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The Role of Nutrition and Inflammation on Cognition in High Risk Groups for Alzheimer's Disease

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M.P.H., Emory University, 2020
B.S., University of Michigan, 2018

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An abstract of a thesis submitted to
the Faculty of the Rollins School of Public Health of Emory University
in partial fulfillment of the requirements of the degree of
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Abstract

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Alzheimer's Disease (AD) is a prevalent neurodegenerative disease. Current treatments are being developed to target people at high risk for AD. Ethnicity and sex play essential roles in aggravating AD risk. Lifestyle factors, including nutrition, also contribute to risk for development of AD. Inflammation is crucial to the development of AD pathophysiology. Tumor necrosis factor alpha (TNFα) plays a role in the cytokine cascade during an inflammatory response. Consuming a high-fat diet induces increased tissue expression of TNFα. This study investigates the relationship between nutrition, inflammation, and cognition in African American women (age: M = 59.5, SD = 8.20 [42–73 years]) at risk for developing AD. Participants were split into high-fat and low-fat groups based on total fat consumption self-reported on the Lower Mississippi Delta Nutrition Intervention Research Initiative Food Frequency Questionnaire (Delta NIRI JHS FFQ). A high-fat diet was associated with a significant 2-fold increase in TNFα (OR=2.14; 95% CI: 0.2043-22.4781) and had a significant mean difference associated with increased blood serum TNFα (p = 0.039). In addition, global cognition was higher in those who consumed a higher fat diet (p = 0.024). There was no significant difference across groups for executive function, dual-tasking, and visuospatial performance. However, visual attention and task switching ability were significantly statistically higher in those who consumed a higher fat diet (Normal range: 44.2 seconds). These results indicate that there may be multiple biological pathways involved in AD development, suggesting the need for more holistic approaches to mitigating AD-development risk.

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Table of Contents:

INTRODUCTION

Alzheimer's Disease is the 6th leading cause of death in the United States. Furthermore, one in three seniors die from Alzheimer's or another form of dementia, which kills more than breast cancer and prostate cancer combined [1]. Alzheimer's Disease (AD) is a disorder that gradually and progressively destroys cognitive function. While the disease first begins to affect declarative memory, it progresses to affect nondeclarative memory and ultimately leads to dementia [2]. AD has become more prevalent in recent years, and its prevalence is expected to increase. By 2050 it is predicted that one in 85 people world-wide will have AD, including 13 million Americans [3,4]. This increase in prevalence makes it imperative to develop better diagnostic measures and more efficient screening procedures for those in early stages of the disease [5,6].

Ethnic minorities and female sex are aggravating factors of AD. The Alzheimer's Association estimates that the prevalence of AD and other dementias in African Americans above the age of 65 years is about twice the rate among elderly whites [7]. Similarly, women are disproportionally affected by AD. They are two to three times more likely to develop AD than men [8], and are also more likely to become caregivers to AD patients. Important next steps in investigating treatment for AD and those with dementia is to target those who are at a high risk for the disorder and institute preventative strategies in order for them to receive early intervention [9].

The APOE-e4 allele is a widely recognized hereditary risk factor for the development of AD with a single allele increasing the risk of development by 2-to-3 fold. The APOE gene, in the central nervous system, transports cholesterol to neurons via APOE receptors [10]. It is not known exactly how the APOE e4 allele is related to the risk of Alzheimer Disease. However, there is an association between carrying the APOE-e4 allele and having a family history of AD [11,12]. Independent of genetic factors, other studies reveal that those with parental history of AD have a greater risk of developing dementia [13,14]. Having one or both parents with dementia has been associated with greater cognitive impairment, thereby effecting disease severity [11]. Conversely, race and ethnicity have also been found to contribute to an increased frequency of APOE-e4 allele exposure. Recent data shows that a higher percentage of Blacks

and African Americans, over European Americans, have at least one copy of the e4 allele [1], which increases the risk of developing AD.

