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Research Article

DASH and Mediterranean-Dash Intervention for Neurodegenerative Delay (MIND) Diets Are Associated With Fewer Depressive Symptoms Over Time

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Abstract

Background: Depression is common in older adults and more prevalent in those with cognitive impairment, vascular risk factors, or stroke. Nonpharmacologic strategies to reduce depression, such as diet, may be effective; however, few studies have investigated the relation.
Methods: A total of 709 participants (23.3% men, mean age 80.4), from an observational prospective cohort study were assessed annually for an average of 6.53 years of follow-up. Participants with missing or invalid baseline dietary evaluations or fewer than two depression assessments were excluded. Depressive symptoms were assessed with a 10-item version of the Center for Epidemiologic Studies Depression scale. High burden of depressive symptoms was defined as the presence of four or more depressive symptoms. Diet scores were computed using a validated food frequency questionnaire for the Dietary Approaches to Stop Hypertension (DASH) diet, Mediterranean diet, Mediterranean-DASH Intervention for Neurodegenerative Delay (MIND) diet, and Western diets. Diet scores were modeled in tertiles. A generalized estimating equation (GEE) model was performed for the longitudinal analysis of depression as a binary outcome.
Results: Participants in the highest tertile of the DASH (β = −0.10, confidence interval [CI]: −0.20, −0.0064) and MIND (β = −0.12, CI: −0.23, −0.0092) diet scores had lower rates of depressive symptoms over time when compared to those in the respective lowest tertiles. The Western diet was positively associated with depressive symptoms over time (β = 0.093, *p*-trend = .05).
Conclusions: Diet may be effective in reducing depressive symptoms in older adults. A diet intervention trial may be needed to determine the optimal nutritional components for prevention of late onset depression.

Keywords: Depression, Aging, Nutrition

Depression is common, often recurrent, and disabling. Lifetime prevalence estimates for major depressive disorder are as high as 20% (1). While older adults typically have rates of depression comparable to the general population (2), those with medical comorbidities, such as coronary artery disease and stroke are at higher risk (3). Additionally, depression may exacerbate comorbid conditions, such as diabetes (4). There is also concern that depression may be underdiagnosed in the older adults, and for unknown reasons, the prevalence of depression has been increasing worldwide.

The discovery of antidepressants has revolutionized the treatment of depression, but challenges remain for many patients, such as troubling side effect profiles, poor compliance, delayed therapeutic onset, and ineffectiveness for some people, particularly those with mild depression (5). In severe depression, individuals may remain refractory to even multimodal interventions of antidepressants, cognitive behavioral therapy, and electroconvulsive therapy (6). As such, complimentary strategies to prevent and treat depression are needed. A limited number of studies reported lower rates of depression among individuals whose diets resembled the cardio-protective Mediterranean and DASH diets (7–9), suggesting that diet may be a promising nonpharmacologic approach to ward off depression in older adults. In this study, we examined how the MIND diet that is

specifically designed for brain health compares with these cardiovascular protective diets and the westernized diet pattern in the development of depressive symptoms in a community-based longitudinal cohort study.

Methods

Study Population

The study was conducted using data from the Rush Memory and Aging Project (MAP), a study of volunteers living in retirement communities and senior public housing units in the Chicago area. The ongoing open cohort study began in 1997 and includes annual clinical examinations, as previously described (10). Beginning in 2004, the MAP study participants began completing comprehensive food frequency questionnaires (FFQs). Of the 1,911 older persons enrolled in the MAP study, 1068 had at least one valid FFQ that served as the baseline for these analyses. Of these, 709 had two or more annual assessments of depressive symptoms. The Institutional Review Board of Rush University Medical Center approved the study, and all participants gave written informed consent.

Depression Evaluations

Participants completed a 10-item version of the Center for Epidemiologic Studies Depression scale (Radloff, 1977) at each evaluation (11,12). Individuals were asked if they had experienced any of the 10 depressive symptoms in the past week (eg, "I felt like everything I did was an effort"). High burden of depressive symptoms was defined as a score greater than or equal to 4 (13). Use of antidepressant medication was recorded.

