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ORIGINAL RESEARCH

Adherence to Life's Simple 7 and Cognitive Function Among Older Adults: The National Health and Nutrition Examination Survey 2011 to 2014

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BACKGROUND: The American Heart Association proposed the Life's Simple 7 (LS7; including diet, physical activity, smoking, body mass index, blood pressure, plasma fasting glucose, total cholesterol) to promote cardiovascular health. Adherence to LS7 has been found to be associated with better cognitive health as well, but the generalizability of previous studies is limited. We aimed to examine the associations of adherence to LS7 and cognitive function among older adults in a nationally representative sample of population.

METHODS AND RESULTS: A total of 2585 older adults (≥60 years, 54% female, 80% non-Hispanic White) in the National Health and Nutrition Examination Survey 2011 to 2014 were included for analysis. Components of LS7 were measured, and adherence to LS7 was calculated on the basis of established cutoff points of individual components. Cognitive function was examined using the Consortium to Establish a Registry for Alzheimer's Disease Word List Memory Task (immediate and delayed memory), Digit Symbol Substitution Test (DSST), and Animal Fluency Test. Test-specific and global cognition *Z* scores were created. Multivariable linear regression models were conducted on the associations of adherence to LS7 with domain-specific and global cognition *Z* scores. Each incremental point in adherence to LS7 was associated with higher *Z* scores for global cognition (β=0.05; 95% CI, 0.02–0.07), Digit Symbol Substitution Test (β=0.05; 95% CI, 0.03–0.07), Consortium to Establish a Registry for Alzheimer's Disease Word Learning subtest immediate memory (β=0.03; 95% CI, 0.004–0.05), and animal fluency test (β=0.05; 95% CI, 0.02–0.07).

CONCLUSIONS: Greater adherence to LS7 metrics is associated with better cognitive function among older US adults in a nationally representative sample of population.

Key Words: aging ■ cognition ■ Life's Simple 7 ■ lifestyle

Dementia is a growing public health epidemic in the United States and globally.[1] It is estimated that the number of people around the world living with dementia in 2050 will reach 100 million, growing from 43 to 47 million people in 2015/2016.[2] Dementia is also ranked among the top 5 causes of death.[2] Since no cure for dementia is currently available, prevention of dementia becomes particularly important. Dementia refers to a clinical syndrome characterized by loss of cognitive function, and it is therefore important to identify risk factors associated with poor cognitive function.

The existing literature indicates that dementia is associated with a variety of risk factors, including those related to cardiovascular disease.[3,4] Particularly, some of the modifiable cardiovascular risk factors such as physical inactivity, cigarette smoking, and high blood pressure are also important to an individual's brain health.[5] The American Heart Association proposed

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CLINICAL PERSPECTIVE

What Is New?

- Greater adherence to Life's Simple 7 metrics is associated with better cognitive function among older US adults in a nationally representative sample of population.
- The adherence to certain components of Life's Simple 7, including diet and physical activity, has not been satisfactory.

What Are the Clinical Implications?

- Since no threshold was detected for the association between Life's Simple 7 scores and cognitive function, population strategies that aim for modest improvement of Life's Simple 7 in the whole population is critical for reducing the burden of dementia.

Nonstandard Abbreviations and Acronyms

AFT	Animal Fluency Test
CERAD-WL	Consortium to Establish a Registry for Alzheimer's Disease Word Learning subtest
DSST	Digit Symbol Substitution Test
FPG	fasting plasma glucose
LS7	Life's Simple 7
NHANES	National Health and Nutrition Examination Survey
TC	total cholesterol

Life's Simple 7 (LS7), a matrix to promote cardiovascular health, which includes 7 modifiable cardiovascular risk factors, namely, diet, physical activity, cigarette smoking, body mass index (BMI), blood pressure, fasting plasma glucose (FPG), and total cholesterol (TC).[6] The associations of 7 individual components with cognitive outcomes have been widely studied,[7–13] and a few recent studies have also examined the associations between the adherence of LS7 and cognitive outcomes, and higher score of LS7 are associated with better cognitive outcomes in several domains.[14–21] However, most of these studies were based on individual cohorts with different characteristics, and it is desirable that the associations are examined in a sample representative of the US population.

Therefore, we aimed to examine the association between adherence to LS7 and cognitive function among older adults. The National Health and Nutrition Examination Survey (NHANES) data have been used to monitor the health of the US population and allow examination of prevalent health conditions and their risk factors. With the large and nationally representative sample of the US population, the NHANES study is ideal to examine the association between adherence to LS7 and cognitive function among older adults.

METHODS

Anonymized data and materials have been made publicly available at the NHANES website and can be accessed at https://wwwn.cdc.gov/nchs/nhanes/Default.aspx.

The NHANES is a serial ongoing cross-sectional survey of the civilian, noninstitutionalized US population, conducted by the National Center for Health Statistics at the Centers for Disease Control and Prevention. The 2011 to 2014 NHANES conducted measurements of LS7 components and cognitive performance for participants. We combined data from the 2 survey cycles for analysis. A total of 19 931 people of all ages were enrolled for NHANES interviews from 2011 to 2014. Among these participants, we excluded participants who were aged <60 years (n=16 299), those who had missing information of cognitive tests (n=444), those who missed any information in components of LS7 (diet, physical activity, smoking, BMI, blood pressure, FPG, TC; n=408), those who had missing information in education (n=2), and those who had prevalent stroke (n=193). Our final sample size for analyses included a total of 2585 participants aged ≥60 years.

The NHANES was conducted in accordance with the recommendations of National Center for Health Statistics Research Ethics Review Board with written informed consent from all subjects, according to the Declaration of Helsinki. The protocol was approved by the National Center for Health Statistics Research Ethics Review Board.

The LS7 metrics is defined, per American Heart Association guidelines,[6] as shown in Table S1. Dietary intake in NHANES was measured using two 24-hour dietary recall interviews among all participants. The first interview was conducted in person in the Mobile Examination Center, and the second interview was conducted via telephone 3 to 10 days after the first interview.[22] We also used the intake of food and nutrients using the Food Patterns Equivalents Database from the US Department of Agriculture, 2011 to 2014.[23] Physical activity was measured using the validated Global Physical Activity Questionnaire, which asked participants to report time spent on moderate and vigorous activity.[24] BMI was calculated with body height and weight measured by trained health technicians. Cholesterol and glucose were analyzed with blood specimens at University of Minnesota (Minneapolis, MN). Three consecutive blood pressure readings were obtained by certified blood pressure in the mobile examination center, and a fourth attempt was made if the measurement was incomplete. An average of blood pressure was calculated for evaluation. Information of smoking (not including secondhand smoking) was self-reported by participants. To calculate a total score for LS7, a component that achieved ideal, intermediate, and poor were given 2 points, 1 point, and 0 point, respectively. Therefore, the total score ranged from 0 to 14 points, with higher scores indicating better cardiovascular health.

The cognitive tests in NHANES 2011 to 2014 include 3 components: the Digit Symbol Substitution Test (DSST), the Consortium to Establish a Registry for Alzheimer's Disease Word Learning subtest (CERAD-WL), and the Animal Fluency test (AFT). The DSST focused on executive function and processing speed, which was conducted using a paper form with a key at the top that contained 9 numbers paired with symbols. Participants were asked to copy the corresponding symbols in the 133 boxes that adjoin the numbers in 2 minutes, and a point was awarded for each correct match.[25] The CERAD-WL tested immediate (including 3 consecutive learning trials) and delayed verbal memory (1 delayed recall trial). During the learning trial, participants were asked to read 10 unrelated words aloud 1 at a time as presented, with the order of the 10 words being changed for each trial. In the delayed recall test, which occurred after the other 2 cognitive tests, participants were asked to then recall as many words as possible, for those in the same 10-word list. The score ranges from 0 to 133 as the sum of correct matches.[26] The AFT assessed language ability and executive function, in which participants were asked to name as many animals as possible in 1 minute, and 1 point was awarded for each named animal.[27]

In addition to these measurements, we considered age, sex, race and ethnicity, education level, and coronary heart disease as covariates, which were obtained from self-reported questionnaires.

Descriptive statistics were computed on participants' characteristics. The prevalence of ideal, intermediate, and poor levels for each component of LS7 were described, and the proportion of different numbers in ideal and poor levels of LS7 components was calculated. Test-specific *Z* scores (including DSST, CERAD-WL delayed memory, CERAD-WL immediate memory, AFT) were created using sample means and SDs of test scores. A standardized global cognition *Z* score was then generated by averaging the test-specific *Z* scores divided by SD. Multivariable linear regression models were used to examine the associations of different levels of each LS7 component with test-specific and global cognition *Z* scores. Furthermore, multivariable linear regression models were used to examine the associations of total LS7 score (continuous and by quintiles) with test-specific and global cognition *Z* scores, which were also stratified by sex and race and ethnicity. In addition, we also examined the associations of each incremental ideal and poor item with test-specific and global cognition *Z* scores. Finally, we examined the associations of different clusters of behavioral factors (diet, physical activity, smoking, BMI) and biological factors (blood pressure, FPG, TC) with cognitive function. The estimated effect sizes shown as βs and 95% CIs were estimated and presented in the models. The analyses were weighted for the stratified, multistage probability sampling design of NHANES and survey nonresponse. Full sample 2-year mobile examination center exam weight was used for subsamples in 2011 to 2012 and 2013 to 2014, and the weights were recalculated (divided by 2) after the combination of NHANES 2011 to 2012 with 2013 to 2014.[28] All analyses were conducted using SAS 9.4 (SAS Institute, Cary, NC).

RESULTS

A total of 2585 participants were included in the analysis, including 1251 participants in 2011 to 2012 and 1334 participants in 2013 to 2014, which represented a population size of 47 684 724. The characteristics of participants are shown in Table 1. More than half of the participants were female and 13.1% were aged ≥80 years. About 80% of participants were non-Hispanic White participants, and 83% had an education level of high school or above. About 9% of all participants had self-reported coronary heart disease. Compared with those who were aged ≥60 years but not included in the analysis, the included participants had a smaller proportion of older adults aged ≥80 years, a larger proportion of non-Hispanic White participants, higher level of education, a lower proportion of people smoking, a larger BMI, TC, and diastolic blood pressure. In addition, those who were included had better performance in all cognitive tests (Table S2).

Among all components of the LS7, smoking (88.4%) and FPG (59.1%) had a high prevalence of ideal level, while that of diet was <1%. The prevalence of poor level for both diet and physical activity was >50% (Figure). For the number of ideal or poor level in individual components achieved, no participant had all 7 components ideal or poor. About 80% of the participants achieved ideal levels in 2 to 4 LS7 components, and a similar proportion was observed for participants who achieved poor levels (Figure S1).

After adjustment for age, sex, race and ethnicity, education, other lifestyle components, and coronary heart disease, compared with poor level, intermediate level of physical activity was associated with higher *Z* scores of global cognition (β=0.17; 95% CI, 0.08–0.27), DSST (β=0.13; 95% CI, 0.03–0.24), CERAD-WL immediate memory (β=0.16; 95% CI,

Table 1. Weighted Characteristics of Participants Included in the Analysis.