Another risk factor in the progression of AD is the inflammatory cytokine called tumor necrosis factor – alpha (TNFα). Previous studies have suggested that neuroinflammation augments responses in various pathological pathways, ultimately leading to AD. Healthy adults, on average, have low levels of TNFα present in the blood while AD patients typically exhibit a higher level of TNFα present in their blood [15]. High-levels of TNFα expression induces biosynthesis of molecules that cause tissue necrosis, as well as apoptosis [16]. High levels of TNFα expression can be caused by numerous factors including a high-fat diet. A high-fat diet invokes a pro-inflammatory response; consequently, obesity has been reported to be associated with low-grade inflammatory status due to an increased production of pro-inflammatory mediators [17].

Although risk factors such as age, ethnicity, and family history cannot be changed, other risk factors can be modified to reduce risk of cognitive decline and dementia seen in AD. There are lifestyle factors that have increased risk for development of AD, which are often shared among families, such as nutrition, exposure to toxins, and lack of mental activity [18]. Monitoring the functioning of those who are at high risk for AD is important in targeting groups for intervention before diagnosis. In this study, we investigated African American women who are predisposed for Alzheimer's (have a parental history), and who consume a high-fat diet to determine if they show early signs of memory deficits and cognitive functioning.

MATERIALS AND METHODS

The Institutional Review Board at Emory University School of Medicine and the Research and Development Committee of the Atlanta VA approved this work. Participants provided written informed consent before participating. Participants were recruited from the Emory Alzheimer's Disease Research Center from registries derived from previous studies of individuals with parental history of AD. Forty-two participants with parental history of AD participated. Participants were at least 40 years of age, self-identified as African American (AA), and identified as women. The participants' parents had a diagnosis

of probable AD as defined by National Institute of Neurological Disorders and Stroke-Alzheimer's Disease and Related Disorders Association (NINDS-ADRDA) criteria, which was verified using the validated Dementia Questionnaire and medical records when available [19].

Participants underwent blood draws for inflammatory cytokines after an 8-hour overnight fast. Blood samples were collected by members of the research team. Measured biomarkers included those that have been linked to AD and family caregiver stress [19], including interleukin 10 (IL-10). Four panels of biomarkers were measured in plasma using singleplex or multiplex assays in a Luminex 200 platform. Participants completed the Lower Mississippi Delta Nutrition Intervention Research Initiative Food Frequency Questionnaire (Delta NIRI JHS FFQ) to assess the participants' dietary habits. Participants also performed mobility and cognitive testing. Cognitive testing included evaluation of global and executive function, using the Montreal Cognitive Assessment (MoCA), the Reverse Corsi task (Corsi), the Trails Making Task (TMT) and the D-KEFS Tower of London (TOL) task. Widely-accepted methods of reporting the data for each assessment were employed, including raw scores and scaled scores based on age norms when appropriate [20].

Nutrition Data

Delta NIRI JHS FFQ: This questionnaire was used because it highlighted the unique food, preparation, and portion sizes used by AA and White adults from the Southern region [21]. Participants used a 24-hour dietary intake recall answering the 158-item (short FFQ) Delta NIRI FFQ. Some of the regional foods included in the FFQ included foods such as grits, ham hocks, chitterlings, etc. The short FFQ is a categorical subset of the long FFQ, shortened to fit the time constraints for dietary assessments. This FFQ was designed to include all foods on the longer FFQ, by collapsing similar foods to combine line items and simplifying adjustment questions (Table 1).

Cognitive Data

Montreal Cognitive Assessment (MoCA): is a global cognitive screening tool for mild cognitive impairment [22]. It includes eight cognitive domains assessing clock drawing and 3-D cube copy task, Trail Making B task, phonemic fluency task, two-item verbal abstraction task, sustained attentional task,

serial subtraction task, naming task, repetition of sentence task, and orientation to time and place task. Throughout the assessment, a score is given out of 30. One point is added for those with less than 12 years of education. A score greater than or equal to 26 is considered normal.

Reverse Corsi Blocks (Corsi): assesses short-term and working memory using nonverbal analog. The task consists of a board containing nine cubes at fixed, pseudorandom positions. The blocks are labeled with numbers only visible to the experimenter. The experimenter taps a certain number of blocks, after which the participant has to tap this block sequence in the reverse order as presented. The block sequences gradually increase in length, and the score that is obtained is generally the number of correctly remembered sequences or the length of the longest sequence that was remembered correctly [23].

