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Dairy food intake and cardiovascular health: The Maine-Syracuse Longitudinal Study

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Higher Cognitive Performance Is Prospectively Associated with Healthy Dietary Choices: The Maine Syracuse Longitudinal Study

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Abstract

OBJECTIVES—Few studies have examined whether cognitive function predicts dietary intake. The majority of research has focused on how diet can influence cognitive performance or risk for cognitive impairment in later life. The aim of this study was to examine prospective relationships between cognitive performance and dietary intake in participants of the Maine-Syracuse Longitudinal Study.

DESIGN—A prospective study with neuropsychological testing at baseline and nutritional assessments measured a mean of 18 years later.

SETTING—Community-dwelling individuals residing in central New York state.

PARTICIPANTS—333 participants free of dementia and stroke.

MEASUREMENTS—The Wechsler Adult Intelligence Scale (WAIS) was assessed at baseline and dietary intake was measured using the Nutrition and Health Questionnaire.

RESULTS—Higher WAIS Scores at baseline were prospectively associated with higher intakes of vegetables, meats, nuts and legumes, and fish, but inversely associated with consumption of total grains and carbonated soft drinks. After adjustment for sample selection, socioeconomic indicators, lifestyle factors (smoking and physical activity), and cardiovascular risk factors, the

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relations between higher cognitive performance and greater consumption of vegetables, meat, and fish, and lower consumption of grains remained significant.

CONCLUSION—These data suggest that cognition early in life may influence dietary choices later in life.

Keywords

Cognitive function; dietary choice; Maine-Syracuse Longitudinal Study; prospective

Introduction

Alarge body of research has demonstrated associations between diet and cognitive performance in later years. Observational studies have shown associations between different dietary patterns, including a 'healthy or prudent' diet (1-3), a 'Mediterranean diet' (4-8), a 'Western' diet (1, 9, 10), and cognitive function or dementia. Other research has shown associations between specific food items and cognitive performance, with recent attention on fatty acids and fish (11, 12), dairy products (13, 14), antioxidants (15), and alcohol (16).

Studies assessing relations between cognition and diet have generally foccused on diet as a predictor of cognitive status in later life. We are aware of only one study, conducted in children, that has specifically examined relations in the reverse direction, i.e., this study investigated whether cognitive performance predicted dietary intakes in older age. The 1970 British Cohort Study showed that children with higher mental (cognitive) ability scores at age 10 reported significantly more frequent consumption of fruit, vegetables, wholemeal bread, fish and foods fried in vegetable oil in adulthood (age 30 years) (17). These children also had less frequent intakes of fries, nonwholemeal bread, cakes and biscuits in adulthood. These associations were particularly evident for verbal abilities, and remained after statistical adjustment for social class, education, and income.

The main objective of the present study was therefore to examine whether cognitive performance predicts intakes of particular food and beverage items, using a prospective design in which cognitive functioning early in life is employed to predict nutritional choices later in life. Because we are are interested in examining associations between cognitive performance and diet in people free from severe or residual cognitive impairment, persons with dementia (and stroke) were excluded in the present study. While dementia is of ultimate major concern, the dementing process can itself effect performance; therefore there is a current trend to move backward in time and examine cognitive performance prior to dementia (18).

Single food items were used in this study, rather than dietary patterns, as this strategy allows for simple interpretation and ease of communicating diet messages to the general public, and people from different nationalities may not adhere to specific, pre-established patterns. We hypothesized that higher cognitive performance at baseline (earlier in the adult lifespan) would be associated with higher intakes of 'healthy' foods, and lower intakes of 'unhealthy' foods later in life. We expected that these associations may be attenuated with the addition of socioeconomic indicators to the model, but that significant associations would remain.

