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Association Between the Mediterranean Diet and Cognitive Decline in a Biracial Population

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Background. Results from numerous studies suggest protective effects of the Mediterranean diet for cardiovascular disease, cancer, and mortality. Evidence for an association with a decreased risk of cognitive decline is less consistent and studies are limited by a lack of diversity in their populations.

Methods. We followed 2,326 older adults (38.2% black, 51.3% female, aged 70–79 at baseline) over 8 years in a prospective cohort study in the United States (Health, Aging and Body Composition study). To measure adherence to a Mediterranean diet, we calculated race-specific tertiles of the MedDiet score (range: 0–55) using baseline food frequency questionnaires. Cognitive decline was assessed using repeated Modified Mini Mental State Examination scores over the study. We used linear mixed models to assess the association between MedDiet score and trajectory of cognitive decline.

Results. Among blacks, participants with high MedDiet scores had a significantly lower mean rate of decline on the Modified Mini Mental State Examination score compared with participants with lower MedDiet scores (middle and bottom tertiles). The mean difference in points per year was 0.22 (95% confidence interval: 0.05–0.39; $p = .01$) after adjustment for age, sex, education, body mass index, current smoking, physical activity, depression, diabetes, total energy intake, and socioeconomic status. No association between MedDiet scores and change in Modified Mini Mental State Examination score was seen among white participants ($p = .14$).

Conclusions. Stronger adherence to the Mediterranean diet may reduce the rate of cognitive decline among black, but not white older adults. Further studies in diverse populations are needed to confirm this association and pinpoint mechanisms that may explain these results.

Key Words: Epidemiology—Nutrition—Cognitive aging—Alzheimers—Cognition.

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OVER 5.2 million individuals are currently living with dementia in the United States with approximately 450,000 new cases per year.[1] Current treatment options are limited and unable to limit progression of the disease, emphasizing the importance of prevention. Many factors are thought to be involved with risk of dementia and cognitive decline, including dietary components.[2,3] Numerous observational studies and clinical trials have investigated the possible effects of individual nutrients such as antioxidants or n-3 fatty acids with mixed results.[4] It has been hypothesized that investigating an overall dietary pattern may be more meaningful, as it more accurately reflects actual eating habits and can take into account interactive effects between individual nutrients.[5]

The Mediterranean diet is a well-known dietary pattern associated with a reduced risk of cardiovascular disease.[6] Some prospective studies also suggest it is associated with a decreased risk of cognitive decline.[3,7] However, results are not consistent, which may be due to differences in the composition of study participants or the methods used to describe adherence to the Mediterranean diet. For example, most prospective studies investigating the association between diet and cognitive outcomes have used the

Mediterranean diet score which defines thresholds of intake based on median levels within the population being studied.[8] Therefore, results in one population cannot be directly compared with the results in another population whose dietary habits differ.[7] Although alternatives not subject to this limitation exist, they are less frequently employed. One such alternative is the MedDiet score,[9] which uses predefined levels of intake for each food category.

It is also possible that the association between diet and cognitive decline may differ by race. Incidence of dementia varies by race, with blacks and other minorities often having the highest reported rates,[10] as well as higher levels of known risk factors for dementia.[10] Furthermore, the pattern of cognitive decline may differ by race, with blacks possibly having more rapid rates of decline and different secondary symptoms.[11] Differences in dietary pattern and diet quality also exist by race, which can be due to both cultural differences as well as racial disparities in socioeconomic factors.[11,12] Moreover, since cultural factors can be difficult to directly measure, it can be of interest to measure diet as a way to partially capture cultural differences by race. We therefore conducted a study using the MedDiet score to examine the relationship between the Mediterranean diet and cognitive decline, and to determine if any such association differs between black and white older adults.

Methods

Study Population

The Health, Aging, and Body Composition (Health ABC) study is an ongoing, prospective study of well-functioning older adults. The first study visit occurred between 1997 and 1998, with 3,075 participants aged 70–79 recruited from a random sample of Medicare-eligible, community-dwelling older adults residing in two large metropolitan areas in the United States (Memphis, Tennessee; Pittsburgh, Pennsylvania). Participants were required to report no difficulty walking a quarter of a mile, climbing 10 steps without resting and performing any activities of daily living, be free of life-threatening cancers with no treatment within the past 3 years, and plan to remain in the study area for at least 3 years. Because the food frequency questionnaire (FFQ) was first administered at the second visit (1998–1999), this time point serves as the baseline for the present study. Of the 2,732 participants at our baseline, 249 did not have complete FFQ data, 144 did not have at least two cognitive assessments, and 12 had prevalent dementia, resulting in an analytic cohort of 2,326 participants. Participants who did not have complete FFQ data or at least two cognitive assessments were more likely to be black, have fewer years of education, be a current smoker, and have more comorbidities. This study was approved by an institutional review board (University of California, San Francisco) and written informed consent was obtained from all participants.