Tower of London (TOL): assesses planning ability by having participants move three rings of different sizes on pegs in specific arrangements printed on cards that were presented by the administrator [24]. They were told to attempt to make the arrangement in the least amount of moves possible. The number of moves as well as time was recorded.

Trails Making Task (TMT)**:** assesses executive function, visual attention and task switching among participants. This task contains two parts: part A and part B. In TMT A, participants need to connect 25 numbered circles continuously in an ascending order. In TMT B, 13 numbers and 12 letters must be alternately connected in ascending numerical and alphabetical order. The test is terminated after 5 minutes even if not completed. Once complete, a difference score (TMT B – TMT A) is calculated [25].

Statistical Analysis

Information on age, income status, housing type, marital status, occupation, and education level was collected by questionnaire at the time of the participant's assessment visit. Other covariates (Table 2) were collected. Participant height and weight were self-reported and used to calculate their body mass index (BMI). Participants who completed less than half of the FFQs (N=11) were excluded. Participants whose biomarker data was not completed (N=5) were also excluded from analyses resulting in a sample of 26 individuals.

We converted participants' self-reported dietary consumption habits into an overall fat score based on dietary consumption frequency and portion sizes. Once calculated, the sample was categorized into high and low dietary fat intake through calculating an overall "fat score". Any value below the median fat score is put it the category "Low" and every value above it is labeled "High."

The sample was categorized into elevated and normal TNFα groups through a literature-determined cutoff [26]. A study assessing TNFα levels in adults with knee – joint osteoarthritis measured TNFα in a group of 50 healthy control individuals for comparison. The mean serum level was 4.25 pg/ml with a standard deviation of 0.98 pg/ml. Based on these values, TNFα levels 4.25 pg/ml and higher were considered high while values equal to 4.25 pg/ml or lower were categorized as normal [27].

Once separated and categorized, descriptive analyses were used to assess the demographics of the study population using *t* – tests or Fisher's exact tests. Once complete, the data from the baseline observations were used to examine the association between fat consumption and cognitive variables. The data were tested for normality and skewness using the Shapiro-Wilk test.

Mann-Whitney U tests were utilized to assess the association between dietary fat intake and scores on MoCa, TOL, Corsi, and TMT. All analyses were conducted using SAS (SAS version 9.4, 2013, SAS Institute, Cary, NC). Alpha for all analyses was set at the 0.05 level.

RESULTS

At baseline, twenty-six women with first degree parental history of AD (59.5 $\pm$ 8.20 years) were included in the sample analyses. Participants in the high-fat group and low-fat group did not differ significantly in the following measures: education, quality of life, number of medications, age, number of falls, BMI, learning disabilities, comorbidities, level of exercise, marital status, occupation, and income (Table 2).

To ensure that high-fat was an appropriate substitute for TNFα a construct validity test was used to assess if a high-fat intake was significantly associated with increased blood serum TNFα ($p = 0.039$). Given that TNFα positively correlated with a high-fat intake, we determined that participants' primary

sources of fat were derived from desserts, sweet, and snacks (16%), lunch meat, bacon and eggs (14%), beef and pork (13%), and dairy products (13%).

Using Mann-Whitney U, participants in the high-fat group performed significantly better on the MoCA assessment ($p=0.0226$) compared to those who consumed a lower fat intake through their mean difference indicating that there is a difference in global cognition between the two groups. However, there was no significant difference between the groups in terms of performance on the Trails Making Test, Tower of London, and the Corsi Blocks task (Table 3).

By way of contrast, participants in the low-fat group scored an average difference of 50.32 seconds on the Trail Making Task. The average Trail Making Task difference, as determined by previous literature, is approximately 44.2 seconds indicating a slight impairment in the low-fat group compared to the high-fat group whose members scored an average difference of 41.80 seconds.

DISCUSSION

It was shown that AA women, at higher risk of developing AD, who consumed a high-fat diet had higher levels of global cognition based on MoCA scores Additionally, there were no significant differences in performance of the Corsi, Tower of London, and the Trails Making Task difference. In this study, we utilized high dietary fat intake as an indicator of higher TNFα values. This is because a high dietary fat intake was significantly associated with increased blood serum TNFα. However, all results should be interpreted with caution given the small sample.