Participants and methods

Participants

Subjects were community-dwelling participants of the Maine Syracuse Longitudinal Study (MSLS), recruited from central New York for studies of blood pressure, related risk factors, and cognitive performance, excluding from recruitment persons with diagnosed alcoholism or psychiatric disorder, were institutionalized or with an inability to speak English. Details of initial study recruitment have been previously described (19-22). Community-living individuals were recruited for studies of blood pressure and aging by various forms of public announcements including various news media, and postings both in public places and hospitals and clinics. Persons of all adult ages and blood pressure levels were permitted to participate. There were four waves of entry into the study for a baseline assessment, conducted between 1974 and 2000. Stroke and probable dementia were exclusion criteria at each study wave (details later). Participants for the present study (n=333) were those who completed a baseline assessment (waves 1 to 4), and returned for the sixth study wave (2001-2006) where dietary intakes were measured for the first time (21, 22). This allowed for a prospective design in which cognitive function at baseline (waves 1-4) were used to predict diet at wave 6. The nutrition assessment was conducted a mean of 18.0 (±5.3) years later after data on the original Wechsler Adult Intelligence Scale (WAIS) (23) cognitive data were obtained. In the MSLS, new subjects are added at each wave of the study and thus baseline data (examination 1 for each subject) were collected at waves 1 to 4 on the WAIS. Baseline assessments for each cohort were conducted within the following time frames: cohort 1: 1974-1981, cohort 2: 1978-1985, cohort 3: 1982-2000, and cohort 4: 1988-2000. The age range of participants within cohorts at baseline was similar: cohort 1: 17-89 years, cohort 2: 17-88 years; cohort 3: 17-91 years, and cohort 4: 17-93 years. The original WAIS was not administered after wave 4. Data were collected on a broad array of cardiovascular risk factors, as well as dietary intake, at wave 6.

At baseline (wave 1, 2, 3, or 4), 1161 participants completed the WAIS. The mean (and range) of non-age corrected Total WAIS score at baseline was 127.4 (range: 29.0 - 181.0). The range of scores was well within normal levels of performance. Between the baseline assessments and follow-up at wave 6, 792 (68.2%) subjects were lost to the study. Of the 369 study participants that returned, 36 were excluded for the following reasons: history of acute stroke (n=15), probable dementia (n=4), and missing dietary data (n=17), leaving 333 participants included in this prospective analyses.

Acute stroke was defined as a focal neurological deficit persisting for >24 hours and probable dementia was defined by cognitive measures, medical records and a multidisciplinary dementia review using the National Institute of Neurological Diseases and Communicative Diseases and Stroke/ Alzheimer's Disease and Related Disorders (NINCDS-ADRDA) criteria (24) and following the dementia review protocol in the Framingham Heart Study (25). The University of Maine Institutional Review Board approved this study and informed consent was obtained from all participants.

Predictor variables: cognitive function

Following the baseline medical interview (first examination at waves 1-4), the WAIS test was given by a psychologist or psychological examiner specifically trained in administration of the original WAIS protocol (23). As we are concerned with WAIS-defined intellect, non-age corrected scaled scores, rather than IQ scores, were employed as cognitive outcome measures (23), which also allowed for age to be included in the covariance models and avoided over-adjustment for age. Therefore, the orginal index variables for the WAIS were used: total WAIS score, Verbal subscale score and Performance subscale score. The following sub-tests of the WAIS are included in the Verbal and Performance scores respectively (23): Verbal - Information, Vocabulary, Comprehension, Arithmetic, Digit Span, Similarities; and Performance - Picture Completion, Object Assembly, Block Design, Picture Arrangement, Digit Symbol Substitution. Examiners were blind to the study outcomes as the dietary data were collected many years after these initial WAIS examinations.

Dependent variables: diet

Dietary intake was based on self-report from the Nutrition and Health Questionnaire (26-28), and includes questions about diet, smoking, physical activity, medical history, self-reported health, and medication use. The questionnaire has been used in a large investigation of cancer and nutrition and its acceptable validity has been demonstrated by comparison with dietary recall, protein excretion and total energy expenditure data (26). The dietary component questions participants about their frequency of consumption of 37 foods and beverages. Participants are required to stipulate their frequency of consumption, with six response options: never, seldom, once per week, 2-3 times per week, 5-6 times per week or once or more per day. The median value within each response option was used to estimate total intakes per week; for example, 5-6 times per week was estimated at 5.5. As portion or serving sizes were not stipulated, these totals are an estimate of the number of times each food was consumed weekly. Individual foods were categorized into several major food groups - grains (white bread, wholemeal bread, rice, pasta, crackers, cereal, rolls), vegetables (fresh and raw vegetables), meat (red and white, including chicken), fish (tinned and cooked), nuts and legumes (all nuts, lentils, peas, beans), fruit (fresh, dried, stewed), dairy foods (milk, cheese plus yogurt), and added sugars (cake, chocolate, pies and puddings, sweets, jam). Weekly intakes of each group, as continuous variables, were used as the dependent variables. A number of individual foods and beverages were also examined: white bread, eggs, pizza, fries carbonated soft drinks, and alcohol. As there were a large number of non-consumers for some food items (e.g., carbonated soft drinks), these variables were dichotomized into consumer or non-consumer.