Dietary Assessment

Dietary patterns were recorded using a modified 108-item semi-quantitative Block FFQ (Block Dietary Data Systems, Berkeley, CA). Food lists in the FFQ were modified to best represent the intake of participants in the Health ABC cohort using NHANES III 24-hour recall data for individuals aged over 65, either white or black, and residing in either the Northeast or Southern regions of the United States. Although a FFQ is usually completed by the participant, in order to improve data validity, centrally trained examiners at each study site recorded FFQ data through participant interview. Throughout the study period, randomly selected interviews were taped and reviewed to maintain quality control. Total energy intake (kcal/d) was measured using estimated daily dietary intake from FFQ data. To determine any effect of potentially erroneous reporting of dietary intake, we also conducted analyses excluding participants with implausibly low or high daily caloric intakes (<500 or >4,000 kcal for men and <400 or >3,800 kcal for women).

To assess adherence to the Mediterranean diet, we used data from the FFQ to construct a MedDiet score for each participant. Details on the development and validation of the MedDiet score are available elsewhere[9,13,14]. In brief, the MedDiet score ranges from 0 to 55, with higher scores representing a stronger adherence to a Mediterranean diet. Eleven food categories are included, with a score of 0–5 within each category. Scores for food categories representative of a Mediterranean diet (nonrefined grain products, fruits, vegetables, potatoes, legumes, fish) increase as consumption frequency increases (1–4, 5–8, 9–12, 13–18, >18 servings per month). Olive oil intake is scored similarly but using frequencies of weekly intake. Those foods less representative of a Mediterranean diet (red meat, poultry, full fat dairy products) are given lower scores as monthly consumption frequency increases. Only alcohol intake was scored nonlinearly, with a score of 0 for no consumption or ≥700 ml/d and scores of 1 to 5 for 600–700, 500–600, 400–500, 300–400, and up to 300 ml/d, respectively.

Measurements

At baseline, demographic variables included age, sex, race, and education (<12, 12, or >12 years). Body mass index (kg/m^2) was calculated from measured height and weight. Lifestyle factors included self-reported current smoking status and alcohol use (≥1 drink/d). Physical activity was estimated using self-reported frequencies of everyday walking or walking for exercise (measured as kcal/kg/wk). The short form Geriatric Depression Scale[15] was used to measure depression. Geriatric Depression Scale scores range from 0 to 15 with higher scores representing more depressive symptoms. Diabetes was defined by self-reported physician diagnosis, use of diabetes medication, or a fasting glucose level of ≥126 mg/dL. Hypertension was indicated for a participant with either: a self-reported

physician diagnosis, use of hypertension medication, or elevated blood pressure (systolic ≥140 mmHg or diastolic ≥90 mmHg). History of stroke and myocardial infarction were recorded from self-reported physician diagnosis. Onset of dementia was determined by both hospital records indicating a dementia related hospital event and a Modified Mini Mental State Examination (3MS) score of 90 or below, a record of prescribed dementia medication, or race stratified change of at least 1.5 *SD* on the 3MS from baseline to the last available visit. Socioeconomic status (SES) was categorized based on three questionnaire items assessing financial status, discretionary income, and living arrangement (own or rent). Apolipoprotein E genotype was coded according to the presence of least one copy of the ε4 allele.

Cognitive Assessment

Cognitive function was assessed using the 3MS score,[16] an extensively used and validated interviewer-administered instrument designed to measure several cognitive domains including orientation, registration, attention, recall, and visuospatial ability. The 3MS exhibits high interrater reliability and test–retest reliability,[17] and has been used in a variety of populations.[18,19] Scores for the 3MS range from 0 to 100, with higher scores indicating better cognitive function and scores below 80 suggestive of cognitive impairment. Because the 3MS was not administered at our baseline time point, we used the 3MS assessment at the visit 1 year prior to our baseline. Follow-up assessments occurred 1, 3, 6, and 8 years after baseline. The 3MS was administered by trained interviewers who were required to complete at least two mock interviews before certification by a quality control co-ordinator.