Participants who consumed a high-fat diet showed a significant difference in performance on MoCA compared to those with a lower intake of dietary fat, the majority of which derived most of their dietary fat from desserts, sweet, and snacks followed by lunch meat, bacon, eggs, beef, pork, and dairy products. Individuals who consumed a high-fat diet, on average, performed at MoCA's normative level of 27 points. Individuals who consumed a lower fat intake, however, performed significantly worse scoring an average MoCA of 24.68 points. This result contradicts the original hypothesis that higher fat intake results in decreased cognitive ability.

Even though the Trail Making Task difference proved to have no statistical difference, we believe that it may be clinically relevant. A study examined well-educated (education = 12-19 years), community-dwelling residents with no CNS trauma, alcohol abuse, or cardiac problems. The sample contained 35 females (55-64 years) with a mean score of 34.3 seconds on Trails A with a standard deviation of 9.7 seconds. Additionally, the sample had mean score of 78.5 seconds on Trails B with a standard deviation of 26.4 seconds. Based on these values, a normative average of 44.2 seconds was determined to indicate normative cognitive flexibility [27]. Under those circumstances, our high-fat diet group is believed to be normal in calculated difference between Trails A and B times. The average Trail Making Task difference was approximately 44.2 seconds yet those in the high-fat group scored 50.32 seconds. As a result, this may indicate mild cognitive impairment in abilities such as working memory, executive function, and cognitive flexibility. Deficiencies in these areas may impair everyday normative functions such as driving which requires moderate cognitive flexibility.

Yet, this finding raises new questions about the role of diet and cognitive function. Researchers often examine the role of nutrition on global cognition, yet present contrasting conclusions. For example, a prospective cohort study from 1988-2016 found that adhering to a Mediterranean diet or a plant based polyunsaturated fatty acid diet increases global cognitive function and executive function support [26]. Whereas, in another prospective cohort, a higher intake of a Western style diet was correlated with worse cognitive performance. These associations were found on tasks that assessed visual spatial learning, long-term memory and reaction times [28].

The role of nutrition is one that is often studied; however, results vary. The human body is a complex system of networks and biology, and it is possible that multiple physiologies are active. During the post-hoc analysis, it was discovered that there was a correlation between high TNFα values and high IL-10 values. As opposed to TNFα, IL-10 is an anti-inflammatory cytokine and has been proposed as having an inhibitory effect on the production of TNFα. Our analysis found a high number of both cytokines. This evidence may be hinting that there may be multiple pathways at play in relation to inflammation.

This study had several limitations. The study is likely underpowered to determine some effects due to the small sample size in both groups. Our ability to detect significant correlations was limited in this study given the small sample. Furthermore, USDA Food Composition Database was temporarily affected by political factors and not updated regularly. This may have affected the total fat average on the various food options which was used to compute the overall fat score.

Caregiver status was also not considered. Caregiver status may influence inflammatory variables measured. Many studies have suggested a link between family caregiving and adverse mental and physical health consequences. However, family caregiving may also have positive effects on health and well-being. Several population-based studies have found longer lifespans for family caregivers compared to individuals who did not have family caregiver responsibilities [29]. However, AD caregiving is associated with higher levels of subjective stress measures, as well as elevated levels of C-reactive protein and inflammatory cytokines [30, 31].

Alzheimer's Disease is the most prevalent age-related neurodegenerative disease and is clinically characterized by a progressive loss of memory and other cognitive functions. Although it is difficult to identify which environmental factors induce AD and other dementia-based disorders, it is important to take preventative measures to delay cognitive impairments in high-risk individuals. Deficits in cognition lead to impairments in everyday inferences because they mediate processes involved in reasoning, synthesis, and problem-solving. In this study, we reject the original hypothesis that consuming a high-fat diet would cause cognitive impairments. Yet, it is interesting to note that nutrition science often has various conflicting information involved in what effects the human body. Nutritional evidence-based science data often reverse or contradict one another over time. This may explain why we saw more prominent cognitive deficits in the low-fat consumption group. Ultimately, this is a pilot study to power future studies involved in nutrition and cognitive functioning. By understanding which dietary modifications are needed to delay or mitigate the onset of AD, more nutritional based programs can be implemented. Subsequently, diet and nutrition-based interventions for those at risk for developing AD

may result in decreasing mortality rates linked to AD, especially in regions where nutrition influences culture.