Additional predictor variables. Additional covariables were age (years at follow-up), gender, education (years), income (annual income in four categories), ethnicity, Centre for Epidemiologic Studies Depression Scale (CES-D; raw score), smoking (cigarettes/day), physical activity (MET minutes/week), body mass index (BMI, kg/m2), C-reactive protein (CRP, mg/L), folic acid (ng/dL), systolic blood pressure (SBP, mm Hg), and diastolic blood pressure (DBP, mm Hg).

Statistical analysis

Preliminary—According to the type of variable (continuous or categorical), independent samples t-tests and Chi-square tests were used to compare baseline demographic variables and WAIS scores, in those who completed a baseline assessment but did not return to wave 6 for the nutrition study, with those who participated though wave 6. Cognitive scores were normally distributed.

Adjustment for attrition and primary analyses. Due to the large amount of attrition between the baseline cognitive assessment and follow-up, the Heckman, two-stage estimation method to correct for this bias from attrition was used (29). This was based on the full sample of 1161 persons with complete baseline cognition data. For continuous outcome variables, Heckman models were estimated using simultaneous equations (model and nonresponse) via maximum likelihood. For binary outcomes, we estimated logistic regression models using a two-stage procedure, first calculating probability of non-response via probit models, and then including inverse Mills ratio when estimating models of substantive interest. Several models of nonresponse were evaluated building from bivariate differences between responders and nonresponders. Baseline variables were used to adjust for the probability of non-response (i.e., selection). The final selection model included baseline WAIS total scores, baseline age, and baseline SBP.

For the main analyses of the prospective study, multiple linear regression analyses were performed for each combination of predictor (WAIS total, Verbal and Performance scores) and dependent variable (weekly intakes of food items, continuous variables). Logistic regression analyses were performed for those food items which were dichotomized (white bread, pizza, fries, carbonated soft drinks).

Three regression covariate sets were used for all analyses. Due to the strong associations demonstrated in past research between socioeconomic factors, including education and income, with both cognitive performance and diet (1, 4, 10, 30, 31), education and income were added to the second regression covariate set. Variables measured at wave 6 that correlated significantly with both the predictor (total WAIS at baseline) and diet (weekly intakes at wave 6), were included in the third covariate set. As these covariates were measured at follow-up, the models essentially adjust for both sets of variables (i.e., from baseline and follow-up). The covariate sets were as follows:

Covariate set 1 - Basic: age, gender

Covariate set 2 - Socioeconomic: age, gender, education, income

Covariate set 3 - Cardiovascular/lifestyle: age, gender, education, income, ethnicity, CES-D, smoking, physical activity, BMI, CRP, folic acid, SBP, and DBP.

Sensitivity analyses. Interaction terms between the primary cognitive measure (WAIS total) with both age (continuously distributed) and gender were tested for associations with intakes of the six major food groups and alcohol. Sensitivity analyses were performed excluding those with a reported history of cardiovascular disease (21.6% of total sample) or type 2 diabetes (17.1% of total sample). These participants may have altered their eating habits in response to their diagnosis. As some investigators prefer to express WAIS scores as percent correct scores so as to retain sensitivity to individual scores lost with scaling, we also repeated the analyses using these scores.

All statistical analyses were performed with PASW for Windows® version 21.0 software (formerly SPSS Statistics Inc. Chicago, Illinois). P <0.05 was considered statistically significant.

Results

Preliminary

A comparison of those who completed the study (n=333) with those who were lost to follow-up (n=828) was conducted prior to the Heckman adjustment for attrition, and is shown in Supplementary Table 1 (See online http://www.jpreventionalzheimer.com/all-issues.html?article=77). Of the 828 who do not return, 211 (25.5%) died before the follow-up examination at wave 6. The differences among the demographic variables for those who returned and those who did not were small and both groups were well educated. Those who remained in the study had higher total WAIS, Verbal and Performance scores (all P <0.001).