	Mean (95% CI) or n (%)
Weighted frequency	47 684 724
Age, ≥80 y	387 (13.1)
Sex, female, n (%)	1319 (54.1)
Race and ethnicity, n (%)	
Mexican American	241 (3.5)
Other Hispanic	277 (3.9)
Non-Hispanic White	1216 (79.7)
Non-Hispanic Black	621 (8.4)
Other races*	230 (4.6)
Education, n (%)	
<9th grade	314 (6.0)
9–11th grade	365 (10.1)
High school graduate	586 (21.6)
Some college	719 (31.5)
College graduate or above	601 (30.7)
Ever smoking, n (%)	1261 (48.7)
Moderate to vigorous physical activity, min/wk	121.8 (107.6–136.1)
Diet	
Sodium intake, g/day	3.1 (3.0–3.2)
Sugar sweetened beverage, g/day	246.8 (227.3–266.4)
Fish consumption, oz/day	0.7 (0.6–0.8)
Fruits and vegetables, cups/day	2.0 (1.9–2.2)
Whole grain, oz/day	1.1 (1.1–1.2)
Body mass index, kg/m^2	29.3 (28.9–29.7)
Total cholesterol, mg/dL	193.6 (190.9–196.4)
Fasting plasma glucose, mg/dL	112.7 (109.7–115.8)
Systolic blood pressure, mm Hg	132.1 (131.0–133.2)
Diastolic blood pressure, mm Hg	68.6 (67.5–69.6)
Coronary heart disease, n (%)	222 (9.0)
Cognitive function	
Digit symbol score	53.2 (52.0–54.3)
Delayed recall score	6.3 (6.1–6.5)
Immediate recall score	19.8 (19.3–20.2)
Animal Fluency Test score	18.3 (17.9–18.7)

*Other not defined by The NHANES but it does include multi-racial and non-Hispanic Asian.

0.04–0.27), AFT (β=0.17; 95% CI, 0.06–0.27), and ideal level of physical activity was associated with higher *Z* scores of global cognition (β=0.22; 95% CI, 0.12–0.33), DSST (β=0.20; 95% CI, 0.08–0.31), and AFT (β=0.33; 95% CI, 0.22–0.43). Ideal level of smoking was associated with a higher *Z* score of DSST (β=0.20; 95% CI, 0.08–0.32); intermediate level of blood pressure was associated with higher *Z* scores of global cognition (β=0.11; 95% CI, 0.03–0.19) and CERAD-WL immediate memory (β=0.14; 95% CI, 0.02–0.25), and ideal level of blood pressure was associated with higher *Z* scores of global cognition (β=0.19; 95% CI, 0.02–0.35), CERAD-WL immediate memory (β=0.21; 95% CI, 0.04–0.39), and AFT (β=0.16; 95% CI, 0.02–0.30); ideal level of FPG was associated with higher *Z* scores of DSST (β=0.22; 95% CI, 0.04–0.41) and AFT (β=0.15; 95% CI, 0.001–0.31) (Table 2).

After adjustment for age, sex, race and ethnicity, education, and coronary heart disease, each unit increase in LS7 score was associated with higher *Z* scores for global cognition (β=0.05; 95% CI, 0.02–0.07), DSST (β=0.05; 95% CI, 0.03–0.07), CERAD-WL immediate memory (β=0.03; 95% CI, 0.004–0.05), and AFT (β=0.05; 95% CI, 0.02–0.07). Compared with participants with the lowest quintile of LS7 score, those who were in the highest quintile were associated with higher *Z* scores of global cognition (β=0.29; 95% CI, 0.15–0.43), DSST (β=0.29, 95% CI, 0.16–0.42), CERAD-WL immediate memory (β=0.16; 95% CI, 0.03–0.28), and AFT (β=0.27; 95% CI, 0.13–0.41) (Table 3). Stratified by sex, higher LS7 score was associated with higher *Z* scores of global cognition, DSST, and AFT among men, as well as higher *Z* scores of global cognition and DSST among women. The highest quintile of LS7 was associated with higher *Z* scores of DSST and AFT among men, as well as higher *Z* scores of global cognition, DSST, CERAD-WL delayed memory, and AFT among women (Table S3). Stratified by race and ethnicity, higher LS7 scores were associated with higher *Z* scores of global cognition, DSST, CERAD-WL immediate memory, and AFT among non-Hispanic White participants. The highest quintile of LS7 was associated with higher *Z* scores of global cognition, DSST, CERAD-WL immediate memory, and AFT among non-Hispanic White participants. Higher LS7 was associated with a lower *Z* score of AFT among participants other than Hispanics, non-Hispanic White participants, and Non-Hispanic Black participants (Table S4).

Each increment on ideal components was associated with higher *Z* scores of global cognition (β=0.07; 95% CI, 0.02–0.11), DSST (β=0.06; 95% CI, 0.02–0.10), and AFT (β=0.07; 95% CI, 0.02–0.11). In contrast, each increment on poor items was associated with lower *Z* scores of global cognition (β=−0.07; 95% CI, −0.11 to −0.04), DSST (β=−0.09; 95% CI, −0.13 to −0.06), CERAD-WL immediate memory (β=−0.04; 95% CI, −0.08 to −0.01), and AFT (β=−0.07; 95% CI, −0.10 to −0.03) (Table S5).

For clusters created on the basis of behavioral factors (diet, physical activity, smoking, BMI) and biological factors (blood pressure, FPG, TC), combinations of better biological factors were associated with better cognitive function, while combinations of better behavioral factors were associated with better or poorer cognitive function, although the sample size was small (Tables S6 and S7).

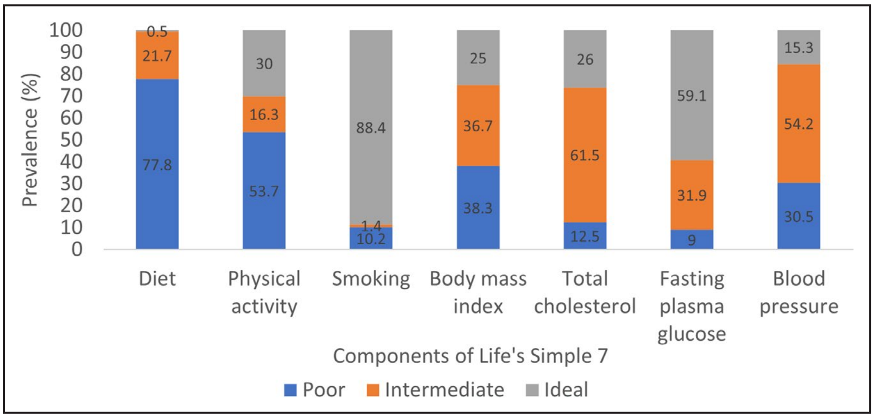

Figure. Prevalence of poor, intermediate, and ideal levels achieved in each component of Life's Simple 7 among US adults aged ≥60 years, NHANES 2011 to 2014.

DISCUSSION

In this nationally representative sample of older adults, the adherence to LS7 was not adequate among older adults in the United States, particularly in diet, physical activity, FPG, and blood pressure. We found that better adherence to LS7 was associated with better global and test-specific cognitive function.

The associations between adherence to LS7 and cognitive outcomes have been examined in previous studies. González et al[14] found that better LS7 metrics were associated with higher scores in verbal learning and memory, verbal fluency, and psychomotor processing speed in a cohort of 9623 middle-aged and older Hispanics/Latinos (aged 45–74 years). Thacker et al[16] found that compared with low adherence to LS7, intermediate and high levels of adherence were both associated with lower incidence of cognitive impairment in 17 761 middle-aged and older adults with normal global cognitive status at baseline. Samieri et al[17] found that a higher number of LS7 scores was associated with a lower risk of dementia and lower rates of cognitive decline over a mean follow-up of 8.5 years among 6626 older adults. González et al found that higher midlife LS7 score was associated with lower cognitive decline over 20 years among 13 270 White and Black participants.[15] All of these studies pointed to the associations between higher adherence to LS7 and better cognitive function. The results of our study are consistent with these previously published studies. Given the fact that our study is based on a large and nationally representative sample of the US population, it provides stronger evidence of importance of the association between LS7 and cognitive function. A previous study indicated that the rate of cognitive decline among older adults with normal cognitive aging is 0.04 SDs per year,[29] and our results suggested that healthy lifestyle may preserve cognition for a few more years.

The associations between LS7 and cognitive function among older adults may be explained by the associations of individual components of LS7 with cognitive function, and each of the associations has different mechanisms. Physical inactivity and smoking are associated with higher risk of hypertension, diabetes, and cardiovascular disease, which are highly related to cognitive impairment.[30–35] Physical activity may also enhance social engagement and reduce depressive symptoms, which could improve cognitive function.[36,37] Physical activity, blood pressure, fasting glucose, and smoking are associated with cerebral small-vessel disease, which is a predictor of cognitive impairment.[38–41] In addition, inflammation may also play a role between lifestyle behaviors, such as diet and physical activity with cognitive health.[42,43]

Although the importance of lifestyle in the maintenance and improvement of cardiovascular and cognitive health has been widely acknowledged, the adherence to some of the LS7 components has been poor. Particularly, the prevalence of ideal diet is close to 0, which is consistent with previous report in the United States from 2003 to 2016.[44] This suggested that health-related behaviors, such as diet and physical activity are unlikely to be changed in a simple manner. Therefore, a joint effort of public health professionals, experts of medicine, and policy makers is needed to make changes to lifestyle behaviors. Also, given the low prevalence of ideal level in physical activity and diet, the goal for diet and physical activity may be set to a more realistic and feasible level, so that older adults may be more motivated to engage in physical activity and pursue a healthy diet.

This study provided important results to guide future public health endeavors. Dementia has been

Table 2. Multivariable Linear Regression for the Associations of Individual Life's Simple 7 Components With Test-Specific and Global Cognition*

	Diet		PA		Smoking		BMI		BP		FPG		TC	
	β (95% CI)	*P* value	β (95% CI)	*P* value	β (95% CI)	*P* value	β (95% CI)	*P* value	β (95% CI)	*P* value	β (95% CI)	*P* value	β (95% CI)	*P* value
Poor	Reference		Reference		Reference		Reference		Reference		Reference		Reference	
Global cognition														
Intermediate	0.0005 (−0.10 to 0.11)	0.9925	0.17 (0.08 to 0.27)†	0.0007†	0.16 (−0.13 to 0.56)	0.3360	-0.06 (−0.16 to 0.04)	0.2379	0.11 (0.03 to 0.19)†	0.0108†	0.11 (−0.08 to 0.29)	0.2404	-0.09 (−0.24 to 0.05)	0.2042
Ideal	0.001 (−0.36 to 0.36)	0.9977	0.22 (0.12 to 0.33)†	0.0001†	0.08 (−0.07 to 0.22)	0.2871	-0.05 (−0.17 to 0.08)	0.4534	0.19 (0.02 to 0.35)†	0.0275†	0.14 (−0.05 to 0.33)	0.1510	-0.06 (−0.21 to 0.10)	0.4681
DSST														
Intermediate	0.05 (−0.06 to 0.15)	0.3667	0.13 (0.03 to 0.24)†	0.0125†	0.29 (−0.10 to 0.68)	0.1356	0.02 (−0.08 to 0.12)	0.6753	0.06 (−0.03 to 0.16)	0.1636	0.15 (−0.05 to 0.35)	0.1264	-0.01 (−0.12 to 0.10)	0.8637
Ideal	0.29 (−0.20 to 0.77)	0.2403	0.20 (0.08 to 0.31)†	0.0011†	0.20 (0.08 to 0.32)†	0.0019†	-0.07 (−0.18 to 0.05)	0.2534	0.11 (−0.02 to 0.24)	0.1021	0.22 (0.04 to 0.41)†	0.0177†	-0.05 (−0.17 to 0.07)	0.3650
CERAD-WL delayed memory														
Intermediate	0.001 (−0.11 to 0.11)	0.9788	0.08 (−0.04 to 0.20)	0.1957	-0.19 (−0.60 to 0.23)	0.3647	-0.10 (−0.21 to 0.01)	0.0666	0.09 (−0.01 to 0.20)	0.0828	0.05 (−0.22 to 0.31)	0.7293	-0.11 (−0.27 to 0.06)	0.2012
Ideal	0.10 (−0.36 to 0.55)	0.6632	0.09 (−0.02 to 0.20)	0.1219	-0.003 (−0.16 to 0.15)	0.9719	-0.06 (−0.18 to 0.06)	0.3011	0.14 (−0.07 to 0.35)	0.1838	0.04 (−0.22 to 0.29)	0.7756	0.01 (−0.15 to 0.16)	0.9074
CERAD-WL immediate memory														
Intermediate	0.03 (−0.08 to 0.14)	0.5667	0.16 (0.04 to 0.27)†	0.0074†	0.17 (−0.11 to 0.46)	0.2271	-0.04 (−0.12 to 0.05)	0.4014	0.14 (0.02 to 0.25)†	0.0187†	0.01 (−0.19 to 0.20)	0.9537	-0.14 (−0.30 to 0.02)	0.0750
Ideal	-0.15 (−0.70 to 0.40)	0.5893	0.07 (−0.03 to 0.17)	0.1717	0.03 (−0.13 to 0.20)	0.6850	-0.01 (−0.12 to 0.10)	0.8490	0.21 (0.04 to 0.39)†	0.0198	-0.02 (−0.20 to 0.15)	0.8060	-0.03 (−0.22 to 0.16)	0.7416
AFT														
Intermediate	-0.09 (−0.19 to 0.01)	0.0773	0.17 (0.06 to 0.27)†	0.0026†	0.26 (−0.15 to 0.68)	0.2063	-0.06 (−0.18 to 0.05)	0.2782	0.08 (−0.04 to 0.19)	0.1804	0.14 (−0.01 to 0.28)	0.0712	-0.09 (−0.24 to 0.05)	0.2068
Ideal	-0.12 (−1.33 to 1.09)	0.8379	0.33 (0.22 to 0.43)†	<0.0001†	0.01 (−0.16 to 0.18)	0.9211	-0.04 (−0.20 to 0.12)	0.6224	0.16 (0.02 to 0.30)†	0.0226†	0.15 (0.001 to 0.31)†	0.0480†	-0.10 (−0.28 to 0.07)	0.2479

