Reference)
T2	422	2.14 (-0.06, 4.35)	0.67 (-0.05, 1.40)	0.25 (0.02, 0.47)[*]
T3	422	5.32 (3.10, 7.54)[***]	1.33 (0.60, 2.06)[***]	0.55 (0.32, 0.77)[***]
P_{trend}[5]		⬚0.001	⬚0.001	⬚0.001
Model2				
T1	423	0 (Reference)	0 (Reference)	0 (Reference)
T2	422	0.62 (-1.04, 2.27)	0.38 (-0.28, 1.03)	0.10 (-0.07, 0.28)
T3	422	2.22 (0.53, 3.92)[*]	0.80 (0.13, 1.47)[*]	0.27 (0.10, 0.45)[**]
P_{trend}		0.010	0.019	0.003
Model3				
T1	423	0 (Reference)	0 (Reference)	0 (Reference)
T2	422	0.53 (-1.11, 2.18)	0.36 (-0.30, 1.01)	0.10 (-0.08, 0.27)
T3	422	2.12 (0.43, 3.82)[*]	0.76 (0.10, 1.43)[*]	0.26 (0.08, 0.44)[**]
P_{trend}		0.014	0.025	0.004

[1]The regression cofficients and 95%CI were calculated using multiple linear regression model. HEI-2015: Healthy Eating Index; B is unstandardized regression cofficient; T, tertile; [***]$P < 0.001$, [**]$P < 0.01$, [*]$P < 0.05$.

[2]DSST, Digit Symbol Substitution Test; AFT, Animal Fluency Test; The global cognition score was calculated by summing the z scores ((test score - mean score)/SD) of the two individual tests.

[3]Model 1: adjusted for age and gender; Model 2: Model1 + daily energy intake, ethnicity, body mass index, drinker, smoker, education level, family monthly poverty level, sedentary time and depression symptom; Model 3: Model2 + hypertension, hypercholesterolaemia and diabetes.

[4]T1 represents the unhealthiest diet quality, T3 represents the healthiest diet quality.

[5]P_{trend}: Test for trend based on variable containing median value for each tertile.

Table 3. Odds ratios and 95% confidence intervals of HEI-2015 for cognitive impairment (n =1278)[1]

		Cognitive function		
		DSST[2]	AFT	Global cognition
Tertiles of HEI-2015	n	OR(95%CI)	OR(95%CI)	OR(95%CI)
Model1[3]				
T1[4]	423	1(Reference)	1(Reference)	1(Reference)
T2	422	0.75 (0.55, 1.02)	0.73 (0.53, 0.99)*	0.74 (0.54, 1.01)
T3	422	0.68 (0.50, 0.93)*	0.55 (0.40, 0.78)***	0.51 (0.37, 0.70)***
P_{trend}[5]		0.016	⏈0.001	⏈0.001
Model2				
T1	423	1(Reference)	1(Reference)	1(Reference)
T2	422	0.80 (0.55, 1.18)	0.79 (0.57, 1.10)	0.82 (0.57, 1.19)
T3	422	0.89 (0.60, 1.32)	0.66 (0.46, 0.94)*	0.60 (0.41, 0.89)*
P_{trend}		0.540	0.020	0.011
Model3				
T1	423	1(Reference)	1(Reference)	1(Reference)
T2	422	0.81 (0.55, 1.18)	0.80 (0.57, 1.12)	0.83 (0.58, 1.20)
T3	422	0.90 (0.60, 1.33)	0.68 (0.47, 0.96)*	0.62 (0.42, 0.91)*
P_{trend}		0.568	0.029	0.015

[1]The regression cofficients and 95%CI were calculated using multiple linear regression model. HEI-2015: Healthy Eating Index; OR, odds ratios; T, tertile; ***P< 0.001, **P< 0.01, *P< 0.05.

[2]DSST, Digit Symbol Substitution Test; AFT, Animal Fluency Test; The global cognition score was calculated by summing the z scores ((test score - mean score)/SD) of the two individual tests.