Diet Pattern Scoring

Diet pattern scores were based on responses to a modified Harvard semiquantitative FFQ, which was validated for use in older Chicago community residents (14). The typical intake frequency of 144 food items was reported by participants over 12-month period. Caloric content and nutrient levels for each food item were based on age- and sex-specific portion sizes from national dietary surveys, or by a logical portion size (eg, slice of bread). Details of the dietary components and scorings for the MIND, DASH, and Mediterranean diets have been previously reported (15–17).

The MIND diet score is based on a combination of 10 healthy food groups (green leafy vegetables, other vegetables, nuts, berries, beans, whole grains, fish, poultry, olive oil, and wine) and 5 unhealthy food groups (red meats, butter and stick margarine, cheese, pastries and sweets, and fried/fast food). If olive oil was reported as the primary oil used at home, it was scored 1. Otherwise, olive oil consumption was scored 0. For the remaining components, the frequency of consumption of each food item for a given score component was summed and then given a concordance score of 0, 0.5, or 1, where 1 represents highest concordance (15). The final MIND diet score was the sum of the 15 component scores.

Scoring for the DASH diet was determined based on consumption of three dietary components (total fat, saturated fat, and sodium) and seven food groups (grains, fruits, vegetables, nuts, seeds and legumes, dairy, and meat) (17). Scores of 0, 0.5, and 1 were assigned to each food group based on the frequency of consumption. Total possible scores ranged from 0 (lowest) to 10 (highest) diet concordance.

The Mediterranean diet pattern was based on the MedDiet score as described by Panagiotakos and colleagues (16), which uses serving quantities of the traditional Greek Mediterranean diet as the comparison metric. Eleven dietary components (nonrefined cereals, potatoes, fruits, vegetables, legumes, fish, red meat and products, poultry, full fat dairy products, use of olive oil in cooking, and alcohol) were each scored from 0 to 5 and then summed for a total score ranging from 0 (lowest concordance) to 55 (highest concordance).

The Western diet pattern was based on the 40 foods or food groups described by Hu et al. (1999). A rotated factor pattern analysis was then run using the factor procedure in SAS, and two major patterns were found. We then computed the factor score for each pattern by combining the variables that were observed for that pattern, with weights that were proportional to their individual components and factor loadings (Kim et al. 1978). A dietary pattern consistent with the Western and prudent diets were found. From the analyses, the western diet pattern was characterized by intake of food items that are processed and/or high in fat and simple carbohydrates: red and processed meat, eggs, refined grains, French fries, high-fat dairy products, sweets, and snacks.

Covariates

Nondietary variables in the analysis were obtained at the participant's baseline clinical evaluation through structured interview questions and measurements. Participants self-reported their birth date and years of education. Physical activity was determined by participants self-reported minutes spent over the previous 2 weeks on 5 activities (walking for exercise, yard work, calisthenics, biking, and water exercise) (18). Height and weight were measured to determine body mass index (BMI = weight in kg/height in m^2) and modeled as two indicator variables, BMI ≤ 20 and BMI ≥ 30. Hypertension was defined by an average of two blood pressure measurements ≥ 160 mmHg systolic or ≥ 90 mmHg diastolic, or if the patient reported a history of hypertension or was currently taking antihypertensive medications. Myocardial infarction history was based on current use of cardiac glycosides (eg, lanoxin, digoxin) or by self-reported history. History of diabetes was obtained by self-reported medical diagnosis or by current use of diabetic medications. Diagnosis of stroke was obtained by self-reported history and neurologic examination (19). Medication use was based on interviewer inspection.

Statistical Analysis

A generalized estimating equation (GEE) model was performed for the longitudinal analysis of burden of depressive symptoms as a binary outcome for the MIND, DASH, Mediterranean, and Western diets to describe the relationship between dietary patterns and depression over time in older adults. The four dietary patterns were examined in a basic-adjusted model that included potential confounders that have been previously associated with depression: age, caloric intake, education, sex, and use of antidepressant medications. Additional adjustments were then made for (a) cardiovascular disease (hypertension, diabetes, myocardial infarction, and stroke) and (b) physical activity. The dietary scores were modeled as indicators of the top two tertiles in each of these models. Additionally, a test of linear trend was assessed for each by assigning the median tertile intake level to all those in a given tertile and modeling as a single categorical variable. A sensitivity analysis was then performed excluding subjects who have ever taken antidepressants.