Statistical Analysis

We compared baseline characteristics by MedDiet score using one-way analysis of variance for normally distributed continuous variables, Kruskal–Wallis tests for non-normally distributed variables and Chi-square tests for categorical variables. Because standard cutoffs are not available for the MedDiet score, race-specific tertiles were used (whites: 12–29 [low], 30–34 [middle], 35–50 [high]; blacks: 12–26 [low], 27–30 [middle], 31–50 [high]). To test for a significant mean difference in the rate of cognitive change by MedDiet score and race, we used linear mixed models with a random slope and intercept. For covariate selection, we first selected variables that were known or suspected risk factors for cognitive decline based on existing literature. We conducted two multivariate adjusted models. The first multivariate model adjusted for demographic factors (age, sex, education) and total energy intake.[20] The full model further adjusted for any other variables found to be significantly associated with MedDiet score in the study population (body mass index, current smoking, physical activity, depression, diabetes, SES). An interaction term between time and each variable was also added. Alcohol consumption was not included to avoid collinearity since intake is already coded as part of the MedDiet score. Because of no observed association with cognitive change comparing the middle versus lowest tertile, final analyses used a "high" and "lower" category of MedDiet score. High MedDiet scores represented the top race-specific tertile, and lower MedDiet scores consisted of the middle and lowest tertiles combined. Because the 3MS scores for all participants declined over time on average, the coefficients represent the mean reduction in decline for participants with high MedDiet scores compared with those with lower MedDiet scores. We also tested for any association per 5-point increase in MedDiet score. SAS 9.3 (SAS Institute Inc., Cary, NC) was used for all statistical analyses.

Results

Population Characteristics

A total of 2,326 participants were followed for a mean of 7.9 ± 0.1 years. The mean age at baseline was 74.6 ± 2.9, women made up 51.3% of the participants, and 61.8% were white. Over the follow-up period, 207 cases of incident dementia occurred. Table 1 shows the consumption frequency of individual food categories in the MedDiet score by race. On average, whites consumed more nonrefined grain products, fruits, vegetables, legumes, olive oil, and alcohol, while blacks consumed more red meat, poultry, and full fat dairy products. Whites had higher mean MedDiet scores than blacks (mean ± *SD*: 32.2 ± 5.9 and 28.7 ± 6.0, respectively). Baseline characteristics by MedDiet score are shown in Table 2. Participants with high MedDiet scores were more likely to have more years of education, have a higher SES, drink alcohol more frequently, not currently smoke, have a higher total energy intake, be more physically active, have a higher 3MS score, and have fewer comorbidities. Scores for the 3MS on average declined from 93.3 ± 5.4

Table 1. Consumption Frequency of MedDiet Food Categories by Race (mean ± *SD* of servings/mo)

Food Category	Whites	Blacks	*p* Value
Nonrefined grain products	27.6 ± 20.9	25.0 ± 21.0	<.001
Potatoes	10.1 ± 7.5	10.3 ± 8.5	.39
Fruits	57.6 ± 33.4	54.8 ± 38.3	.001
Vegetables	47.4 ± 26.3	42.8 ± 30.3	<.001
Legumes	15.4 ± 12.4	14.3 ± 11.8	.02
Fish	6.0 ± 5.1	6.4 ± 6.2	.50
Red meat	21.1 ± 15.3	27.9 ± 20.5	<.001
Poultry	8.0 ± 6.5	10.1 ± 8.5	<.001
Full fat dairy	8.7 ± 15.8	10.2 ± 18.7	.03
Olive oil (times per wk used for cooking)	4.4 ± 10.0	2.2 ± 6.3	<.001
Alcohol (ml/d)	60.6 ± 151.5	44.8 ± 176.7	<.001
MedDiet score	32.2 ± 5.9	28.7 ± 6.0	<.001

Table 2. Baseline Characteristics of Participants, by MedDiet Score (n = 2,326)