Participant characteristics and dietary intakes, prospective study

Table 1 shows the cardiovascular health and lifestyle characteristics, and dietary intakes at wave 6 for the 333 participants included in the prospective study. Mean (±SD) age at baseline was 42.4 (±13.3) years, and at follow-up was 60.5 (±12.8) years. The mean number of education years at baseline was 14.6 (±2.5) years, compared to 14.9 (±2.8) years at follow-up. Cognition scores (±SD) at baseline were as follows: total WAIS Verbal subscale: 75.0 ± 12.8, and Performance subscale: 57.6 ± 10.2. These equate to IQ scores of 120 and 112 respectively. IQ scores were not used as we modeled age and other covariates based on our own sample. In clinical practice, IQ scores below 69 on the original WAIS are in the 'mentally defective' range, and between 70 and 79 are 'borderline'. No participants scored at these levels of IQ, and less than 1% (0.9%) scored in the 'dull normal' range (80-89). These terms are no longer used in more recent versions of the WAIS or in clinical practice.

Table 2 shows the mean intakes for each of the main food groups, soft drinks and alcohol, at wave 6.

Major findings with Heckman adjustment

Overall, higher cognitive ability scores were associated with more frequent consumption of foods considered to be healthy, 18 years later (Table 3). In age- and gender-adjusted analyses, participants with higher total cognitive and subscale scores consumed significantly more vegetables, meats, and nuts and legumes (all P <0.05). For example, a ten point difference in a total WAIS score was associated with an increased vegetable intake of 1.5 serves per week. Higher cognitive scores were associated with lower consumption of total grains (P = 0.003). Those who performed better on the Verbal subscale were less likely to consume carbonated soft drinks (P <0.05).

These relationships were generally attenuated after the addition of education and income to the regression covariate set (correlation of education with WAIS total: r = 0.52, P <0.001).

Statistical significance was retained in the second covariate set (socioeconomic) for positive relations between cognitive performance and intakes of vegetables and meats (P <0.0001 for total WAIS and Verbal subscale for both), and for inverse relations beween cognitive performance and intakes of grains (P <0.05 for total WAIS and Performance subscale), but lost for other foods.

With the addition of cardiovascular and lifestyle variables (covariate set 3), higher cognitive performance (total WAIS and Verbal subscale) remained as significant predictors of vegetable and meat intakes (all P <0.001). In addition, positive associations were observed between total WAIS and Performance subscale scores and intakes of fish (both P <0.01). Lower cognitive scores (total WAIS and Performance subscale) remained significantly associated with higher intakes of grains (both P <0.05).

Cognitive performance was not prospectively associated with intakes of white bread, fruit, dairy foods, eggs, added sugars, pizza, fries, or alcohol (data not shown).

Sensitivity analyses

Neither the WAIS*age or WAIS*gender interaction terms were significantly associated with food intakes, with age and gender controlled (all P >0.05). Prospective associations between cognitive performance and diet were largely unchanged when excluding those with a reported history of cardiovascular disease or type 2 diabetes. We also found the same pattern of results when percent correct scores for the WAIS were used (data not shown).

Discussion

Unlike previous studies of cognition and diet, in this study we have examined whether cognitive function in middle age is prospectively associated with dietary choices up to 20 years later. In age- and gender-adjusted analyses, better global cognitive performance was prospectively associated with higher intakes of healthy foods, namely vegetables, meats, nuts and legumes, and fish. Those with higher cognitive scores ate fewer grains and were less likely to consume carbonated soft drinks. With the addition of socioeconomic indicators (education and income), lifestyle and cardiovascular risk factors, higher cognitive scores remained significant predictors of higher vegetable, meat and fish intakes, and lower intakes of grains.

The findings are consistent with those of Batty and colleagues, who have demonstrated the predictive role that cognitive ability in childhood plays with a number of health outcomes and behaviors in adulthood in the 1970 British Cohort Study (17, 32, 33). Of most relevance to the present study, children with higher cognitive ability scores at age 10 reported significantly more frequent consumption of fruit, vegetables, wholemeal bread, and fish in adulthood (17). We have shown that those with higher cognitive scores in adulthood also consumed vegetables and fish more frequently up to nearly 20 years later. These results suggest that the association between diet and cognition may not be unidirectional in the sense that diet necessarily predicts cognitive function, but may be bidirectional with cognitive functioning early in life influencing food choices later in life. In support, obesity research has indicated that cognitive function may drive obesity, albeit obesity may have an adverse impact on cognition (18).