AFT indicates Animal Fluency Test; BMI, body mass index; BP, blood pressure; CERAD-WL, Consortium to Establish a Registry for Alzheimer's Disease Word Learning subtest; DSST, Digit Symbol Substitution Test; FPG, fasting plasma glucose; PA, physical activity; and TC, total cholesterol.

*Models were adjusted for age, sex, race and ethnicity, education, other Life's Simple 7 components, coronary heart disease.

†$P<0.05$.

Table 3. Multivariable Linear Regression for the Associations of Total Life's Simple 7 Score With Test-Specific and Global Cognition*

	Quintile 1 Total score<6 (n=609)		Quintile 2 Total score=6 (n=512)		Quintile 3 Total score=7 (n=473)		Quintile 4 Total score=8 (n=425)		Quintile 5 Total score>8 (n=566)		Continuous score	
	β (95% CI)	*P* value	β (95% CI)	*P* value	β (95% CI)	*P* value	β (95% CI)	*P* value	β (95% CI)	*P* value	β (95% CI)	*P* value
Global cognition	Reference		0.15 (−0.01 to 0.31)	0.0681	0.15 (0.04 to 0.27)†	0.0108†	0.12 (−0.02 to 0.27)	0.0969	0.29 (0.15 to 0.43)†	0.0001†	0.05 (0.02 to 0.07)†	0.0002†
DSST	Reference		0.10 (−0.02 to 0.23)	0.1027	0.16 (0.02 to 0.30)†	0.0255†	0.26 (0.12 to 0.40)†	0.0007†	0.29 (0.16 to 0.42)†	<0.0001†	0.05 (0.03 to 0.07)†	<0.0001
CERAD-WL delayed memory	Reference		0.11 (−0.07 to 0.28)	0.2190	0.09 (−0.05 to 0.23)	0.2196	-0.03 (−0.20 to 0.14)	0.7266	0.13 (−0.02 to 0.28)	0.0862	0.02 (−0.01 to 0.04)	0.1254
CERAD-WL immediate memory	Reference		0.15 (−0.02 to 0.31)	0.0757	0.04 (−0.07 to 0.14)	0.4668	0.02 (−0.15 to 0.19)	0.8102	0.16 (0.03 to 0.28)†	0.0201†	0.03 (0.004 to 0.05)†	0.0218†
AFT	Reference		0.09 (−0.08 to 0.26)	0.2785	0.16 (−0.01 to 0.32)	0.0595	0.08 (−0.07 to 0.24)	0.2798	0.27 (0.13 to 0.41)†	0.0006†	0.05 (0.02 to 0.07)†	0.0004†

AFT indicates Animal Fluency Test; CERAD-WL, Consortium to Establish a Registry for Alzheimer's Disease Word Learning subtest; and DSST, Digit Symbol Substitution Test.
*Models were adjusted for age, sex, race and ethnicity, education, other Life's Simple 7 components, coronary heart disease.
†*P*<0.05.

associated with multiple risk factors, and it may be reasonable to prevent dementia through targeting a multitude of risk factors simultaneously to make the prevention more scalable. As shown in our results, better levels of physiological factors (such as blood pressure) and greater adherence to healthy lifestyle factors were associated with better cognitive function. Also, small changes in lifestyle factors and behaviors could potentially be beneficial for improving cognition. Given the fact that other prospective cohort studies have also found the associations between adherence to LS7 and beneficial cognitive outcomes, multidomain lifestyle intervention should be considered. A few multidomain lifestyle trials have been conducted for prevention of cognitive outcomes, such as the FINGER (Finnish Geriatric Intervention Study to Prevent Cognitive Impairment and Disability),[45] MAPT (Multidomain Alzheimer Preventive Trial),[46] and preDIVA (Prevention of Dementia by Intensive Vascular Care) trials.[47] Some of the results were mixed, and it may be likely from the limitations of the fact that participants were in their late life and had a short period of intervention, while the process of cognitive aging starts from an early stage in life and lasts for a long time. However, it is challenging to conduct these intervention trials among midlife adults for several decades. Therefore, alternative epidemiological methods may be applied to estimate the long-term impact of multidomain lifestyle intervention in preventing cognitive outcomes among older adults in population.[48]

In our study, the association between adherence to LS7 and cognitive function was linear, which suggests that there is no threshold for the LS7 score in its relationship with cognition, and any small increment in the score is helpful for improving cognitive performance. Therefore, "population strategy",[49] which aims for modest improvement of risk factors in the whole population, is critical for reducing the burden of dementia.

One major limitation of our study is the cross-sectional design, which precludes causal inferences for LS7 and cognitive function among older adults. We cannot exclude the possibility that poor cognitive function can potentially reduce adherence to LS7. Also, some components of LS7 (eg, physical activity, smoking, coronary heart disease) were obtained by self-report. This may contribute to misclassification, as participants may overreport their physical activity while underreporting their unhealthy diet. We also lacked information on the participants' places of residence as neighborhood socioeconomic status may be an important covariate for our analyses. Selection bias is also possible, with different characteristics of participants included and not included in the analysis. It is possible that our findings were more conservative, as participants who were excluded were older, reported a lower level of education, and had worse health status than those included in the analysis. Finally, there are only 3 sets of cognitive tests, which may not be sufficient to capture the overall cognitive function. Despite these limitations, we had access to validated assessments of cognitive function and all components of LS7 (including biological factors) that strengthened our analyses. Furthermore, NHANES has a large and diverse representative sample, which makes the results generalizable to the US population.

CONCLUSIONS

In conclusion, greater adherence to LS7 metrics is associated with better cognitive function among older adults. Future research is expected to learn how improvement in lifestyle and physiological factors can affect cognitive performance and understanding the mechanistic pathways.

ARTICLE INFORMATION

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Disclosures

None.

Supplemental Material

Tables S1–S7
Figure S1

REFERENCES

1. Larson EB, Yaffe K, Langa KM. New insights into the dementia epidemic. *N Engl J Med*. 2013;369:2275–2277. doi: 10.1056/NEJMp1311405
2. Nichols E, Szoeke CEI, Vollset SE, Abbasi N, Abd-Allah F, Abdela J, Aichour MTE, Akinyemi RO, Alahdab F, Asgedom SW, et al. Global, regional, and national burden of Alzheimer's disease and other dementias, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet Neurol*. 2019;18:88–106. doi: 10.1016/s1474-4422(18)30403-4
3. Paciaroni M, Bogousslavsky J. Connecting cardiovascular disease and dementia: further evidence. *J Am Heart Assoc*. 2013;2:e000656. doi: 10.1161/jaha.113.000656
4. Fillit H, Nash DT, Rundek T, Zuckerman A. Cardiovascular risk factors and dementia. *Am J Geriatr Pharmacother*. 2008;6:100–118. doi: 10.1016/j.amjopharm.2008.06.004
5. Parial LL, Lam SC, Ho JYS, Suen LKP, Leung AYM. Public knowledge of the influence of modifiable cardiovascular risk factors on dementia: a systematic literature review and meta-analysis. *Aging Ment Health*. 2020;1–15: doi: 10.1080/13607863.2020.1786801
6. Lloyd-Jones DM, Hong Y, Labarthe D, Mozaffarian D, Appel LJ, Van Horn L, Greenlund K, Daniels S, Nichol G, Tomaselli GF, et al. Defining and setting national goals for cardiovascular health promotion and disease reduction. *Circulation*. 2010;121:586–613. doi: 10.1161/CIRCULATIONAHA.109.192703
7. Radd-Vagenas S, Duffy SL, Naismith SL, Brew BJ, Flood VM, Fiatarone Singh MA. Effect of the Mediterranean diet on cognition and brain morphology and function: a systematic review of randomized controlled trials. *Am J Clin Nutr*. 2018;107:389–404. doi: 10.1093/ajcn/nqx070
8. Erickson KI, Hillman C, Stillman CM, Ballard RM, Bloodgood B, Conroy DE, Macko R, Marquez DX, Petruzzello SJ, Powell KE, et al. Physical activity, cognition, and brain outcomes: a review of the 2018 physical activity guidelines. *Med Sci Sports Exerc*. 2019;51:1242–1251. doi: 10.1249/MSS.0000000000001936
9. Anstey KJ, von Sanden C, Salim A, O'Kearney R. Smoking as a risk factor for dementia and cognitive decline: a meta-analysis of prospective studies. *Am J Epidemiol*. 2007;166:367–378. doi: 10.1093/aje/kwm116
10. Qu Y, Hu HY, Ou YN, Shen XN, Xu W, Wang ZT, Dong Q, Tan L, Yu JT. Association of body mass index with risk of cognitive impairment and dementia: a systematic review and meta-analysis of prospective studies. *Neurosci Biobehav Rev*. 2020;115:189–198. doi: 10.1016/j.neubiorev.2020.05.012
11. Ou Y-N, Tan C-C, Shen X-N, Xu W, Hou X-H, Dong Q, Tan L, Yu J-T. Blood pressure and risks of cognitive impairment and dementia. *Hypertension*. 2020;76:217–225. doi: 10.1161/HYPERTENSIONAHA.120.14993
12. Anstey KJ, Ashby-Mitchell K, Peters R. Updating the evidence on the association between serum cholesterol and risk of late-life dementia: review and meta-analysis. *J Alzheimers Dis*. 2017;56:215–228. doi: 10.3233/jad-160826
13. Yaffe K, Blackwell T, Kanaya AM, Davidowitz N, Barrett-Connor E, Krueger K. Diabetes, impaired fasting glucose, and development of cognitive impairment in older women. *Neurology*. 2004;63:658. doi: 10.1212/01.WNL.0000134666.64593.BA
14. González HM, Tarraf W, Gouskova N, Rodríguez CJ, Rundek T, Grober E, Pirzada A, González P, Lutsey PL, Camacho A, et al. Life's Simple 7's cardiovascular health metrics are associated with Hispanic/Latino neurocognitive function: HCHS/SOL results. *J Alzheimers Dis*. 2016;53:955–965. doi: 10.3233/jad-151125
15. González HM, Tarraf W, Harrison K, Windham BG, Tingle J, Alonso A, Griswold M, Heiss G, Knopman D, Mosley TH. Midlife cardiovascular health and 20-year cognitive decline: Atherosclerosis Risk in Communities Study results. *Alzheimers Dement*. 2018;14:579–589. doi: 10.1016/j.jalz.2017.11.002
16. Thacker EL, Gillett SR, Wadley VG, Unverzagt FW, Judd SE, McClure LA, Howard VJ, Cushman M. The American Heart Association Life's Simple 7 and incident cognitive impairment: the REasons for Geographic and Racial Differences in Stroke (REGARDS) study. *J Am Heart Assoc*. 2014;3:e000635. doi: 10.1161/jaha.113.000635
17. Samieri C, Perier MC, Gaye B, Proust-Lima C, Helmer C, Dartigues JF, Berr C, Tzourio C, Empana JP. Association of cardiovascular health level in older age with cognitive decline and incident dementia. *JAMA*. 2018;320:657–664. doi: 10.1001/jama.2018.11499
18. Sabia S, Fayosse A, Dumurgier J, Schnitzler A, Empana J-P, Ebmeier KP, Dugravot A, Kivimäki M, Singh-Manoux A. Association of ideal cardiovascular health at age 50 with incidence of dementia: 25 year follow-up of Whitehall II cohort study. *BMJ*. 2019;366:l4414. doi: 10.1136/bmj.l4414
19. Atkins JL, Delgado J, Pilling LC, Bowman K, Masoli JAH, Kuchel GA, Ferrucci L, Melzer D. Impact of low cardiovascular risk profiles on geriatric outcomes: evidence from 421,000 participants in two cohorts. *J*