Results

The cohort was predominantly female (75%), with 15 (±2.9) years of education and mean age of 80.4 (±7.2) years (Table 1). Subjects

Table 1. Baseline Characteristics by Tertile of DASH Diet Score Among 709 Participants of Memory and Aging Project

Baseline Characteristics	Total	Tertile 1	Tertile 2	Tertile 3
n	709	302	197	210
Dash diet score (median, q1 q3)	4.0 (3.0, 5.0)	3.0 (2.5, 3.5)	4.5 (4.0, 4.5)	5.5 (5.0, 6.5)
Age (years, mean)	80.4	80.3	81.0	80.1
Males (%)	23.3	24.5	21.3	23.3
Education (years, mean)	15.1	14.6	15.1	15.5
Late-life social activity (mean)	2.7	2.7	2.7	2.8
Physical activity (mean)	3.5	2.8	3.3	4.3
Diabetes (%)	13.5	15.2	16.8	8.1
Hypertension (%)	69.9	74.8	69.1	63.8
Stroke (%)	10.4	10.3	11.2	9.7
Myocardial infarction (%)	16.1	17.6	16.2	13.8
Baseline antidepressant use (%)	12.9	13.9	10.2	14.3

Table 2. Estimated Effects (β [95% CI]) of the DASH, Mediterranean, MIND and Western Diet Scores on the Rate of Change in Depressive Symptoms Among MAP Participant (*n* = 709) Over an Average of 6.53 Years of Follow-up Using Linear Mixed Models Adjusted for Age, Sex, Education, Total Calories and Physical Activity

		N	T1	T2 β (95% CI)	T3 β (95% CI)	Linear trend, *P*-value
DASH diet score	Model 1	709	Ref	*–0.041 (–0.121, 0.038)*	***–0.103 (–0.200, –0.006)***	***.03***
	Model 2	651	Ref	*–0.045 (–0.125, 0.035)*	***–0.102 (–0.203, –0.0005)***	***.03***
Mediterranean diet score	Model 1	709	Ref	0.001 (–0.068, 0.073)	–0.020 (–0.119, 0.078)	.71
	Model 2	651	Ref	0.002 (–0.071, 0.075)	–0.024 (–0.127, 0.078)	.69
MIND Diet Score	Model 1	709	Ref	–0.011 (–0.081, 0.058)	***–0.121 (–0.233, –0.009)***	***.04***
	Model 2	651	Ref	–0.012 (–0.084, 0.060)	***–0.132 (–0.249, –0.016)***	***.03***
Western Diet Score	Model 1	709	Ref	0.061 (–0.026, 0.148)	***0.093 (0.011, 0.176)***	***.05***
	Model 2	651	Ref	0.064 (–0.026, 0.153)	***0.105 (0.021, 0.189)***	***.02***

Note: Basic Adjustments, Model 1adjusted for age, sex, education, total caloric intake, and use of antidepressant medications.
Model 2 adjusted for Model 1 + cardio vascular conditions (hypertension, diabetes, myocardial infarction and stroke).
Italicized and bold—statistically significant *Italicized*—approaching significance.
CI = confidence interval.

were assessed annually for an average of 6.53 years. The median overall diet scores for the population were the following: DASH 4.0 (interquartile range [IQR] 3.0, 5.0), MIND 8.0 (IQR 6.5, 9.0), Mediterranean 32.0 (IQR 28.0, 35.0), and Western 2.8 (IQR 2.0, 3.8). Late-life cognitive activity between tertiles was similar. Tertile 3 was more physically active, and had lower rates of diabetes, hypertension, myocardial infarction, and stroke. The DASH diet score was moderately positively associated with Mediterranean diet score (r = .49, p < .0001) and Mind diet score ((r = .61, p < .0001) but negatively associated with Western diet score (r = –.38, p < .0001) in the overall study population. Mean age between tertiles was similar (range 80.3–81.0).