Our findings also support those from the Lothian Birth Cohort (4). Although this study examined dietary patterns in relation to cognitive performance in older age, the results suggested a pattern of reverse association - that higher cognitive ability in childhood (and adult socioeconomic status) predicts adherence to a ‘healthy’ diet and better cognitive performance in old age. More specifically, a Mediterranean style dietary pattern (rich in fruits, vegetables, fish, nuts, legumes, wine, and olive oil) was significantly associated with higher scores on all cognitive domains at 70 years (processing speed, memory, verbal ability, general cognitive ability), while following a more ‘traditional’ pattern was associated with poorer cognition on all tested domains (4). The attenuation of most of these associations with the addition of general intelligence at age 11 and occupational social class led the researchers to conclude that cognition in childhood may be impacting upon diet. Similarly, negative associations between a ‘traditional’ dietary pattern (more tinned vegetables, bottle sauces, savoury pastries, potatoes, puddings, less coffee) and cognitive abilities were attenuated with the same adjustments in the Lothian Birth Cohort. In addition to overall diet patterns, general intelligence in childhood has attenuated associations between higher intakes of fruit, antioxidants and B vitamins, and caffeine and better cognitive performance scores in Lothian Birth Cohort studies (34-36).

Other studies examining relationships between diet quality or diet patterns and cognition in later years, have also shown that socioeconomic variables, including education and family income, account for a large amount of variance in diet-cognition associations (30, 37). Education has been shown to attenuate observed associations between a healthy or whole food dietary pattern and decreased odds of cognitive deficit in the Whitehall II study (30). Similarly, associations between a ‘processed food’ pattern and increased odds of cognitive impairment were attenuated with additional adjustment for education in this study.

The influence of socioeconomic status, including income and education, on diet quality are well documented (31, 38). Age, education, and income are major determinants of diet quality in Americans (31). Low education and/or income may be associated with poorer diet and health related knowledge, the purchase of foods that are cheaper, an increased risk for obesity, and poorer health behaviors in addition to diet (e.g., smoking, less physical activity) (39-41). In agreement, higher intellect at age 5 or 10, as well as cognitive performance in adulthood have been associated with reduced prevalence of current smoking, overweight and obesity, hypertension, and with higher levels of physical activity (33, 42). However, socioeconomic status may not always match dietary choices and the quality of the diet. Individuals with low diet quality can also have a high socioeconomic status, just as those of lower socioeconomic status can achieve adequate intakes of healthy foods (10, 43). In addition to socioeconomic factors, there are a multitude of other factors which may impact upon the consumption of healthy foods such as fruit and vegetables, including a perceived lack of time for preparation, the early home food environment, dieting status, and perceived availability and affordability (43-45). Further, these factors, such as the perceived availability and quality of healthy foods may influence the perceived cost, irrespective of education level and actual income, therefore suggesting that affordability is not solely driven by financial resources (45). Other research has shown that income may not have the same impact upon diet quality in older adults as it does in young and middle-aged adults (31). This finding may also be relevant to the present study (mean age of 60.5 years at the time of dietary assessment), as vegetables were the only food group in which intake was positively associated with income. Intakes of fruit, meat, fish, nuts and legumes, or grains were unrelated to income, and neither were 'fast foods' such as pizza, fries, carbonated soft drinks or sweets. As such, we controlled for income and education in the present study, but extensive analyses regarding mediating or moderating effects was not the purpose of this study. It is also important to note that approximately 75% of MSLS participants reported an annual income above the poverty line (at least $30 000 US) and thus poverty was not likely to have played a role in food choices over the years intervening between baseline and evaluation of nutritional choices. Lower income paricipants at baseline were students who subsequently continued on to professional and skilled-clerical occupatios.