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CONFLICT OF INTEREST

The author has no conflicts of interest to report.

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Table 1. Food Grouping Used in Dietary Pattern Analysis	
Food Groups	**Food Items**
Fried Potatoes / Onion	French Fries, Fried Potatoes, Potato Logs, Fried Onion Rings
Poultry and Game	Fried Chicken, "How often do you eat the skin on the chicken"
Lunch Meat, Bacon, and Eggs	Hot Dogs, Sausage (non-breakfast type), Ham, Bologna, Salami, Potted Meat, Luncheon Meat, Bacon, Breakfast Sausage, Eggs
Mixed Meat, Pizza, and Pasta	Mixed Dishes with Cheese (Macaroni and Cheese, Lasagna, Broccoli and Rice Casserole), Pizza
Dairy	Cottage Cheese, Cheese Spread and Dips, Yogurt (Not Frozen)
Beef and Pork	Fried Beef, Pork (chops, roasts, spareribs), "How often do you trim the fat from the meat"
Other Meat	Neck bones, Ham Hock, Pig's Feet, Liver
Fish	Fried Fish or Fish Sandwich (including catfish), Sardines, Maceral, Canned Salmon, Tuna Salad, Tuna Casserole,
Condiments	Gravy, Salad Dressing (Regular, Light, and Fat-Free), Mayonnaise
Desserts, Sweets, and Snacks	Ice Cream, Pudding, Custard, Cheesecake, Doughnuts, Cookies, Sweet Rolls, Muffins, Potato Chips, Corn Chips, Cracklings, Popcorn, Peanuts, Other Nuts, and Peanut Butter
Oils	Stick Margarine, Soft Tub Margarine, Butter, Salt Pork, Bacon Fat, Olive Oil, Canola Oil, Vegetable Oil
Vitamins	Omega 3 Fatty Acids
Other Beverages	Milk

Table 1. Food groupings were determine based on their section placement in the Lower Mississippi Delta Nutrition Intervention Research Initiative Food Frequency Questionnaire (Delta NIRI JHS FFQ).

Table 2. Characteristics of 26 African-American Women with Parental History of AD				
	Overall (n (%))	**High-fat**	**Low-Fat**	**P - Value**
Occupation Status				
Disabled	3(11.54)	1(14.29)	2(10.53)	0.1974
Retired	11(42.31)	1(14.29)	10(52.63)	
Unemployed/seeking employment	2(7.69)	0(0)	2(10.53)	
Work full-time	7(26.92)	4(57.14)	3(15.79)	
Work part-time	3(11.54)	1(14.29)	2(10.53)	
Type of Housing				
House/Apartment/Condominium	24(92.31)	6(85.71)	18(94.74)	0.4738
Relatives Home	2(7.69)	1(14.29)	1(5.26)	
Income				
$19,000 or less	5(19.23)	2(28.57)	3(15.79)	0.6978
$20,000-$39,000	6(23.08)	2(28.57)	4(21.05)	
$40,000-$59,000	8(30.77)	1(14.29)	7(36.84)	
$60,000-$79,000	2(7.69)	0(0)	2(10.53)	
$80,000 or more	5(19.23)	2(28.57)	3(15.79)	
Marital Status				
Married/partnered	7(26.92)	1(14.29)	6(31.58)	0.4303
Separated/Divorced	12(46.15)	3(42.86)	9(47.37)	
Single	4(15.38)	1(14.29)	3(15.79)	
Widowed	3(11.54)	2(28.57)	1(5.26)	
Education				
High school graduate/GED	1 (3.85)	0(0)	1(5.26)	0.0858
Vocational training	2 (7.69)	2(28.57)	0(0)	
Some college/associate's degree	4 (15.38)	0(0)	4(21.05)	
Bachelor's Degree (BA,BS)	13 (50)	5(71.43)	8(42.11)	
Master's degree (or other post-graduate training)	4 (15.38)	0(0)	6(21.05)	
Doctoral degree (PhD, MD, EdD, DDS, JD, etc)	2(7.69)	0(0)	2(10.53)	
Exercise Activity				
Never	2(7.69)	0(0)	2(7.69)	0.9315
Once a month	2(7.69)	1(14.29)	1(3.85)	
1 - 4 times per month	6(23.08)	2(28.57)	4(15.38)	
Greater than once a week	15(57.69)	4(57.14)	11(57.89)	
Don't know	1(3.85)	0(0)	1(5.26)	
Smoking Present				
Yes	7(26.92)	3(42.86)	8(42.11)	1