With adjustments for age, caloric intake, education, sex, and use of antidepressant medications, those with the highest DASH diet scores were significantly less likely to screen positive for depressive symptoms over time, as compared to those with the lowest scores (Table 2) Participants in the highest tertile of MIND diet scores also had a lower incidence of depressive symptoms over time (Table2). There were no significant differences between tertiles for the Mediterranean diet scores (Table 2). However, the Western diet was positively associated with depression over time (Tertile 3 vs. Tertile 1: β = 0.093, p-trend = .05). Additional adjustments to the basic models (Model 2) for cardiovascular conditions (defined as hypertension, diabetes, myocardial infarction, and stroke) did not alter results (Table 2).

Lack of physical activity could predispose an individual to depression or may also result from an individual being depressed. Thus, we further adjusted Model 2 for physical activity. Tertile comparisons and linear trends remained unchanged for each of the diet patterns. The highest tertile of DASH (β = –0.10, confidence interval [CI]: –0.21, –0.0047, p-trend = .027) and MIND (β = –0.13, CI: –0.25, –0.018, p-trend = .025) diet scores were associated with fewer depressive symptoms over time. The Western diet pattern continued to be associated with more depressive symptoms over time (β = 0.11, CI: 0.021, 0.189, p-trend = .016)

A sensitivity analysis was performed excluding subjects who have ever taken antidepressants. The highest tertile of the DASH diet remained significantly associated with fewer depressive symptoms (T3 vs T1: β = –0.2082 [SE = 0.0803, p = .010]; p-trend = .007) and the Western diet remained associated with more depressive symptoms over time (T3 vs T1: β = 0.1570 [SE = 0.0678, p = .021], p-trend = .02). Results for the highest tertile of the MIND diet showed a nonsignificant trend towards fewer depressive symptoms (T3 vs T1: β = –0.1559 [SE = 0.0840, p = .06]; p-trend = .08). Results for the Mediterranean diet remained unchanged.

Discussion

Depression is a common and disabling condition that is projected to be the leading cause of disability-adjusted life years lost by 2030 (WHO Update, Geneva 2004). Our study found that high DASH and MIND diet scores were associated with lower rates of depressive symptoms over time. In contrast, a dietary pattern highly consistent with the Western diet was associated with higher rates of depressive symptoms over time. Our study adjusted for other factors commonly associated with depression, including age, caloric intake, education, sex, and use of antidepressant medications. Results remained unchanged with additional adjustments for cardiovascular disease (diabetes, hypertension, myocardial infarction, and stroke) and physical activity.

Our results replicate previous findings that a healthy dietary pattern may be effective in preventing depressive symptoms. A prospective cohort study of 14,051 participants from the SUN project found that after a median follow-up of 8 years, a diet pattern that moderately resembled the DASH diet was related to lower depression risk (8). Findings supporting the role of a healthy diet in the prevention of depression have been reported across a variety of age groups, including a study in adolescent girls that found a diet that highly resembled the DASH diet was associated with a lower odds of depression compared to subjects with a diet that was less consistent with the DASH diet (lowest quartile) (20).

Where this study did not find an association between the Mediterranean Diet and depressive symptoms, other studies have reported this association. In both a study from the SUN project (9) and in the PREDIMED study (where subjects with type 2 diabetes who were assigned to the intervention arm of a Mediterranean diet supplemented with nuts), participants were significantly less likely to develop depression over time (21). A recent study by Fresan and colleagues specifically suggested that the Mediterranean diet, but not the MIND diet, may be effective in preventing depressive symptoms (22). It is important to point out several key aspects of that study in comparison to our study. The first is that the population studied was different, with a much younger cohort. At baseline, the mean age in Fresan and colleagues' study was approximately 35–40 years old, while the mean age in our study was 80 years old. Secondly, different scoring was used for the Mediterranean diet in Fresan and colleagues' study, with a 0–10 scale frequently known as the Mediterranean diet adherence score, as opposed to the 55-point Mediterranean score used in this study. Finally, the main outcome variable in the Fresan and colleagues' study is based on self-reported physician made diagnosis of depression or use of antidepressant rather than any score, such as the CESD in our study.

While most data on the role of dietary pattern for preventing depression come from large epidemiological cohort studies, several randomized controlled trials also support this finding (23,24). In a study by Garcia-Toro and colleagues, 80 nonseasonal depressive outpatients on antidepressant treatment were randomly assigned to a lifestyle intervention that included a dietary intervention consisting of four hygienic-dietary recommendations: eat at regular hours without snacking between meals, avoid of sugary drinks, eat fish at least three times per week, and consume fruit, cereals, nuts, and vegetables daily. Outcome measures were assessed blind before and after the 6-month intervention period. Results suggested that lifestyle intervention can be used as an effective antidepressant complementary strategy in daily practice.