A significant time period between baseline and follow-up is a desirable feature of prospective studies from an epidemiological perspective but questions can always be raised as to events during the interum between baseline and follow-up. Each cohort similarly contained participants across the adult age range, despite commencing at different times (between 1974 and 2000) for the baseline assessment. The WAIS Performance tests were designed to be independent of secular influences and we see that the Performance tests as well as the Verbal are related to the outcomes. We did not follow major life events but it is very clear that hypertension and all hypertension-related complications were well-managed during the interum period of the study. Moreover, random events would act in favor of the null hypothesis over this time period and we still observed relationships between baseline cognition and dietary intakes 20 years after baseline, with correction for attrition using the Heckman procedure.

Diets high in fruit and vegetables, legumes, and fish have been consistently associated with decreased incidence of dementias and Alzheimer's Disease, and better cognitive performance (2, 6, 7, 10, 12); these are foods which characterize the Mediterranean Diet. Our findings with regard to these food items is consistent. However, in contrast, meat is considered deterimental within a traditional Mediterranean pattern (46), but we found positive associations between cognitive performance and meat intakes, with full adjustment for potential economic, lifestyle and cardiovascular confounders and bias introduced by attrition. One possible explanation for this finding is that those with greater cognition also had better cardiovascular health (47), and were therefore able to incorporate recommended intakes of meat into their diets. The meat variable included in the questionnaire included both red and white meats. Although a very recent meta-analysis of cohort studies examining meat consumption (total, red, white, and processed) and mortality, found red meat consumption to be positively but weakly associated with cardiovascular disease mortality, no significant associations were found for total or white meat consumption (48). Protein is a necessary and important part of the diet, and a number of studies have demonstrated its benefits on brain function. Dietary protein has been positively associated with memory function (49), and high-protein, low-carbohydrate diets have been shown to effectively reduce depression and improve self-esteem in obese women (50).

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Consistent findings of good food preferences with higher cognitive function were observed for the total WAIS score, which combines both verbal and performance abilities. While few studies have considered the association of intellect with food choices, intellect is positively correlated with effective decision making, and the use of good strategies of all kinds (51). We may speculate that this extends to dietary choices. We found more statistically significant relations between food choices and cognitive performance on the Verbal score, as might be expected because the Verbal score reflects learned behaviors, knowledge, and information (crystallized abilities). The Verbal component includes tests of Information, which measures the degree of general information acquired from culture, and Comprehension, a measure of the ability to deal with social conventions, rules and expressions. These two aspects of cognition are particularly relevant in making decisions regarding dietary intake and the selection of foods to consume. Fewer statistically significant relations between food choices and cognitive performance were seen for the Performance score, as might be expected because it reflects novel problem solving abilities under time constraints.

Strengths and limitations

Nutritional data were not collected at the baseline assessment, which precluded any assessment of dietary change over the study period. We were interested in examining relationships between cognition and diet separated by a lengthy period of time, as this, to our knowledge, has not been examined. As a result, however, we are unable to rule out potential confounding from the multitude of factors that influence dietary choice, such as food-related perceptions. Even with incomplete information about many of these potential confounders and other daily influences on food selection, we have still observed significant associations between cognitive performance and several key food groups. It is also not possible to distinguish whether an individual's diet as a child (which the person may or may not continue to adhere to as an adult) may have contributed to the individual's cognitive function.

The dietary questionnaire required participants to report the number of times they consumed foods and beverages on a daily or weekly basis, however serving sizes were not quantified and we were unable to calculate total energy intake. Differentiation between intakes of different types of meat was another limitation of the dietary questionnaire used. Details regarding the nutritional content of some foods, such as cereal type (wholegrain versus other types) was not specified; therefore these distinctions were unable to be made. Like all dietary assessment techniques, we can not rule out recall bias and measurement error. Other limitations include the attrition of subjects between baseline (waves 1-4, WAIS measurement) and wave 6 (dietary outcome measures). Attrition was significant given the large number of years between the WAIS data and the outcome measures (food references) in this prospective design allowing for the predictor to be clearly separated in time from the outcome measures. However, this is a natural consequence of studying older adults prospectively for a long period of time. Persons who remained in the study until wave 6 measurement of nutrition were of lower age, education, and had lower total WAIS, Verbal, and Performance scores. However, the Heckman procedure was employed to carefully adjust for attrition, using the characteristics we have, and thus to correct for attrition bias and report the most conservative set of data. Findings were stronger with the Heckman adjustment, not weaker.