Gerontol Series A, Biol Sci Med Sci. 2019;74:350–357. doi: 10.1093/gerona/gly083
20. Guo J, Brickman AM, Manly JJ, Reitz C, Schupf N, Mayeux RP, Gu Y. Association of Life's Simple 7 with incident dementia and its modification by the apolipoprotein E genotype. *Alzheimers Dement*. 2021. doi: 10.1002/alz.12359
21. Malik R, Georgakis MK, Neitzel J, Rannikmäe K, Ewers M, Seshadri S, Sudlow CLM, Dichgans M. Midlife vascular risk factors and risk of incident dementia: longitudinal cohort and Mendelian randomization analyses in the UK Biobank. *Alzheimers Dement*. 2021. doi: 10.1002/alz.12320
22. CDC. National Health and Nutrition Examination Survey 2011–2012 Data Documentation, Codebook, and Frequencies. https://wwwn.cdc.gov/Nchs/Nhanes/2011-2012/DR1IFF_G.htm. Accessed April 27, 2021.
23. Bowman S, Clemens J, Thoerig R, Friday J, Shimizu M, Moshfegh A. Food Patterns Equivalents Database: Methodology and User Guide [Online]. Food Surveys Research Group, Beltsville Human Nutrition Research Center. 2013. Agricultural Research Service, US Department of Agriculture, Beltsville, Maryland. Available at: http://www.ars.usda.gov/ba/bhnrc/fsrg. Accessed October 4, 2016.
24. Bull FC, Maslin TS, Armstrong T. Global physical activity questionnaire (GPAQ): nine country reliability and validity study. *J Phys Act Health*. 2009;6:790–804. doi: 10.1123/jpah.6.6.790
25. Jaeger J. Digit symbol substitution test: the case for sensitivity over specificity in neuropsychological testing. *J Clin Psychopharmacol*. 2018;38:513–519. doi: 10.1097/JCP.0000000000000941
26. Morris JC, Heyman A, Mohs RC, Hughes JP, van Belle G, Fillenbaum G, Mellits ED, Clark C. The Consortium to Establish a Registry for Alzheimer's Disease (CERAD). Part I. Clinical and neuropsychological assessment of Alzheimer's disease. *Neurology*. 1989;39:1159–1165. doi: 10.1212/wnl.39.9.1159
27. Strauss E, Sherman E, Spreen O. *A Compendium of Neuropsychological Tests*. New York: Oxford University Press; 2006.
28. Gu Y, Guo J, Moshfegh AJ. Race/ethnicity and gender modify the association between diet and cognition in U.S. older adults: National Health and Nutrition Examination Survey 2011–2014. *Alzheimer's Dement*. 2021;7:e12128. doi: 10.1002/trc2.12128
29. Hayden KM, Reed BR, Manly JJ, Tommet D, Pietrzak RH, Chelune GJ, Yang FM, Revell AJ, Bennett DA, Jones RN. Cognitive decline in the elderly: an analysis of population heterogeneity. *Age Ageing*. 2011;40:684–689. doi: 10.1093/ageing/afr101
30. Rêgo ML, Cabral DA, Costa EC, Fontes EB. Physical exercise for individuals with hypertension: it is time to emphasize its benefits on the brain and cognition. *Clin Med Insights Cardiol*. 2019;13:1179546819839411. doi: 10.1177/1179546819839411
31. Kivimäki M, Singh-Manoux A, Pentti J, Sabia S, Nyberg ST, Alfredsson L, Goldberg M, Knutsson A, Koskenvuo M, Koskinen A, et al. Physical inactivity, cardiometabolic disease, and risk of dementia: an individual-participant meta-analysis. *BMJ*. 2019;365:l1495. doi: 10.1136/bmj.l1495
32. Willi C, Bodenmann P, Ghali WA, Faris PD, Cornuz J. Active smoking and the risk of type 2 diabetes: a systematic review and meta-analysis. *JAMA*. 2007;298:2654–2664. doi: 10.1001/jama.298.22.2654
33. Colpani V, Baena CP, Jaspers L, van Dijk GM, Farajzadegan Z, Dhana K, Tielemans MJ, Voortman T, Freak-Poli R, Veloso GGV, et al. Lifestyle factors, cardiovascular disease and all-cause mortality in middle-aged and elderly women: a systematic review and meta-analysis. *Eur J Epidemiol*. 2018;33:831–845. doi: 10.1007/s10654-018-0374-z
34. Wahid A, Manek N, Nichols M, Kelly P, Foster C, Webster P, Kaur A, Friedemann Smith C, Wilkins E, Rayner M, et al. Quantifying the association between physical activity and cardiovascular disease and diabetes: a systematic review and meta-analysis. *J Am Heart Assoc*. 2016;5. doi: 10.1161/jaha.115.002495
35. Halperin RO, Gaziano JM, Sesso HD. Smoking and the risk of incident hypertension in middle-aged and older men. *Am J Hypertens*. 2008;21:148–152. doi: 10.1038/ajh.2007.36
36. Wang HX, Karp A, Winblad B, Fratiglioni L. Late-life engagement in social and leisure activities is associated with a decreased risk of dementia: a longitudinal study from the Kungsholmen project. *Am J Epidemiol*. 2002;155:1081–1087. doi: 10.1093/aje/155.12.1081
37. Schuch FB, Vancampfort D, Firth J, Rosenbaum S, Ward PB, Silva ES, Hallgren M, Ponce De Leon A, Dunn AL, Deslandes AC, et al. Physical activity and incident depression: a meta-analysis of prospective cohort studies. *Am J Psychiatry*. 2018;175:631–648. doi: 10.1176/appi.ajp.2018.17111194
38. Palta P, Sharrett AR, Gabriel KP, Gottesman RF, Folsom AR, Power MC, Evenson KR, Jack CR, Knopman DS, Mosley TH, et al. Prospective analysis of leisure-time physical activity in midlife and beyond and brain damage on MRI in older adults. *Neurology*. 2021;96:e964–e974. doi: 10.1212/wnl.0000000000011375
39. Ma Y, Song A, Viswanathan A, Blacker D, Vernooij MW, Hofman A, Papatheodorou S. Blood pressure variability and cerebral small vessel disease: a systematic review and meta-analysis of population-based cohorts. *Stroke*. 2020;51:82–89. doi: 10.1161/strokeaha.119.026739
40. Sims RC, Katzel LI, Lefkowitz DM, Siegel EL, Rosenberger WF, Manukyan Z, Whitfield KE, Waldstein SR. Association of fasting glucose with subclinical cerebrovascular disease in older adults without type 2 diabetes. *Diabet Med*. 2014;31:691–698. doi: 10.1111/dme.12385
41. Power MC, Deal JA, Sharrett AR, Jack CR Jr, Knopman D, Mosley TH, Gottesman RF. Smoking and white matter hyperintensity progression: the ARIC-MRI Study. *Neurology*. 2015;84:841–848. doi: 10.1212/WNL.0000000000001283
42. McGrattan AM, McGuinness B, McKinley MC, Kee F, Passmore P, Woodside JV, McEvoy CT. Diet and inflammation in cognitive ageing and Alzheimer's disease. *Curr Nutr Rep*. 2019;8:53–65. doi: 10.1007/s13668-019-0271-4
43. Stranahan AM, Martin B, Maudsley S. Anti-inflammatory effects of physical activity in relationship to improved cognitive status in humans and mouse models of Alzheimer's disease. *Curr Alzheimer Res*. 2012;9:86–92. doi: 10.2174/156720512799015019
44. Virani SS, Alonso A, Aparicio HJ, Benjamin EJ, Bittencourt MS, Callaway CW, Carson AP, Chamberlain AM, Cheng S, Delling FN, et al. Heart disease and stroke statistics—2021 update. *Circulation*. 2021;143:e254–e743. doi: 10.1161/CIR.0000000000000950
45. Ngandu T, Lehtisalo J, Solomon A, Levälahti E, Ahtiluoto S, Antikainen R, Bäckman L, Hänninen T, Jula A, Laatikainen T, et al. A 2 year multidomain intervention of diet, exercise, cognitive training, and vascular risk monitoring versus control to prevent cognitive decline in at-risk elderly people (FINGER): a randomised controlled trial. *Lancet*. 2015;385:2255–2263. doi: 10.1016/s0140-6736(15)60461-5
46. Andrieu S, Guyonnet S, Coley N, Cantet C, Bonnefoy M, Bordes S, Bories L, Cufi M-N, Dantoine T, Dartigues J-F, et al. Effect of long-term omega 3 polyunsaturated fatty acid supplementation with or without multidomain intervention on cognitive function in elderly adults with memory complaints (MAPT): a randomised, placebo-controlled trial. *Lancet Neurol*. 2017;16:377–389. doi: 10.1016/s1474-4422(17)30040-6
47. Moll van Charante EP, Richard E, Eurelings LS, van Dalen JW, Ligthart SA, van Bussel EF, Hoevenaar-Blom MP, Vermeulen M, van Gool WA. Effectiveness of a 6-year multidomain vascular care intervention to prevent dementia (preDIVA): a cluster-randomised controlled trial. *Lancet*: 2016:797–805. doi: 10.1016/s0140-6736(16)30950-3
48. Yaffe K, Barnes DE, Rosenberg D, Dublin S, Kaup AR, Ludman EJ, Vittinghoff E, Peltz CB, Renz AD, Adams KJ, et al. Systematic Multi-Domain Alzheimer's Risk Reduction Trial (SMARRT): study protocol. *J Alzheimer's Dis*. 2019;70:S207–S220. doi: 10.3233/jad-180634
49. Rose G. Sick individuals and sick populations. *Int J Epidemiol*. 1985;14:32–38. doi: 10.1093/ije/14.1.32

Supplemental Material

Table S1. Definition of Life's Simple 7*.