More recently, in a randomized controlled trial from Australia, the SMILES trial, a total of 67 participants with depression were randomized to either a 12-week intervention of seven individual nutritional consulting session promoting the "ModiMedDiet" versus a social support protocol to the same visit schedule and length.The study showed that an intervention to treat moderate to severely depressed individuals with poor diets at baseline resulted in significantly lower rates of depression at the end of the intervention period (24).

Conversely, several studies have found an association between depression and a traditional Western diet, which contains high levels of refined sugars and carbohydrates, fried foods, and saturated fats. Researchers from the Whitehall II longitudinal study found a detrimental influence of the Western diet on depressive symptoms in middle age women (25). A separate study from the Whitehall II prospective cohort found that in middle-aged adults, increased intake of "processed food" such as sweetened desserts, fried food, processed meat, refined grains, and high-fat dairy products was associated with increased odds of depression over time, based on CESD score (26). The western diet was also associated with higher General Health Questionnaire scores in a longitudinal, age-stratified, randomly selected population-based sample of 1,494 women in the Geelong Osteoporosis Study from Australia (27).

The mechanism by which dietary pattern may prevent depression is currently unclear, but it may occur on a cellular level. A wealth of cardiovascular literature supports the role of diet in reducing metabolic and inflammatory processes, including insulin insensitivity, elevations in plasma homocysteine levels, and endothelial dysfunction (28–30). The production of proinflammatory cytokines may interfere with the production and metabolism of neurotransmitters, decreasing the availability of some important precursors such as tryptophan (31). The brain-derived neurotrophic factor (BDNF), which is produced by a healthy cerebral endothelium, may serve as a protector against neuronal dysfunction and degeneration (32). Several meta-analysis have found that depressed patients have lower than normal levels of BDNF and that treatment with antidepressants upregulate these levels (33,34).

A variety of inflammatory markers, including IL-1, IL-6, TNF alpha, and hsCRP have been found to be elevated in depressed individuals (35), and it is hypothesized that a chronic inflammatory state may contribute to the pathophysiology of depression. Diets high in processed foods, including refined sugars, cured meats, and saturated fats have been associated with an increase in inflammatory markers, including inflammation within the central nervous system (36,37).

Conversely, a healthy diet, high in vegetables, fruit, whole grains, nuts, and legumes provides a substrate for anti-inflammatory processes (38,39). Data from the Nurses' Health Study found lower concentrations of CRP and IL-6 in subjects eating a higher intake of vegetables, fruit, whole grains, fish, and legumes (40). A high fiber diet, rich in plant nutrients, may foster a healthy gut microbiome that shifts the entire body away from a chronic inflammatory state (41).

There are several limitations to this study, the most important of which is that it is observational in nature, so a cause and effect relationship cannot be claimed. This study did not find an association between a diet pattern that closely resembledthe Mediterranean diet and depression over time, although it is possible that such an association could appear with a larger sample size, particularly as other large observational cohort studies have found this correlation. The MAP cohort is an older, predominantly non-Hispanic white population, so findings should not be generalized to other ethnic groups or younger cohorts, although previous studies have found associations between a healthy diet pattern and reduced depressive symptoms in

these populations (42–46). The dietary questionnaires had limited questions regarding some of the dietary components and information on frequency of consumption. For example, a single item each provided information on the consumption of nuts, berries, beans, and olive oil. Study strengths include the use of a validated food questionnaire for comprehensive dietary assessment, measurement of depressive symptoms with a validated scale (CESD), and statistical control of the important confounding factors.

Depression is a serious and common condition that is a leading cause of disability. In addition to pharmacologic and behavioral therapy, lifestyle modification such as adopting a healthy dietary pattern may be an effective strategy to reduce depressive symptoms over time. Further randomized trials are needed to ascertain the optimal dietary pattern to treat depression, but this study adds to a large and growing body of evidence that a healthy diet pattern, such as the DASH or MIND diet, may be an effective tool in battling depression.

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Conflict of Interest

None reported.

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