No	19(73.08)	4(57.14)	11(57.89)	
Alcohol in the past month				
Yes	7(26.92)	1(14.29)	12(63.16)	0.3748
No	19(73.08)	6(85.71)	7(36.84)	
High Cholesterol				
No	8 (30.77)	3(42.86)	5(26.32)	0.3006
Yes	16 (61.54)	3(42.86)	13(68.42)	
Unsure	2 (7.69)	1(14.29)	1(5.26)	
Have you ever been told you have high blood pressure?				
Yes	18 (62.23)	4(57.14)	14(73.68)	0.6353
No	8 (30.77)	3(42.86)	5(26.32)	
Do you have diabetes?				
Yes	5 (19.23)	1(14.29)	4(21.05)	1
No	19 (73.08)	6(85.71)	13(68.42)	
Unsure	2(7.69)	0(0)	2(10.53)	
Have you ever had a stroke?				
Yes	0(0)	0(0)	0(0)	
No	26(100)	7(100)	19(100)	
Did you have any learning problems in school?				
Yes	0(0)	0(0)	0(0)	
No	26(100)	7(100)	19(100)	
In general, how would you rate your quality of life?				
Low	2(7.69)	2(28.57)	0(0)	0.0675
Moderate	13(50)	3(42.86)	10(52.63)	
High	9(34.62)	2(28.57)	7(36.84)	
Very High	2(7.69)	0(0)	2(10.53)	
BMI	30.65(4.86)	32.48(5.51)	29.98(4.57)	0.2527
Age	59.5 (8.20)	55.57(5.38)	60.95(8.67)	0.1412
Number of Medications	5.85 (4.24)	6.43(5.09)	5.63(4.02)	0.6796
Number of Falls	0.5833(0.88)	0.7143(0.78)	0.5294(.94)	0.6504
Years of Education	15.50 (3.22)	15.43(0.98)	16.21(2.10)	0.3563

Table 2. Characteristics of 26 African-American Women with Parental History of AD. Independent t tests were used to determine significant differences between groups on age, number of medications, number of falls, and years of education.