	Poor	Intermediate	Ideal
Diet*	Meet 0-1 criteria	Meet 2-3 criteria	Meet 4-5 criteria
Physical activity	No physical activity	1- 149 minutes/week of moderate activity, or 1-74 minutes/week of vigorous activity, or 1-149 minutes/week of moderate and vigorous activity	≥150 minutes/week of moderate activity, or ≥75 minutes/week of vigorous activity, or ≥150 minutes/week of moderate and vigorous activity
Smoking	Current smoking	Quitting smoking for less than 12 months	Never smoking or quit smoking for more than 12 months
Body mass index (BMI)	BMI ≥30 kg/m^2	BMI 25-29.9 kg/m^2	BMI <25kg
Total cholesterol	Total cholesterol ≥240 mg/dL	Total cholesterol 200-239 mg/dL	Total cholesterol <200 mg/dL
Blood pressure	Systolic blood pressure ≥140 mmHg and diastolic blood pressure ≥90 mmHg	Systolic blood pressure 120-139 mmHg, or diastolic blood pressure 80-89 mmHg, or treated to goal	Systolic blood pressure <120 mmHg and diastolic blood pressure <80 mmHg
Fasting plasma glucose (FPG)	FPG ≥126 mg/dL	FPG 100-125 mg/dL	FPG <100 mg/dL

*Criteria for diet: 1) ≥4.5 cups/day of fruits and vegetables; 2) ≥2 servings/week of fish; 3) ≥3 servings/day of whole grains; 4) no more than 36 ounces/week of sugar-sweetened beverage; 5) ≤1500 mg/day of sodium.

Table S2. Comparison between characteristics of participants aged 60 years or older included and not included in the analysis.

	Not included in analysis	Included in analysis
	Mean (95% CI) / n (%)	Mean (95% CI) / n (%)
Weighted frequency	11,974,840	47,684,724
Age, ≥80 years	271 (33.7)	387 (13.1)
Sex, female, n (%)	466 (58.4)	1,319 (54.1)
Race/ethnicity, n (%)		
Mexican American	84 (5.1)	241 (3.5)
Other Hispanic	69 (4.1)	277 (3.9)
Non-Hispanic White	364 (67.9)	1,216 (79.7)
Non-Hispanic Black	216 (11.9)	621 (8.4)
Other races	154 (11.1)	230 (4.6)
Education, n (%)		
Less than 9th grade	197 (15.7)	314 (6.0)
9-11th grade	142 (13.6)	365 (10.1)
High school graduate	211 (24.3)	586 (21.6)
Some college	192 (25.0)	719 (31.5)
College graduate or above	138 (21.0)	601 (30.7)
Ever smoking, n (%)	471 (55.5)	1,261 (48.7)
Moderate to vigorous physical activity, min/week		
Moderate	69.9 (46.5, 93.2)	98.5 (85.7, 111.3)
Vigorous	13.0 (6.5, 19.5)	23.6 (17.7, 29.5)
Diet		
Sodium intake, g/day	2.9 (2.8, 3.0)	3.1 (3.0, 3.2)
Sugar sweetened beverage, g/day	195.8 (161.7, 230.0)	246.8 (227.3, 266.4)
Fish consumption, oz/day	0.8 (0.5, 1.0)	0.7 (0.6, 0.8)
Fruits and vegetables, cups/day	1.8 (1.6, 1.9)	2.0 (1.9, 2.2)
Whole grain, oz/day	1.2 (1.1, 1.4)	1.1 (1.1, 1.2)
Body mass index, kg/m^2	27.6 (26.8, 28.4)	29.3 (28.9, 29.7)
Total cholesterol, mg/dl	185.2 (181.3, 189.1)	193.6 (190.9, 196.4)
Fasting plasma glucose, mg/dl	118.1 (111.0, 125.2)	112.7 (109.7, 115.8)
Systolic blood pressure, mmHg	133.7 (131.3, 136.2)	132.1 (131.0, 133.2)
Diastolic blood pressure, mmHg	65.6 (64.1, 67.0)	68.6 (67.5, 69.6)
Coronary heart disease, n (%)	109 (13.3)	222 (9.0)
Cognitive function		
Digit Symbol score	43.8 (41.9, 45.6)	53.2 (52.0, 54.3)
Delayed Recall score	5.4 (5.1, 5.6)	6.3 (6.1, 6.5)
Immediate Recall score	17.9 (17.3, 18.6)	19.8 (19.3, 20.2)
Animal Fluency test score	15.7 (15.0, 16.3)	18.3 (17.9, 18.7)

Table S3. Multivariable linear regression for the associations of total Life's Simple 7 score with domain-specific and global cognition by sex[*].

	Total score<6	Total score=6		Total score=7		Total score=8		Total score>8		Continuous score	
Men (n=1,266)											
	(n=285)	(n=263)		(n=223)		(n=196)		(n=299)			
	β (95% CI)[†]	β (95% CI)	P value	β (95% CI)	P value	β (95% CI)	P value	β (95% CI)	P value	β (95% CI)	P value
Global cognition	Reference	0.07 (-0.18, 0.33)	0.5563	0.21 (-0.004, 0.42)	0.0549	0.12 (-0.13, 0.36)	0.3459	0.26 (-0.002, 0.51)	0.0520	**0.04 (0.005, 0.08)**	**0.0298**
DSST	Reference	0.06 (-0.15, 0.26)	0.5709	0.19 (-0.04, 0.42)	0.0994	**0.22 (0.03, 0.41)**	**0.0234**	**0.29 (0.08, 0.49)**	**0.0077**	**0.05 (0.02, 0.08)**	**0.0017**
CERAD WL delayed memory	Reference	0.10 (-0.14, 0.34)	0.4112	0.13 (-0.10, 0.36)	0.2494	-0.07 (-0.37, 0.24)	0.6524	0.06 (-0.17, 0.28)	0.6018	0.01 (-0.03, 0.04)	0.6525
CERAD WL immediate memory	Reference	0.07 (-0.19, 0.33)	0.5932	0.05 (-0.12, 0.22)	0.5711	-0.02 (-0.28, 0.24)	0.8681	0.11 (-0.07, 0.30)	0.2269	0.02 (-0.01, 0.05)	0.1843
AFT	Reference	0.03 (-0.22, 0.28)	0.8058	**0.26 (0.02, 0.50)**	**0.0365**	0.18 (-0.07, 0.42)	0.1576	**0.34 (0.06, 0.63)**	**0.0201**	**0.06 (0.02, 0.11)**	**0.0058**
Women (n=1,319)											
	Total score<6 (n=324)	Total score=6 (n=249)		Total score=7 (n=250)		Total score=8 (n=229)		Total score>8 (n=267)		Continuous score	
	β (95% CI)[b]	β (95% CI)	P value	β (95% CI)	P value	β (95% CI)	P value	β (95% CI)	P value	β (95% CI)	P value
Global cognition	Reference	0.19 (-0.003, 0.39)	0.0538	0.10 (-0.09, 0.29)	0.2791	0.13 (-0.08, 0.33)	0.2212	**0.31 (0.15, 0.48)**	**0.0005**	**0.05 (0.02, 0.08)**	**0.0023**
DSST	Reference	0.12 (-0.07, 0.32)	0.1993	0.12 (-0.05, 0.30)	0.1684	**0.28 (0.08, 0.48)**	**0.0065**	**0.27 (0.10, 0.45)**	**0.0035**	**0.05 (0.02, 0.08)**	**0.0021**
CERAD WL delayed memory	Reference	0.10 (-0.10, 0.30)	0.3021	0.05 (-0.11, 0.22)	0.5280	0.01 (-0.21, 0.22)	0.9483	**0.20 (0.01, 0.39)**	**0.0429**	0.03 (-0.003, 0.06)	0.0696
CERAD WL immediate memory	Reference	**0.21 (0.05, 0.37)**	**0.0131**	0.03 (-0.14, 0.20)	0.7257	0.06 (-0.16, 0.27)	0.5987	0.19 (-0.001, 0.38)	0.0510	0.03 (-0.01, 0.06)	0.0941
AFT	Reference	0.14 (-0.06, 0.34)	0.1691	0.07 (-0.18, 0.32)	0.5560	0.002 (-0.20, 0.20)	0.9855	**0.19 (0.02, 0.36)**	**0.0332**	0.03 (-0.004, 0.06)	0.0800

*Models were adjusted for age, sex, race/ethnicity, education, other Life's Simple 7 components, coronary heart disease.

† β: beta; CI: confidence interval; DSST: the Digit Symbol Substitution Test; CERAD WL: the Consortium to establish a registry for Alzheimer's disease Word Learning subtest; AFT: the Animal Fluency test.

Table S4. Multivariable linear regression for the associations of total Life's Simple 7 score with domain-specific and global cognition by race/ethnicity*.