Characteristic, Mean ± *SD* or *n* (%)	Whites			Blacks		
	Lower MedDiet Score[a] (n = 944)	High MedDiet Score[a] (n = 508)	p Value	Lower MedDiet Score[a] (n = 547)	High MedDiet Score[a] (n = 327)	p Value
Age	74.6 ± 2.9	74.8 ± 2.8	.17	74.4 ± 2.8	74.6 ± 2.9	.56
Female	449 (47.3%)	245 (47.9%)	.84	303 (55.3%)	220 (66.9%)	<.001
Education						
<12 y	111 (11.7%)	35 (6.8%)	<.001	229 (42.1%)	95 (28.9%)	<.001
12 y	363 (38.3%)	143 (27.9%)		187 (34.4%)	110 (33.4%)	
>12 y	474 (50.0%)	334 (65.2%)		128 (23.5%)	124 (37.7%)	
Body mass index (kg/m^2)	26.7 ± 4.2	26.2 ± 4.1	.008	28.6 ± 4.5	28.7 ± 5.4	.79
Current smoking	50 (5.3%)	24 (4.7%)	.63	90 (16.5%)	30 (9.1%)	.002
Alcohol (≥1 drink/d)	104 (11.0%)	121 (23.6%)	<.001	38 (6.9%)	22 (6.7%)	.89
Physical activity (kcal/kg/wk walking)	7.0 ± 13.7	8.7 ± 12.3	<.001	4.2 ± 8.6	6.3 ± 12.8	.005
High socioeconomic status	680 (74.5%)	385 (80.5%)	.01	237 (44.6%)	165 (52.1%)	.04
Geriatric Depression scale (range: 0–15)	5.4 ± 1.1	5.2 ± 0.9	.004	5.8 ± 1.3	5.5 ± 1.0	<.001
Stroke	85 (9.0%)	34 (6.6%)	.12	48 (8.8%)	38 (11.6%)	.18
Myocardial infarction	120 (12.7%)	88 (17.2%)	.02	73 (13.4%)	45 (13.7%)	.89
Diabetes	170 (17.9%)	55 (10.7%)	<.001	149 (27.2%)	79 (24.0%)	.30
Hypertension	603 (63.5%)	317 (62.2%)	.60	429 (78.3%)	260 (79.0%)	.80
Energy intake (kcal/d)	1,796.1 ± 679.5	1,860.9 ± 627.4	.03	1,934.6 ± 895.6	2,018.7 ± 874.7	.08
Apolipoprotein E ε4	215 (23.6%)	117 (23.9%)	.90	189 (37.3%)	98 (31.6%)	.10
3MS score	92.9 ± 5.6	93.8 ± 5.3	<.001	86.3 ± 9.2	88.6 ± 7.9	<.001

[a]High = top race-specific tertile of MedDiet score; Lower = middle and bottom race-specific tertiles of MedDiet score.

at baseline to 91.5 ± 8.6 after 8 years for whites, and from 87.2 ± 8.8 to 84.6 ± 11.8 for blacks.

Mediterranean Diet and Cognitive Decline

Results for the association between MedDiet score and trajectories of 3MS score are shown in Table 3. An expanded list describing the association between each model covariate and trajectories of 3MS score is available in : Supplementary Table 1. In the model adjusted for demographic variables (age, sex, education) and total energy, black participants with high MedDiet scores (top tertile) compared with those with lower MedDiet scores (middle and bottom tertiles) had a significantly slower mean rate of decline of 3MS score (mean: 0.26 points/y; 95% confidence interval [CI]: 0.09–0.44; p = .003). In the full model, further adjusted for body mass index, current smoking, physical activity, depression, and diabetes, compared with blacks with lower MedDiet scores, those with high MedDiet scores had a significantly slower rate of cognitive decline (mean: 0.22 points/y, 95% CI: 0.05–0.39 p = .01). After additionally adjusting for apolipoprotein E ε4 status, results remained similar (mean: 0.25 points/y; 95% CI: 0.08–0.42; p = .005). Results did not change when excluding participants with implausibly low or high daily caloric intakes (n = 40). At baseline, the independent effect of high versus lower MedDiet scores was not significant (mean: 0.85, 95% CI: −0.16, 1.86; p = .10). The predicted effect of each year of follow-up time was a mean of −0.27 (95% CI: −0.46, −0.08; p = 0.004) points/y. Findings were also significant in each model when estimating the mean difference in 3MS decline for each 5-point increase in MedDiet score. In both multivariate adjusted models, MedDiet score was not significantly associated with cognitive decline in whites.