The strengths of the present study are its prospective design made possible by availability of data on the WAIS between the time periods of 1976 to 1995, a mean of 18 years before the dietary data were collected. This temporal relation between predictors (WAIS performance) and diet is important in our conclusion that intellectual ability impacts food preference and that this influence may be observed over a signficant period of the life cycle. While the terms prospective and longitudinal are often used simultaneously, the strict definition of a prospective study is that the predictor precedes the outcome measure by a reasonable number of years. Further, our prospective findings are supported by cross-sectional data (52). At wave 6, cognitive function (using pro-rated scores and a newer version of the WAIS) is positively associated with intakes of vegetables, meat, fish, and nuts and legumes, and negatively associated with intakes of white bread, and carbonated soft drinks (all age and gender adjusted, all $P < 0.05$).

The availability of a broad array of cardiovascular risk factors has allowed the ability to include and examine potential confounding factors, i.e. the possibility that cardiovascular illness at the time of dietary assessment influenced food selections. The cognitive assessment was thorough and did not solely rely on a simple screening measure, as many studies examining diet in relation to cognition have done (2, 37, 53). It is, to our knowledge, the first study to examine the relationship between cognition and intake of food items, rather than adherence to a particular pattern, which makes assumptions about the constituents of a 'healthy diet'. The nutritional habits in certain populations, for example certain parts of Europe and the United States may not align with a particular pattern, such as the Mediterranean. The present findings also support the notion that a diet composed of a variety of healthy foods is also associated with other healthy behaviors such as non-smoking, engaging in more physical activity, and maintaining a desirable BMI (54).

Conclusions

The findings from this study suggest that cognitive performance may be prospectively associated with food preferences associated with health and a healthy diet. There is certainly a need to examine the possibility that cognitive performance plays a role in dietary choice, beyond what can be accounted for by age, education, income, health and lifestyle factors. This approach has become very popular in studies of obesity and cognition (see Elias et al. (18) for a review). It is becoming quite clear that intellectual status early in life effects good or poor food choices and therefore body weight status which, in turn, effects cognitive performance. Under no circumstances do we argue that diet does not effect cognition, but rather that these relations may move in both directions and that more work in this area seems to be justified.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Demographic variables and health characteristics of participants at wave 6 (n=333)[1]

Characteristic	Mean ± SD
Age, years	60.5 ± 12.8
Education, years	14.6 ± 2.5
Gender, %	
Males	51.1
Females	48.9
Income (US $), %	
<30 000	19.5
30 000 – 60 000	30.0
60 000 – 120 000	33.6
>120 000	2.4
Unknown	14.4
Race, %	
African American	3.0
Other	97.0
Physical activity, MET mins/wk	1188 ± 1783
Smoking, cigarettes/day	1.4 ± 5.4
Waist circumference, cm	97.7 ± 15.0
BMI, kg/m[2]	29.7 ± 5.9
SBP, mm Hg	133.6 ± 22.3
DBP, mm Hg	72.0 ± 10.5
C-reactive protein, mg/L	0.41 ± 0.43
Total cholesterol, mg/dL	197.0 ± 40.6
HDL cholesterol, mg/dL	50.6 ± 14.2
LDL cholesterol, mg/dL	117.3 ± 33.5
Triglycerides, mg/dL	154.2 ± 129.6
Glucose, mg/dL	102.5 ± 33.2
Folic acid, ng/dL	15.1 ± 5.7
Depressed mood, CES-D[2]	8.1 ± 7.6
Cardiovascular disease[3], %	21.6
Diabetes mellitus, %	17.1
Hypertension, %	75.7

BMI, body mass index; CES-D, Centre for Epidemiologic Studies Depression Scale, DBP, diastolic blood pressure; HDL, high-density lipoprotein; LDL, low-density lipoprotein; MET, metabolic equivalent; SBP, systolic blood pressure

[1]Values are means ± SDs or percent

[2]Higher score indicates greater number of depressive symptoms

[3]Cardiovascular disease was defined as present if there was self-reported history of coronary artery disease, myocardial infarction, congestive heart failure, transient ischemic attack, or angina pectoris.