Mexican Americans (n=241)											
	Total score<6 (n=75)	Total score=6 (n=42)		Total score=7 (n=43)		Total score=8 (n=41)		Total score>8 (n=40)		Continuous score	
	β (95% CI)†	β (95% CI)	P value	β (95% CI)	P value	β (95% CI)	P value	β (95% CI)	P value	β (95% CI)	P value
Global cognition	Reference	0.01 (-0.33, 0.35)	0.9602	0.11 (-0.21, 0.43)	0.4702	0.14 (-0.17, 0.45)	0.3545	0.13 (-0.06, 0.32)	0.1705	0.03 (-0.01, 0.06)	0.1186
DSST	Reference	-0.17 (-0.40, 0.06)	0.1361	0.27 (-0.01, 0.56)	0.0593	0.15 (-0.22, 0.53)	0.4172	0.08 (-0.11, 0.27)	0.3706	0.03 (-0.01, 0.07)	0.1373
CERAD WL delayed memory	Reference	-0.07 (-0.56, 0.42)	0.7633	-0.07 (-0.38, 0.25)	0.6696	-0.15 (-0.65, 0.35)	0.5411	0.13 (-0.15, 0.42)	0.3471	-0.01 (-0.07, 0.05)	0.7495
CERAD WL immediate memory	Reference	-0.01 (-0.40, 0.37)	0.9439	0.03 (-0.35, 0.40)	0.8824	0.07 (-0.33, 0.47)	0.7202	0.25 (-0.01, 0.52)	0.0611	0.04 (-0.01, 0.08)	0.0808
AFT	Reference	0.20 (-0.22, 0.62)	0.3437	0.16 (-0.20, 0.51)	0.3727	0.19 (-0.14, 0.53)	0.2453	-0.01 (-0.28, 0.26)	0.9392	0.01 (-0.03, 0.06)	0.5634
Other Hispanics (n=277)											
	Total score<6 (n=78)	Total score=6 (n=56)		Total score=7 (n=56)		Total score=8 (n=43)		Total score>8 (n=44)		Continuous score	
	β (95% CI)†	β (95% CI)	P value	β (95% CI)	P value	β (95% CI)	P value	β (95% CI)	P value	β (95% CI)	P value
Global cognition	Reference	0.11 (-0.17, 0.40)	0.4254	-0.14 (-0.42, 0.13)	0.2977	0.18 (-0.12, 0.47)	0.2388	0.07 (-0.30, 0.45)	0.6894	0.03 (-0.03, 0.08)	0.3322
DSST	Reference	0.19 (-0.10, 0.48)	0.1989	-0.19 (-0.45, 0.07)	0.1477	0.17 (-0.16, 0.50)	0.3094	0.15 (-0.18, 0.49)	0.3665	0.03 (-0.03, 0.08)	0.3306
CERAD WL delayed memory	Reference	0.22 (-0.10, 0.54)	0.1766	-0.16 (-0.50, 0.17)	0.3282	0.16 (-0.18, 0.49)	0.3529	0.03 (-0.39, 0.45)	0.8887	0.02 (-0.05, 0.09)	0.5625
CERAD WL immediate memory	Reference	0.19 (-0.13, 0.50)	0.2353	-0.04 (-0.36, 0.29)	0.8106	0.02 (-0.27, 0.31)	0.8860	-0.11 (-0.49, 0.27)	0.5661	-0.01 (-0.07, 0.06)	0.8289
AFT	Reference	-0.07 (-0.35, 0.20)	0.5932	-0.04 (-0.37, 0.29)	0.8176	0.21 (-0.21, 0.63)	0.3189	0.05 (-0.35, 0.45)	0.8062	0.03 (-0.04, 0.10)	0.3981
Non-Hispanic White (n=1,216)											
	Total score<6 (n=263)	Total score=6 (n=244)		Total score=7 (n=212)		Total score=8 (n=210)		Total score>8 (n=287)		Continuous score	
	β (95% CI)†	β (95% CI)	P value	β (95% CI)	P value	β (95% CI)	P value	β (95% CI)	P value	β (95% CI)	P value
Global cognition	Reference	0.16 (-0.05, 0.37)	0.1307	**0.18 (0.04, 0.32)**	**0.0126**	0.13 (-0.04, 0.30)	0.1278	**0.34 (0.18, 0.50)**	**0.0001**	**0.05 (0.03, 0.08)**	**<0.0001**
DSST	Reference	0.12 (-0.07, 0.30)	0.2007	**0.19 (0.01, 0.37)**	**0.0432**	**0.30 (0.13, 0.48)**	**0.0014**	**0.33 (0.16, 0.50)**	**0.0004**	**0.06 (0.03, 0.08)**	**<0.0001**
CERAD WL delayed memory	Reference	0.11 (-0.09, 0.30)	0.2616	0.12 (-0.02, 0.26)	0.0959	-0.04 (-0.23, 0.14)	0.6466	0.14 (-0.01, 0.29)	0.0636	0.02 (-0.004, 0.04)	0.1034
CERAD WL immediate memory	Reference	0.16 (-0.04, 0.36)	0.1147	0.06 (-0.07, 0.18)	0.3556	0.02 (-0.18, 0.22)	0.8470	**0.19 (0.04, 0.33)**	**0.0137**	**0.03 (0.01, 0.05)**	**0.0136**
AFT	Reference	0.12 (-0.10, 0.35)	0.2820	0.19 (-0.005, 0.39)	0.0556	0.11 (-0.09, 0.31)	0.2710	**0.35 (0.16, 0.53)**	**0.0005**	**0.06 (0.03, 0.09)**	**0.0002**
Non-Hispanic Black (n=621)											
	Total score<6 (n=171)	Total score=6 (n=140)		Total score=7 (n=129)		Total score=8 (n=77)		Total score>8 (n=104)		Continuous score	
	β (95% CI)†	β (95% CI)	P value	β (95% CI)	P value	β (95% CI)	P value	β (95% CI)	P value	β (95% CI)	P value
Global cognition	Reference	0.14 (-0.05, 0.34)	0.1487	0.06 (-0.12, 0.24)	0.5169	-0.002 (-0.23, 0.23)	0.9831	0.11 (-0.11, 0.32)	0.3158	0.01 (-0.02, 0.05)	0.4658
DSST	Reference	0.11 (-0.10, 0.33)	0.2936	**0.14 (0.02, 0.26)**	**0.0274**	0.11 (-0.10, 0.32)	0.3120	0.16 (-0.06, 0.38)	0.1455	0.03 (-0.01, 0.06)	0.1635
CERAD WL delayed memory	Reference	0.07 (-0.16, 0.31)	0.5400	-0.11 (-0.37, 0.16)	0.4149	0.02 (-0.29, 0.32)	0.9185	0.01 (-0.28, 0.30)	0.9224	0.001 (-0.05, 0.05)	0.9520
CERAD WL immediate memory	Reference	0.16 (-0.05, 0.37)	0.1313	-0.01 (-0.21, 0.20)	0.9457	-0.07 (-0.39, 0.24)	0.6474	0.02 (-0.23, 0.26)	0.8941	-0.004 (-0.05, 0.04)	0.8474
AFT	Reference	0.05 (-0.17, 0.27)	0.6514	0.03 (-0.14, 0.21)	0.6932	-0.12 (-0.27, 0.03)	0.1153	0.15 (-0.09, 0.38)	0.2096	0.01 (-0.02, 0.05)	0.4164
Other (n=230)											
	Total score<6 (n=22)	Total score=6 (n=30)		Total score=7 (n=33)		Total score=8 (n=54)		Total score>8 (n=91)		Continuous score	
	β (95% CI)†	β (95% CI)	P value	β (95% CI)	P value	β (95% CI)	P value	β (95% CI)	P value	β (95% CI)	P value
Global cognition	Reference	0.29 (-0.21, 0.79)	0.2450	0.34 (-0.04, 0.72)	0.0758	0.27 (-0.10, 0.63)	0.1435	0.14 (-0.19, 0.46)	0.3964	0.004 (-0.06, 0.07)	0.9092
DSST	Reference	0.18 (-0.23, 0.58)	0.3751	0.06 (-0.23, 0.35)	0.6801	0.10 (-0.19, 0.40)	0.4757	0.19 (-0.09, 0.47)	0.1721	0.02 (-0.02, 0.06)	0.2821
CERAD WL delayed memory	Reference	0.52 (-0.17, 1.21)	0.1353	0.64 (-0.09, 1.37)	0.0815	0.40 (-0.31, 1.11)	0.2608	0.52 (-0.25, 1.29)	0.1766	0.07 (-0.05, 0.19)	0.2361
CERAD WL immediate memory	Reference	0.22 (-0.22, 0.66)	0.3152	0.02 (-0.62, 0.65)	0.9500	0.19 (-0.29, 0.67)	0.4240	0.03 (-0.39, 0.45)	0.8975	0.01 (-0.07, 0.08)	0.8494
AFT	Reference	-0.20 (-0.89, 0.48)	0.5532	0.10 (-0.43, 0.63)	0.7047	-0.26 (-0.68, 0.16)	0.2129	**-0.51 (-0.97, -0.04)**	**0.0333**	**-0.11 (-0.17, -0.05)**	**0.0014**

*Models were adjusted for age, sex, race/ethnicity, education, other Life's Simple 7 components, coronary heart disease.

† β: beta; CI: confidence interval; DSST: the Digit Symbol Substitution Test; CERAD WL: the Consortium to establish a registry for Alzheimer's disease Word Learning subtest; AFT: the Animal Fluency test.

Table S5. The associations of numbers of ideal and poor items in Life's Simple 7 with cognitive function*.

	Per increment in ideal items		Per increment in poor items	
	β (95% CI)†	P value	β (95% CI)	P value
Global cognition	**0.07 (0.02, 0.11)**	**0.0052**	**-0.07 (-0.11, -0.04)**	**0.0001**
DSST	**0.06 (0.02, 0.10)**	**0.0069**	**-0.09 (-0.13, -0.06)**	**<0.0001**
CERAD WL delayed memory	0.04 (-0.01, 0.08)	0.1290	-0.02 (-0.06, 0.02)	0.3038
CERAD WL immediate memory	0.03 (-0.003, 0.07)	0.0681	**-0.04 (-0.08, -0.01)**	**0.0273**
Language	**0.07 (0.02, 0.11)**	**0.0041**	**-0.07 (-0.10, -0.03)**	**0.0010**

*Models were adjusted for age, sex, race/ethnicity, education, other Life's Simple 7 components, coronary heart disease.
† β: beta; CI: confidence interval; DSST: the Digit Symbol Substitution Test; CERAD WL: the Consortium to establish a registry for Alzheimer's disease Word Learning subtest; AFT: the Animal Fluency test.

Table S6. The associations of levels in behavioral factors and cognitive function among older adults ≥60 years, NHANES 2011-14*.