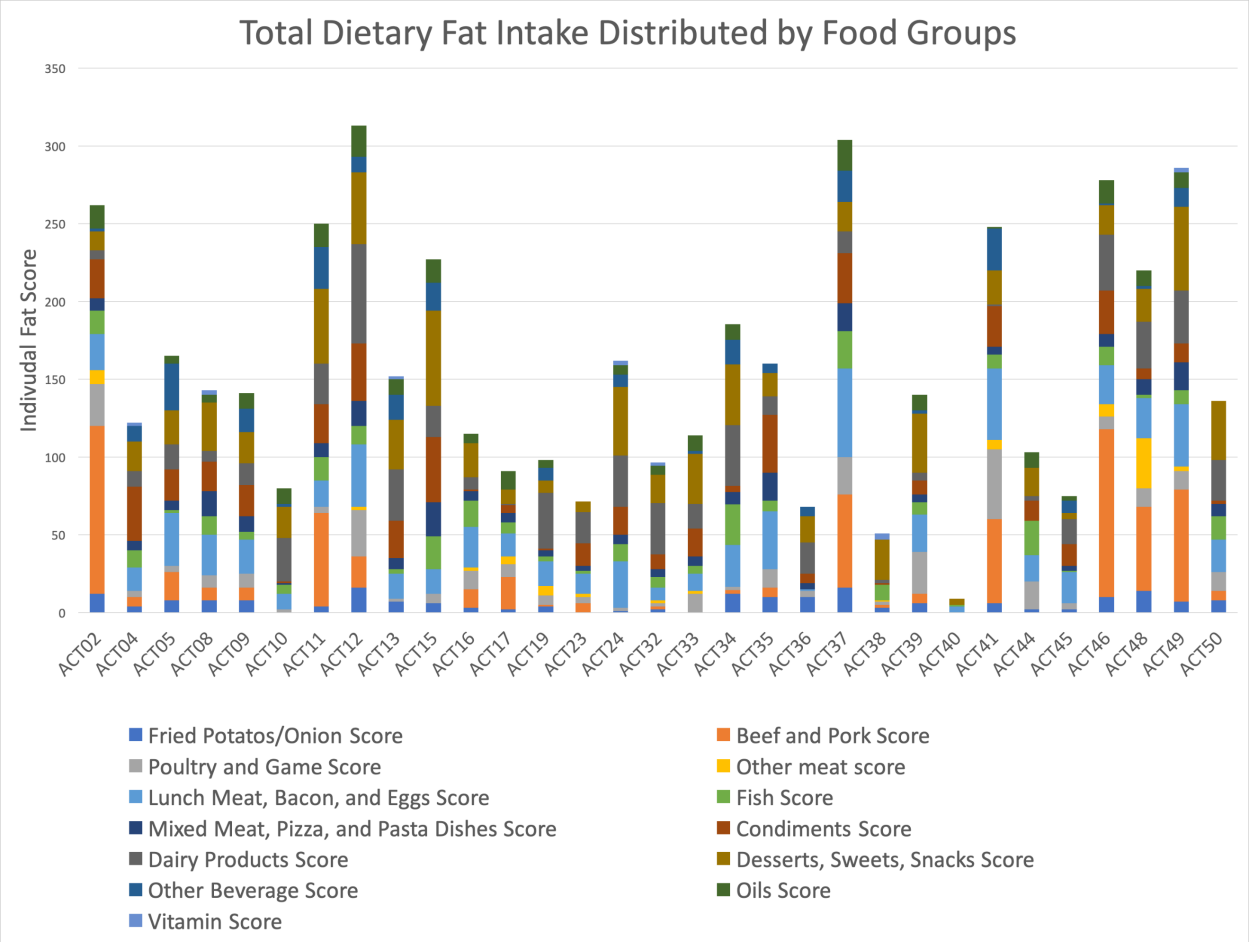

Figure 1. Total individual fat score of 26 African-American Women with Parental History of AD separated by food groups.

Table 3. Cognitive performance of 26 African-American Women with Parental History of AD				
Variable		***M(SD)***	***d***	***p***
MoCA	Low-fat Intake	24.68 (2.67)	0.46^	0.0226*
	High-fat Intake	27 (2.23)	0.75^	
TOL	Low-fat Intake	9.63 (2.31)	0.01	0.9703
	High-fat Intake	9.86 (1.35)	0.01	
TMT Diff. (Trails B – A)	Low-fat Intake	50.32 (23.32)	0.21^	0.3635
	High-fat Intake	41.8 (28.00)	0.35^	
Corsi	Low-fat Intake	9.63 (2.31)	0.01	0.9703
	High-fat Intake	9.85 (1.35)	0.01	

Table 3. Performance of High-fat and Low-fat groups for cognitive Measures in African-American Women with Parental History of AD (n=26). *M* = mean; *SD* = standard deviation