Table 2

Dietary intake of participants at wave 6 (n=333)

Food or beverage	Mean ± SD
Grains[1], times/week	25.8 ± 12.9
Fruit[2], times/week	4.3 ± 2.4
Vegetables[3], times/week	14.7 ± 6.9
Meat[4], times/week	6.7 ± 3.4
Fish, times/week	1.3 ± 0.9
Eggs, no/week	3.3 ± 2.9
Nuts and legumes[5], times/week	5.2 ± 3.1
Milk[6], serves/week	8.8 ± 6.8
Cheese plus yogurt, times/week	5.0 ± 3.2
Added sugar[7], times/week	3.9 ± 3.3
Carbonated soft drinks, glasses/week	2.8 ± 5.6
Alcohol, standard drinks/week	3.3 ± 5.8

[1]Foods included: bread, rolls, rice, pasta, crackers, cereal

[2]Foods included: fresh, dried, and stewed fruit

[3]Foods included: fresh and raw vegetables: tomatoes, carrots, green and other vegetables, raw vegetables, salad

[4]Foods included: red and white meats, chicken

[5]Food included: nuts, beans, peas, lentils

[6]Milk intake based on 250 mL serve

[7]Foods included: cake, chocolate, sweets, nutrition bars, jam, soda, fruit drinks, sports drinks, added sugar to beverages.

Table 3

Magnitude (unstandardized regression coefficients [b] and standard errors [SE]) of associations between baseline cognitive performance and dietary intakes at wave 6[1]

Dietary intake at wave 6 (times/week)	Covariate set[2]	Cognitive performance at baseline								
		Total WAIS			Verbal Subscale			Performance Subscale		
		b	SE	P	b	SE	P	b	SE	P
Vegetables	1	0.152	0.023	<0.0001	0.239	0.033	<0.0001	0.064	0.045	0.15
	2	0.123	0.025	<0.0001	0.202	0.037	<0.0001	0.021	0.045	0.64
	3	0.091	0.025	<0.001	0.149	0.038	<0.0001	0.007	0.045	0.88
Meat	1	0.057	0.011	<0.0001	0.070	0.016	<0.0001	0.037	0.024	0.12
	2	0.062	0.012	<0.0001	0.080	0.019	<0.0001	0.080	0.020	<0.0001
	3	0.056	0.013	<0.0001	0.076	0.020	0.0001	0.029	0.024	0.23
Nuts and legumes	1	0.021	0.010	0.026	0.028	0.015	0.06	0.040	0.019	0.036
	2	0.017	0.011	0.11	0.019	0.018	0.28	0.034	0.020	0.09
	3	0.019	0.012	0.12	0.019	0.019	0.33	0.037	0.021	0.08
Fish	1	0.006	0.003	0.06	0.008	0.004	0.07	0.009	0.005	0.09
	2	0.002	0.003	0.58	0.001	0.005	0.89	0.005	0.006	0.40
	3	0.011	0.003	<0.001	0.002	0.006	0.76	0.018	0.005	0.001
Total grains	1	−0.124	0.042	0.003	0.075	0.066	0.26	0.014	0.081	0.86
	2	−0.096	0.046	0.037	0.128	0.073	0.08	−0.189	0.084	0.025
	3	−0.110	0.049	0.024	0.111	0.080	0.17	−0.226	0.087	0.009
Carbonated soft drinks[3]	1	−0.017	0.012	0.15	−0.038	0.017	0.024	0.005	0.018	0.80
	2	−0.011	0.012	0.38	−0.028	0.018	0.11	0.006	0.018	0.74
	3	−0.008	0.014	0.55	−0.028	0.020	0.16	0.012	0.020	0.56

WAIS, Wechsler Adult Intelligence Scale

[1]Heckman adjustment applied (N=1161)

[2]Covariate set 1 - Basic: adjustment for age, gender; Covariate set 2 - Socioeconomic: adjustment for age, gender, education, income; Covariate set 3 - Cardiovascular/lifestyle: adjustment for age, gender, education, income, ethnicity, CES-D, smoking, physical activity, BMI, CRP, folic acid, SBP, and DBP at wave 6; 3. Binary variable (consumer/non-consumer), logistic regression coefficient presented.

[3]Binary variable (consumer/non-consumer), logistic regression coefficient presented.