				Global cognition		DSST		CERAD WL delayed memory		CERAD WL immediate memory		AFT	
Diet	PA	SMK	BMI	β† (95% CI)	P value	β (95% CI)	P value	β (95% CI)	P value	β (95% CI)	P value	β (95% CI)	P value
				Reference		Reference		Reference		Reference		Reference	
				-0.53 (-1.28, 0.21)	0.1556	-0.48 (-1.06, 0.11)	0.1078	-0.06 (-1.11, 1.00)	0.9143	-0.28 (-0.78, 0.21)	0.2519	-0.23 (-0.58, 0.12)	0.1851
				0.61 (-0.19, 1.40)	0.1305	0.34 (-0.47, 1.16)	0.3971	0.41 (-0.31, 1.13)	0.2577	0.40 (-0.22, 1.02)	0.1969	**0.94 (0.24, 1.64)**	**0.0104**
				0.03 (-0.40, 0.46)	0.8935	0.08 (-0.28, 0.43)	0.6589	0.08 (-0.41, 0.57)	0.7421	-0.04 (-0.53, 0.45)	0.8626	0.23 (-0.25, 0.71)	0.3337
				0.43 (-0.01, 0.87)	0.0568	0.18 (-0.10, 0.46)	0.1953	-0.08 (-0.58, 0.43)	0.7535	0.29 (-0.25, 0.83)	0.2765	**1.10 (0.80, 1.39)**	**<0.0001**
				0.05 (-0.37, 0.47)	0.8103	0.35 (-0.24, 0.94)	0.2373	-0.22 (-0.90, 0.47)	0.5188	**0.40 (0.04, 0.76)**	**0.0326**	-0.07 (-0.75, 0.61)	0.8326
				-0.02 (-0.66, 0.62)	0.9477	0.29 (-0.37, 0.95)	0.3788	-0.19 (-0.96, 0.57)	0.6075	-0.03 (-0.75, 0.70)	0.9419	0.14 (-0.28, 0.57)	0.4975
				-0.09 (-1.24, 1.05)	0.8700	-0.09 (-1.04, 0.86)	0.8486	-0.07 (-1.09, 0.94)	0.8813	-0.12 (-0.98, 0.73)	0.7696	0.34 (-0.79, 1.46)	0.5458
				0.09 (-0.29, 0.46)	0.6415	**0.24 (0.02, 0.46)**	**0.0316**	0.004 (-0.43, 0.43)	0.9869	0.0002 (-0.48, 0.48)	0.9994	0.25 (-0.05, 0.55)	0.0983
				-0.14 (-0.48, 0.21)	0.4278	-0.13 (-0.38, 0.12)	0.2906	-0.16 (-0.70, 0.38)	0.5527	-0.09 (-0.58, 0.39)	0.7038	0.23 (-0.15, 0.61)	0.2299
				0.15 (-0.23, 0.53)	0.4343	**0.25 (0.05, 0.46)**	**0.0147**	-0.02 (-0.51, 0.47)	0.9351	-0.03 (-0.52, 0.47)	0.9098	**0.51 (0.16, 0.86)**	**0.0061**
				-0.03 (-0.37, 0.32)	0.8688	0.21 (-0.01, 0.43)	0.0662	-0.09 (-0.57, 0.38)	0.6968	-0.10 (-0.65, 0.44)	0.7021	0.14 (-0.19, 0.47)	0.4020
				0.07 (-0.46, 0.61)	0.7806	-0.23 (-0.79, 0.32)	0.4012	0.19 (-0.48, 0.86)	0.5683	0.25 (-0.29, 0.79)	0.3532	0.24 (-0.10, 0.57)	0.1564
				0.22 (-0.19, 0.63)	0.2825	**0.30 (0.10, 0.51)**	**0.0045**	0.12 (-0.38, 0.61)	0.6378	0.18 (-0.37, 0.74)	0.5059	0.30 (-0.05, 0.64)	0.0873
				-0.25 (-0.76, 0.26)	0.3330	0.21 (-0.27, 0.70)	0.3767	-0.60 (-1.43, 0.23)	0.1521	-0.32 (-0.97, 0.33)	0.3227	0.25 (-0.27, 0.76)	0.3313
				0.63 (0.16, 1.10)	**0.0106**	**0.68 (0.14, 1.23)**	**0.0154**	0.32 (-0.22, 0.86)	0.2416	0.47 (-0.33, 1.26)	0.2412	**0.72 (0.22, 1.23)**	**0.0064**
				-	-	-	-	-	-	-	-	-	-
				-0.06 (-0.44, 0.33)	0.7662	0.11 (-0.10, 0.33)	0.2946	-0.13 (-0.61, 0.35)	0.5744	-0.05 (-0.55, 0.44)	0.8265	0.15 (-0.08, 0.38)	0.1865
				0.39 (-0.42, 1.20)	0.3355	0.37 (-0.47, 1.20)	0.3776	0.004 (-0.70, 0.70)	0.9909	0.01 (-0.63, 0.66)	0.9651	**1.02 (0.23, 1.81)**	**0.0135**
				-0.56 (-0.93, -0.18)	**0.0048**	-0.11 (-0.56, 0.35)	0.6294	**-1.30 (-1.91, -0.69)**	**0.0001**	-0.19 (-0.75, 0.38)	0.5072	0.19 (-0.11, 0.48)	0.2063
				0.24 (-0.10, 0.59)	0.1570	**0.36 (0.11, 0.61)**	**0.0055**	-0.01 (-0.48, 0.45)	0.9526	-0.07 (-0.57, 0.43)	0.7678	**0.54 (0.20, 0.87)**	**0.0028**
				-0.23 (-0.65, 0.18)	0.2653	0.05 (-0.15, 0.25)	0.6241	**-0.73 (-1.21, -0.25)**	**0.0039**	-0.30 (-0.82, 0.22)	0.2474	**0.55 (0.26, 0.84)**	**0.0005**
				0.22 (-0.21, 0.64)	0.3066	**0.51 (0.25, 0.76)**	**0.0003**	0.02 (-0.56, 0.61)	0.9317	0.10 (-0.44, 0.64)	0.7105	**0.35 (0.03, 0.66)**	**0.0303**
				-0.09 (-0.57, 0.39)	0.7177	**-0.28 (-0.52, -0.04)**	**0.0230**	**-1.20 (-1.81, -0.58)**	**0.0004**	**0.84 (0.22, 1.46)**	**0.0095**	**0.58 (0.18, 0.98)**	**0.0059**
				0.29 (-0.18, 0.76)	0.2153	0.27 (-0.02, 0.55)	0.0646	0.10 (-0.43, 0.63)	0.6969	0.07 (-0.54, 0.68)	0.8125	**0.55 (0.13, 0.98)**	**0.0124**
				-0.02 (-0.54, 0.49)	0.9249	**0.42 (0.03, 0.81)**	**0.0369**	**0.54 (0.04, 1.04)**	**0.0339**	0.20 (-0.31, 0.70)	0.4357	-0.84 (-2.57, 0.88)	0.3266
				0.22 (-0.17, 0.62)	0.2633	**0.45 (0.22, 0.69)**	**0.0004**	-0.06 (-0.55, 0.42)	0.7916	-0.04 (-0.54, 0.46)	0.8833	**0.56 (0.26, 0.87)**	**0.0006**
				-0.32 (-1.14, 0.50)	0.4287	0.02 (-0.80, 0.84)	0.9683	**-0.85 (-1.37, -0.32)**	**0.0025**	-0.47 (-1.04, 0.11)	0.1095	0.57 (-0.48, 1.62)	0.2769
				0.80 (0.29, 1.32)	**0.0032**	0.05 (-0.42, 0.52)	0.8307	0.55 (-0.38, 1.48)	0.2389	0.37 (-0.29, 1.02)	0.2660	**1.77 (0.29, 3.25)**	**0.0209**
				0.63 (0.19, 1.07)	**0.0062**	**0.95 (0.36, 1.54)**	**0.0024**	0.05 (-0.73, 0.83)	0.8953	0.23 (-0.34, 0.80)	0.4148	**0.96 (0.24, 1.67)**	**0.0102**
				-0.17 (-0.71, 0.38)	0.5437	0.43 (-0.14, 1.00)	0.1308	-0.44 (-1.10, 0.23)	0.1888	-0.34 (-1.19, 0.50)	0.4172	0.16 (-0.51, 0.83)	0.6264
				-	-	-	-	-	-	-	-	-	-
				-0.62 (-1.00, -0.25)	**0.0020**	**0.63 (0.43, 0.84)**	**<0.0001**	**0.93 (0.48, 1.39)**	**0.0002**	**-3.39 (-3.93, -2.84)**	**<0.0001**	**0.32 (0.04, 0.59)**	**0.0254**
				-1.44 (-1.98, -0.90)	**<0.0001**	**-0.73 (-1.31, -0.15)**	**0.0148**	**-1.09 (-1.73, -0.45)**	**0.0016**	**-1.73 (-2.27, -1.18)**	**<0.0001**	**-0.58 (-1.05, -0.11)**	**0.0176**
				0.45 (-0.21, 1.11)	0.1736	**0.29 (0.06, 0.52)**	**0.0154**	0.44 (-0.41, 1.30)	0.2993	0.23 (-0.54, 1.00)	0.5440	0.66 (-0.32, 1.64)	0.1789
				0.12 (-0.38, 0.61)	0.6278	**0.31 (0.04, 0.59)**	**0.0282**	0.08 (-0.49, 0.65)	0.7810	-0.06 (-0.66, 0.55)	0.8522	0.23 (-0.13, 0.59)	0.2031
				-0.71 (-1.42, 0.01)	0.0526	-0.25 (-0.83, 0.33)	0.3853	-0.63 (-1.48, 0.22)	0.1428	-0.50 (-1.29, 0.29)	0.2061	-0.49 (-1.20, 0.22)	0.1721
				0.25	0.1587	**0.62**	**0.0002**	-0.10	0.6851	-0.03	0.9136	**0.50**	**0.0121**

Yellow	Green	Green	Red	(-0.10, 0.60)		**(0.32, 0.93)**		(-0.58, 0.39)		(-0.49, 0.44)		**(0.12, 0.88)**	
Yellow	Red	Green	Green	-0.14 (-0.49, 0.21)	0.4213	-0.0002 (-0.32, 0.32)	0.9991	-0.20 (-0.65, 0.26)	0.3859	-0.14 (-0.50, 0.22)	0.4247	0.18 (-0.14, 0.51)	0.2633
Yellow	Green	Red	Green	0.42 (-0.17, 1.02)	0.1555	-0.02 (-0.99, 0.94)	0.9601	**0.76 (0.13, 1.39)**	**0.0193**	0.21 (-0.34, 0.77)	0.4377	**0.57 (0.23, 0.92)**	**0.0018**
Yellow	Yellow	Green	Red	0.03 (-0.38, 0.43)	0.8985	0.22 (-0.23, 0.67)	0.3300	-0.07 (-0.51, 0.37)	0.7452	-0.02 (-0.60, 0.55)	0.9368	**0.28 (0.004, 0.55)**	**0.0467**
Yellow	Red	Yellow	Green	**0.87 (0.46, 1.28)**	**0.0002**	**1.68 (1.44, 1.93)**	**<0.0001**	**0.73 (0.16, 1.31)**	**0.0141**	-0.35 (-0.91, 0.20)	0.2008	**0.92 (0.58, 1.25)**	**<0.0001**
Yellow	Yellow	Red	Green	0.40 (-0.05, 0.84)	0.0768	**1.14 (0.13, 2.15)**	**0.0285**	-0.26 (-0.88, 0.36)	0.4005	0.11 (-0.49, 0.71)	0.7025	**0.55 (0.08, 1.01)**	**0.0228**
Yellow	Green	Yellow	Red	-	-	-	-	-	-	-	-	-	-
Yellow	Red	Green	Yellow	0.12 (-0.38, 0.62)	0.6302	**0.32 (0.05, 0.58)**	**0.0206**	-0.07 (-0.69, 0.54)	0.8123	0.01 (-0.60, 0.62)	0.9713	0.12 (-0.30, 0.53)	0.5625
Yellow	Green	Red	Yellow	0.42 (-0.02, 0.85)	0.0591	0.29 (-0.09, 0.67)	0.1294	0.50 (-0.31, 1.31)	0.2194	0.28 (-0.33, 0.89)	0.3576	**0.44 (0.06, 0.83)**	**0.0254**
Yellow	Yellow	Yellow	Yellow	-0.17 (-0.56, 0.21)	0.3631	0.22 (-0.02, 0.45)	0.0737	-0.40 (-0.91, 0.10)	0.1134	**-1.35 (-1.84, -0.86)**	**<0.0001**	**1.27 (0.90, 1.64)**	**<0.0001**
Yellow	Green	Green	Green	0.40 (-0.03, 0.84)	0.0688	**0.41 (0.14, 0.68)**	**0.0039**	0.25 (-0.32, 0.81)	0.3795	0.44 (-0.17, 1.05)	0.1483	**0.39 (0.11, 0.67)**	**0.0081**
Yellow	Green	Yellow	Yellow	-	-	-	-	-	-	-	-	-	-
Yellow	Yellow	Green	Yellow	0.23 (-0.36, 0.82)	0.4297	**0.41 (0.05, 0.78)**	**0.0263**	0.02 (-0.63, 0.67)	0.9557	0.28 (-0.36, 0.91)	0.3799	-0.06 (-0.56, 0.45)	0.8177
Yellow	Yellow	Yellow	Green	-	-	-	-	-	-	-	-	-	-
Yellow	Yellow	Green	Green	-0.05 (-0.69, 0.59)	0.8740	0.004 (-0.45, 0.46)	0.9844	-0.27 (-0.95, 0.40)	0.4152	0.03 (-0.72, 0.78)	0.9313	0.32 (-0.05, 0.70)	0.0905
Yellow	Green	Yellow	Green	-	-	-	-	-	-	-	-	-	-
Yellow	Green	Green	Yellow	0.18 (-0.17, 0.54)	0.3069	**0.46 (0.17, 0.75)**	**0.0029**	-0.01 (-0.39, 0.37)	0.9598	0.02 (-0.51, 0.55)	0.9334	0.31 (-0.04, 0.67)	0.0825
Green	Red	Red	Red	-	-	-	-	-	-	-	-	-	-
Green	Yellow	Red	Red	-	-	-	-	-	-	-	-	-	-
Green	Red	Yellow	Red	-	-	-	-	-	-	-	-	-	-
Green	Red	Red	Yellow	-	-	-	-	-	-	-	-	-	-
Green	Yellow	Yellow	Red	-	-	-	-	-	-	-	-	-	-
Green	Red	Yellow	Yellow	-	-	-	-	-	-	-	-	-	-
Green	Yellow	Red	Yellow	-	-	-	-	-	-	-	-	-	-
Green	Green	Red	Red	-	-	-	-	-	-	-	-	-	-
Green	Red	Green	Red	-0.86 (-1.76, 0.04)	0.0591	-0.19 (-0.55, 0.16)	0.2782	-0.44 (-1.92, 1.05)	0.5550	-1.17 (-2.74, 0.39)	0.1371	**-0.53 (-0.94, -0.12)**	**0.0131**
Green	Red	Red	Green	-	-	-	-	-	-	-	-	-	-
Green	Green	Green	Red	-	-	**0.76 (0.50, 1.02)**	**<0.0001**	**0.82 (0.32, 1.33)**	**0.0023**	-	-	**1.61 (1.31, 1.90)**	**<0.0001**
Green	Red	Green	Green	-0.07 (-0.54, 0.40)	0.7572	**0.72 (0.37, 1.07)**	**0.0002**	-0.07 (-0.54, 0.40)	0.7672	-0.02 (-0.65, 0.61)	0.9386	-0.57 (-1.18, 0.04)	0.0650
Green	Green	Red	Green	-	-	-	-	-	-	-	-	-	-
Green	Yellow	Green	Red	**0.65 (0.24, 1.07)**	**0.0032**	-0.07 (-0.27, 0.12)	0.4535	0.16 (-0.32, 0.64)	0.4918	-0.05 (-0.57, 0.48)	0.8526	**2.22 (1.93, 2.51)**	**<0.0001**
Green	Red	Yellow	Green	-	-	-	-	-	-	-	-	-	-
Green	Yellow	Red	Green	-	-	-	-	-	-	-	-	-	-
Green	Green	Yellow	Red	-	-	-	-	-	-	-	-	-	-
Green	Red	Green	Yellow	-	-	-	-	-	-	-	-	-	-
Green	Green	Red	Yellow	-	-	-	-	-	-	-	-	-	-
Green	Yellow	Yellow	Yellow	-	-	-	-	-	-	-	-	-	-
Green	Green	Green	Green	0.38 (-0.18, 0.94)	0.1767	**1.06 (0.64, 1.47)**	**<0.0001**	0.39 (-0.75, 1.52)	0.4920	0.11 (-1.93, 1.26)	0.8420	-0.13 (-1.75, 1.49)	0.8702
Green	Green	Yellow	Yellow	-	-	-	-	-	-	-	-	-	-
Green	Yellow	Green	Yellow	**0.57 (0.14, 1.00)**	**0.0117**	**0.83 (0.60, 1.07)**	**<0.0001**	0.01 (-0.54, 0.56)	0.9744	0.33 (-0.27, 0.94)	0.2708	**0.84 (0.54, 1.13)**	**<0.0001**
Green	Yellow	Yellow	Green	-	-	-	-	-	-	-	-	-	-
Green	Yellow	Green	Green	-	-	-	-	-	-	-	-	-	-
Green	Green	Yellow	Green	-	-	-	-	-	-	-	-	-	-
Green	Green	Green	Yellow	**-0.49 (-0.85, -0.12)**	**0.0111**	0.06 (-0.16, 0.28)	0.5699	-0.15 (-0.59, 0.28)	0.4801	**-0.64 (-1.12, -0.15)**	**0.0115**	**-0.38 (-0.67, -0.10)**	**0.0098**