* p-values determined with Mann-Whitney U test

^ Moderate effect size according to Cohen's d

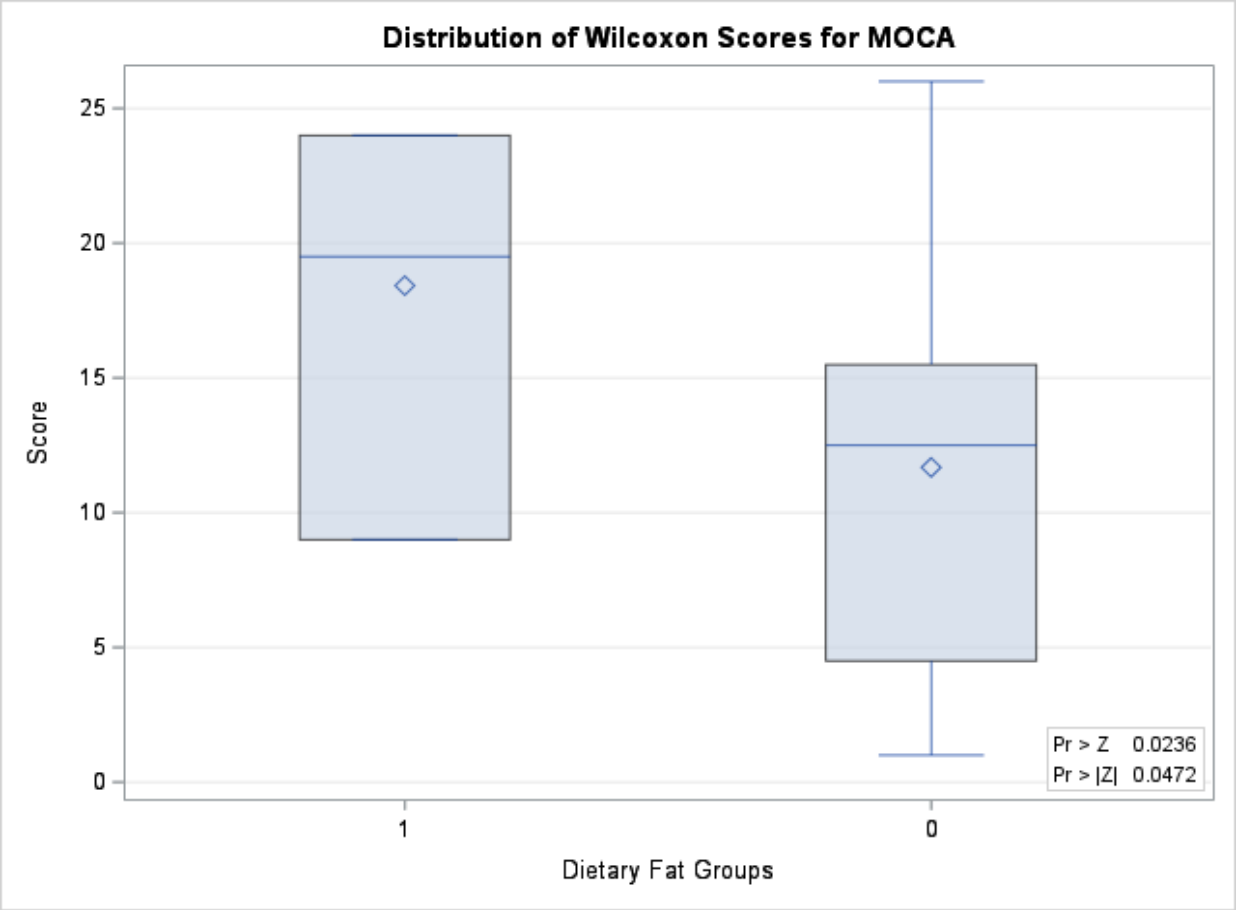

Figure 2. Statistically significant box plots of Montreal Cognitive Assessment Score and Dietary Fat Group (1=High-fat, 0 = Low-fat) Variables.

Table 4. Inflammatory Variables of 26 African-American Women with Parental History of AD								
Variable		***M***	**SD**	**Median**	**IQR**	**Q1**	**Q3**	***p***
CRP^	Whole Sample	0.3877	0.4766	0.21	0.36	0.1	0.46	0.71
	Low-fat Intake	0.3937	0.5235	0.22	0.39	0.07	0.46	
	High-fat Intake	0.3714	0.3517	0.2	0.55	0.11	0.66	
IL-10	Whole Sample	11.1	5.07	9.91	6.3	7.64	13.94	0.6478
	Low-fat Intake	10.96	5.4106	8.84	6.83	7.23	14.06	
	High-fat Intake	11.47	4.3662	10.73	5.6	8.34	13.94	
IL-8	Whole Sample	13.2	32.88	3.8	3.6	2.87	6.47	0.5877
	Low-fat Intake	16.51	38.1752	3.95	3.76	2.87	6.63	
	High-fat Intake	4.24	0.3517	3.65	3.19	2.78	5.97	

Table 4. Inflammatory Variables of 26 African-American Women with Parental History of AD
M = mean; *SD* = standard deviation; IQR = interquartile range; Q1 = quartile 1; Q3 = quartile 3; IL= interleukin; TNFα = Tumor necrosis factor alpha.
*p-values determined with Mann-Whitney U test
^ measured in ng/mL, all others measured in pg/mL