[3]Model 1: adjusted for age and gender; Model 2: Model1 + daily energy intake, ethnicity, body mass index, drinker, smoker, education level, family monthly poverty level, sedentary time and depression symptom; Model 3: Model2 + hypertension, hypercholesterolaemia and diabetes.

[4]T1 represents the unhealthiest diet quality, T3 represents the healthiest diet quality.

[5]P_{trend}: Test for trend based on variable containing median value for each tertile.
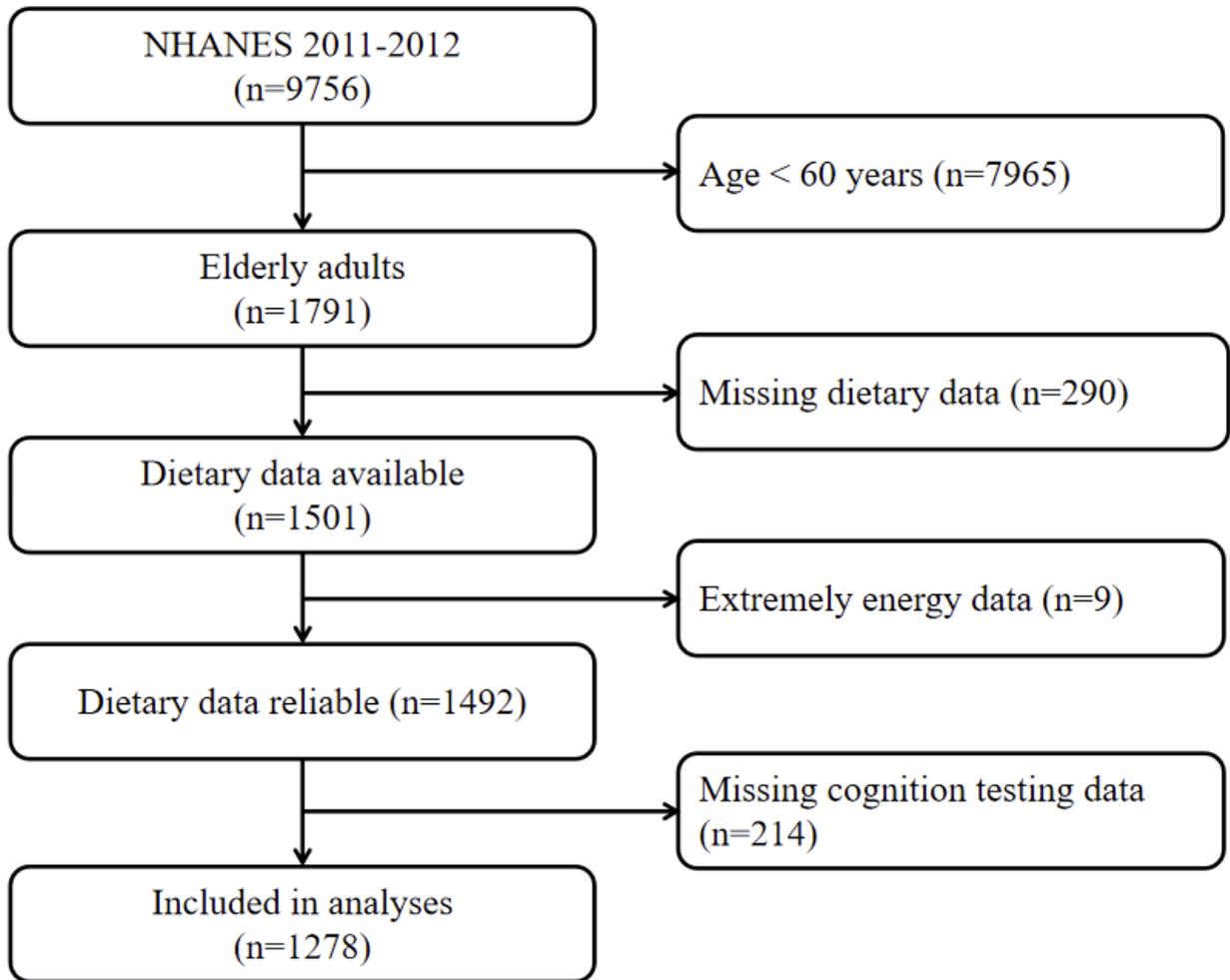
Figures