Red: poor; yellow: intermediate; green: ideal.

*Models were adjusted for age, sex, race/ethnicity, education, other Life's Simple 7 components, coronary heart disease.
† β: beta; CI: confidence interval; PA: physical activity; SMK: smoking; BMI: body mass index; DSST: the Digit Symbol Substitution Test; CERAD WL: the Consortium to establish a registry for Alzheimer's disease Word Learning subtest; AFT: the Animal Fluency test.

Table S7. The associations of levels in biological factors and cognitive function among older adults ≥60 years, NHANES 2011-14*.

			Global cognition		DSST		CERAD WL delayed memory		CERAD WL immediate memory		AFT	
BP	FPG	TC	β† (95% CI)	P value	β (95% CI)	P value	β (95% CI)	P value	β (95% CI)	P value	β (95% CI)	P value
Red	Red	Red	Reference		Reference		Reference		Reference		Reference	
Red	Red	Yellow	0.13 (-0.28, 0.53)	0.5219	0.37 (-0.42, 1.17)	0.3449	-0.24 (-0.64, 0.17)	0.2435	0.18 (-0.45, 0.81)	0.5649	-0.10 (-1.35, 1.15)	0.8707
Red	Yellow	Red	0.38 (-0.004, 0.77)	0.0522	0.48 (-0.44, 1.40)	0.2915	0.16 (-0.19, 0.51)	0.3622	**0.60 (0.04, 1.16)**	**0.0368**	-0.05 (-1.25, 1.16)	0.9387
Red	Yellow	Yellow	0.08 (-0.29, 0.45)	0.6538	0.30 (-0.62, 1.22)	0.5089	-0.20 (-0.57, 0.16)	0.2628	0.16 (-0.43, 0.76)	0.5773	-0.08 (-1.25, 1.08)	0.8847
Red	Red	Green	0.02 (-0.47, 0.52)	0.9240	0.29 (-0.74, 1.32)	0.5701	0.004 (-0.57, 0.57)	0.9892	0.20 (-0.45, 0.85)	0.5372	-0.42 (-1.65, 0.81)	0.4889
Red	Green	Red	0.24 (-0.18, 0.66)	0.2465	0.48 (-0.41, 1.36)	0.2807	-0.15 (-0.56, 0.26)	0.4607	0.26 (-0.34, 0.86)	0.3883	0.16 (-1.04, 1.35)	0.7936
Red	Green	Green	0.08 (-0.27, 0.43)	0.6445	0.42 (-0.47, 1.31)	0.3399	-0.17 (-0.61, 0.28)	0.4492	0.17 (-0.34, 0.68)	0.5033	-0.19 (-1.32, 0.95)	0.7403
Red	Yellow	Green	0.41 (-0.02, 0.85)	0.0630	0.61 (-0.30, 1.51)	0.1822	-0.03 (-0.49, 0.43)	0.8882	0.42 (-0.32, 1.17)	0.2511	0.28 (-0.97, 1.54)	0.6471
Red	Green	Yellow	0.20 (-0.11, 0.52)	0.1954	0.54 (-0.26, 1.35)	0.1762	-0.20 (-0.51, 0.11)	0.1973	0.13 (-0.41, 0.66)	0.6274	-0.003 (-1.21, 1.20)	0.9954
Yellow	Red	Red	0.23 (-0.35, 0.81)	0.4281	0.21 (-0.34, 0.77)	0.4371	-0.41 (-0.82, 0.01)	0.0530	**0.75 (0.22, 1.29)**	**0.0073**	0.14 (-1.16, 1.44)	0.8306
Yellow	Red	Yellow	0.07 (-0.34, 0.47)	0.7418	0.29 (-0.51, 1.09)	0.4628	-0.21 (-0.67, 0.25)	0.3656	0.21 (-0.39, 0.82)	0.4774	-0.11 (-1.33, 1.12)	0.8602
Yellow	Yellow	Red	0.01 (-0.55, 0.57)	0.9716	0.38 (-0.59, 1.36)	0.4305	-0.36 (-0.85, 0.12)	0.1348	0.16 (-0.42, 0.73)	0.5838	-0.14 (-1.39, 1.11)	0.8204
Yellow	Yellow	Yellow	0.27 (-0.07, 0.61)	0.1173	0.48 (-0.35, 1.31)	0.2474	-0.06 (-0.37, 0.26)	0.7232	0.30 (-0.26, 0.87)	0.2853	0.07 (-1.08, 1.22)	0.9017
Yellow	Red	Green	**0.34 (0.05, 0.63)**	**0.0217**	0.50 (-0.52, 1.52)	0.3240	0.14 (-0.35, 0.64)	0.5560	0.67 (-0.08, 1.42)	0.0785	-0.19 (-1.25, 0.88)	0.7233
Yellow	Green	Red	**0.46 (0.13, 0.79)**	**0.0077**	0.63 (-0.29, 1.55)	0.1739	0.07 (-0.37, 0.50)	0.7524	0.44 (-0.03, 0.90)	0.0645	0.24 (-0.88, 1.36)	0.6635
Yellow	Green	Green	**0.34 (0.04, 0.64)**	**0.0263**	0.54 (-0.36, 1.45)	0.2317	0.07 (-0.26, 0.40)	0.6785	0.37 (-0.18, 0.91)	0.1793	0.04 (-1.13, 1.20)	0.9479
Yellow	Yellow	Green	0.37 (-0.02, 0.77)	0.0646	0.56 (-0.34, 1.45)	0.2171	-0.02 (-0.37, 0.32)	0.8893	0.45 (-0.17, 1.08)	0.1492	0.10 (-1.15, 1.34)	0.8759
Yellow	Green	Yellow	0.27 (-0.02, 0.56)	0.0700	0.57 (-0.27, 1.42)	0.1788	-0.14 (-0.43, 0.16)	0.3592	0.30 (-0.22, 0.81)	0.2489	0.02 (-1.15, 1.19)	0.9747
Green	Red	Red	**0.75 (0.16, 1.33)**	**0.0137**	0.85 (-0.04, 1.74)	0.0615	0.52 (-0.59, 1.63)	0.3493	0.83 (-0.05, 1.71)	0.0623	0.17 (-1.26, 1.59)	0.8150
Green	Red	Yellow	0.15 (-0.69, 0.99)	0.7257	0.28 (-0.53, 1.09)	0.4894	-0.17 (-0.81, 0.47)	0.5926	0.46 (-0.37, 1.30)	0.2676	-0.13 (-1.75, 1.50)	0.8759
Green	Yellow	Red	**0.83 (0.43, 1.24)**	**0.0002**	**1.03 (0.07, 2.00)**	**0.0364**	0.38 (-0.07, 0.84)	0.0982	**0.81 (0.25, 1.37)**	**0.0060**	0.30 (-1.01, 1.62)	0.6419
Green	Yellow	Yellow	0.26 (-0.06, 0.58)	0.1017	0.66 (-0.24, 1.56)	0.1449	-0.06 (-0.44, 0.32)	0.7489	0.26 (-0.24, 1.37)	0.2931	-0.07 (-1.30, 1.16)	0.9088
Green	Red	Green	0.19 (-0.12, 0.51)	0.2217	-0.46 (-1.40, 0.47)	0.3214	-0.05 (-0.50, 0.40)	0.8239	0.30 (-0.31, 0.91)	0.3278	0.51 (-0.71, 1.72)	0.4011
Green	Green	Red	0.31 (-0.08, 0.71)	0.1185	0.55 (-0.48, 1.58)	0.2841	-0.01 (-0.44, 0.42)	0.9591	0.36 (-0.10, 0.83)	0.1213	0.06 (-1.08, 1.21)	0.9088
Green	Green	Green	**0.40 (0.04, 0.76)**	**0.0296**	0.43 (-0.42, 1.27)	0.3125	0.07 (-0.23, 0.37)	0.6453	0.50 (-0.08, 1.09)	0.0888	0.20 (-0.99, 1.38)	0.7386
Green	Yellow	Green	-0.02 (-0.45, 0.40)	0.9232	0.30 (-0.61, 1.21)	0.5067	-0.42 (-0.89, 0.06)	0.0813	0.25 (-0.46, 0.96)	0.4767	-0.19 (-1.37, 0.99)	0.7453
Green	Green	Yellow	**0.46 (0.12, 0.81)**	**0.0105**	0.72 (-0.13, 1.56)	0.0945	-0.01 (-0.33, 0.31)	0.9453	0.44 (-0.07, 0.95)	0.0909	0.25 (-0.99, 1.49)	0.6828

Red: poor; yellow: intermediate; green: ideal.

*Models were adjusted for age, sex, race/ethnicity, education, other Life's Simple 7 components, coronary heart disease.
† β: beta; CI: confidence interval; PA: physical activity; SMK: smoking; BMI: body mass index; DSST: the Digit Symbol Substitution Test; CERAD WL: the Consortium to establish a registry for Alzheimer's disease Word Learning subtest; AFT: the Animal Fluency test.

Figure S1. Prevalence of number of components in ideal or poor levels among U.S. older adults ≥60 years, NHANES 2011-14.