Table 3. Association Between MedDiet Score and Trajectories of 3MS (n = 2,326[a])

	Mean Difference in Slope of 3MS Score			
	High vs Lower Scores (points/y)	p Value	Per 5 pt Increase	p Value
Model 1: Demographic adjusted[b]				
Whites	0.12 (−0.01, 0.26)	.07	0.03 (−0.03, 0.08)	.36
Blacks	0.26 (0.09, 0.44)	.003	0.09 (0.02, 0.16)	.01
Model 2: Fully adjusted[c]				
Whites	0.09 (−0.03, 0.21)	.14	0.02 (−0.02, 0.07)	.39
Blacks	0.22 (0.05–0.39)	.01	0.08 (0.01, 0.15)	.02

Notes: SES = socioeconomic status.
[a]Whites: n = 1,452; Blacks: n = 874.
[b]Model 1 adjusted for age, sex, education.
[c]Model 2 adjusted for age, sex, education, body mass index, current smoking, physical activity, depression, diabetes, total energy intake, SES.

Discussion

In a population of initially well-functioning older adults, we found a significant association between stronger adherence to the Mediterranean diet and a slower rate of cognitive decline among black, but not white older adults. Much evidence describes the biological mechanisms on how the Mediterranean diet may reduce cognitive decline. The Mediterranean diet comprises several dietary components associated with a decreased risk of cognitive decline, either through mediating effects such as reducing risk of cardiovascular disease or direct neuroprotective effects.[21–24]

Previous prospective studies investigating the association between the Mediterranean diet and cognition decline or dementia have reported mixed results in predominately white populations,[25–28] while studies including sizeable black populations have had more consistently positive results.[29–31] In line with the collective evidence, our study is the first to show a possible race-specific association between the Mediterranean diet and cognitive decline. Results from previous studies in biracial populations did not show a race effect, yet also reported similar profiles of dietary patterns between races.[30,31] In contrast, the dietary patterns of whites and blacks in our study markedly differed. In addition, the majority of prior studies used the Mediterranean diet score, which may lead to misclassification of a participant's adherence to the Mediterranean diet.[7]

The race effect observed in our study may be explained by socioeconomic factors which can be strongly associated with both diet[32] and cognitive performance[33] and may explain much of the disparities in dementia incidence among black and white older adults.[34] SES can be associated with comorbidities that may increase risk of cognitive decline, as well as predict diet quality, with many components of the Mediterranean diet consumed more often by individuals with a higher SES.[35] Although we adjusted for SES in the analysis, the complex relationship between socioeconomic factors and race disparities in health outcomes may still result in residual confounding.[32] Additionally, a given MedDiet score can represent many different combinations of individual food categories. Cultural differences in dietary choice may be reflected in a distinct dietary pattern more often found in blacks with higher MedDiet scores that is associated with a decreased risk of cognitive decline. Lastly, a race effect of the Mediterranean diet on cognitive decline may be mediated by cardiovascular disease, as existing studies show an increased sensitivity among blacks to specific nutrients on cardiovascular outcomes. For example, blacks are shown to be more sensitive to sodium intake when considering risk of hypertension, as well as showing a stronger benefit on stroke risk from increased potassium intake.[36,37]

Strengths of this study include the prospective design in a biracial population and the use of a validated interviewer-administered FFQ for dietary data collection. Additionally, multiple cognitive test scores allowed for an analysis of trajectories of cognitive decline, minimizing potential reverse causation inherent in the analysis of progressive disease as an incident outcome. Because this is an observational study, we cannot discount the limitation of possible bias from unmeasured or residual confounding. For example, there may be confounding by vitamin supplement use, which was not measured in the study. Additionally, a single baseline measurement of dietary intake may not be representative of a participant's long-term dietary habits. Lastly, older cohorts are particularly susceptible to loss to follow-up. However, if participants who dropped out were more likely to have a poorer diet and have more cognitive decline than those who remained, results would most likely be biased toward the null.

Further studies in diverse populations are still needed to confirm the association between the Mediterranean diet and cognitive decline. Randomized controlled trials in particular can provide stronger evidence of the cognitive benefits of the Mediterranean diet, yet only one trial exists.[38] If a true race effect exists, other studies in multiethnic cohorts can elucidate if such an effect is due to genetic and/or environmental factors. Regardless of any race effect, adherence to a Mediterranean diet should still be recommended for its established beneficial effects on other health outcomes such as cardiovascular disease.[39]

Supplementary Material

Supplementary material can be found at: http://biomedgerontology.oxfordjournals.org/.

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