Figure 1
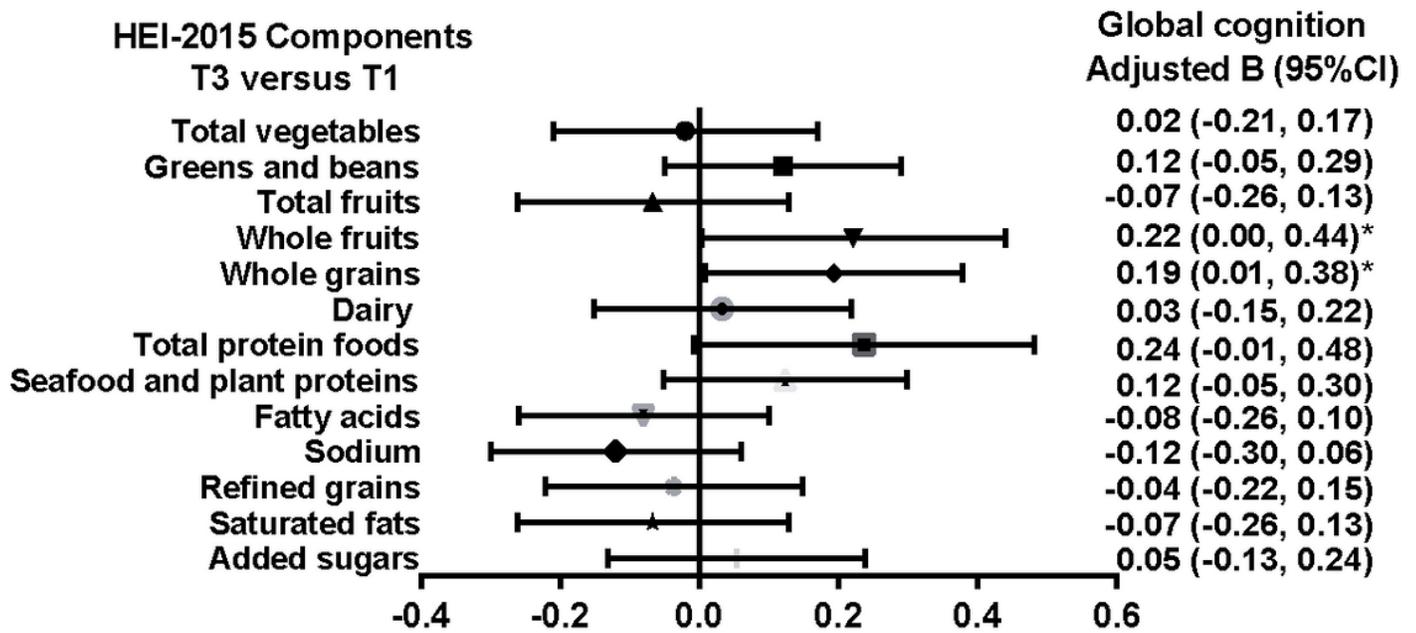
Flow diagram of the study sample selection.

Figure 2

Regression cofficients and 95% confidence intervals of each HEI-2015 components (T3 versus T1). T, tertile; T1 represents the unhealthiest diet quality, T3 represents the healthiest diet quality; B, unstandardized regression cofficient, is adjusted for age, gender, daily energy intake, ethnicity, body mass index, drinker, smoker, education level, family monthly poverty level, sedentary time, depression status, hypertension, hypercholesterolaemia and diabetes; *P < 0.05.