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ORIGINAL ARTICLE

Adherence to the MIND Diet and Its Effect on Glycemic Parameters in Patients with Type 2 Diabetes: A Cross-Sectional Study

Tip 2 Diyabetlilerde MIND Diyetine Uyumun Glisemik Parametreler Üzerindeki Etkisi: Kesitsel Bir Çalışma

[1]Emine KOÇYİĞİT , [2]Tevfik KOÇAK , [3]Yağmur DEMİREL ÖZBEK

[1]Department of Nutrition and Dietetics, Faculty of Health Sciences, Ordu University, Ordu, Türkiye.
[2]Department of Nutrition and Dietetics, Faculty of Health Sciences, Gümüşhane University, Gümüşhane, Türkiye.
[3]Department of Nutrition and Dietetics, Faculty of Health Sciences, Recep Tayyip Erdoğan University, Rize, Türkiye.

Correspondence

Emine KOÇYİĞİT,
Ordu Üniversitesi, Sağlık Bilimleri Fakültesi, Beslenme ve Diyetetik Bölümü, 52200 Ordu, Türkiye.

E-Mail: kocyigitem@gmail.com

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ABSTRACT

Aim: This study aimed to assess the relationship between Mediterranean-Dietary Approach to Stop Hypertension Intervention for Neurodegenerative Delay (MIND) diet score and indicators of glucose control and lipid metabolism in patients with type 2 diabetes mellitus.
Methods: This cross-sectional study involved 459 patients diagnosed with type 2 diabetes mellitus aged 20-64 years. Patients with type 2 diabetes mellitus completed a general information form and anthropometric measures. The MIND diet scores obtained from the MIND diet components form. The biochemical parameters gathered from individuals over the last three months were documented.
Results: The mean age and body mass index in the study population were 49.10±10.10 years and 30.62±5.48 kg/m2. Overall, the mean MIND diet score was 8.64±1.75, and 47.10% had high adherence to the MIND diet. A significant difference was found between HbA1c and fasting plasma glucose (FBG) in the MIND groups, as well as a substantial negative association identified among HbA1c, FBG, and MIND scores.
Conclusions: This study emphasized the significant incidence of overweight and obesity among Turkish adults with type 2 diabetes mellitus. Higher adherence to the MIND diet is associated with better glycemic control. Higher MIND diet scores associated with reduced HbA1c and FBG levels. However, no significant associations with the parameters of lipid metabolism were found. By emphasizing nutrient-dense foods and supporting both metabolic and psychological health, the MIND diet may represent a valuable adjunct to conventional diabetes management.

Keywords: Cross-sectional, MIND diet, nutrition, type 2 diabetes mellitus

ÖZ

Amaç: Bu çalışma, tip 2 diabetes mellitus hastalarında Nörodejeneratif Gecikme için Akdeniz-Hipertansiyonun Önlenmesi için Beslenme Yaklaşımı Müdahalesi (MIND) diyet skoru ile glikoz kontrolü ve lipit metabolizması göstergeleri arasındaki ilişkiyi değerlendirmek amacıyla yapılmıştır.
Gereç ve Yöntemler: Bu kesitsel çalışmaya, 20-64 yaşları arasında tip 2 diabetes mellitus tanısı almış 459 hasta katılmıştır. Tip 2 diabetes mellitus tanılı bireyler, genel bilgi formunu doldurmuş ve antropometrik ölçümleri kaydedilmiştir. Bireylerin MIND diyeti skorları, MIND diyeti bileşenleri formu kullanılarak hesaplanmıştır. Katılımcıların son üç ay içerisinde elde edilen biyokimyasal parametreleri kaydedilmiştir.
Bulgular: Bireylerin ortalama yaşı 49,10±10,10 yıl, beden kütle indeksi ise 30,62±5,48 kg/m² olarak belirlenmiştir. Ortalama MIND diyeti skoru 8,64±1,75 olup, katılımcıların %47,10'u MIND diyetine yüksek düzeyde uyum göstermiştir. MIND grupları arasında HbA1c ve açlık plazma glukozu (APG) değerleri açısından anlamlı fark saptanmış, ayrıca HbA1c, APG ve MIND skorları arasında negatif yönlü anlamlı ilişki tespit edilmiştir.
Sonuçlar: Bu çalışma, tip 2 diyabetli Türk yetişkinlerde aşırı kilo ve obezitenin yüksek prevalansa sahip olduğunu ortaya koymuştur. MIND diyetine yüksek düzeyde uyum, daha iyi glisemik kontrol ile ilişkili bulunmuştur. Yüksek MIND diyeti puanları, HbA1c ve FBG düzeylerinde azalma ile ilişkilendirilmiştir. Ancak, lipid metabolizması parametreleri ile anlamlı bir ilişki bulunmamıştır. Besin değeri yüksek gıdalara odaklanarak metabolik ve psikolojik sağlığı destekleyen MIND diyeti, diyabetin geleneksel tedavisine değerli bir tamamlayıcı olabilir.

Anahtar Kelimeler: Beslenme, kesitsel, MIND diyet, tip 2 diabetes mellitus

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Introduction

Type 2 diabetes mellitus (T2DM) is a chronic metabolic condition marked by persistently increased blood glucose levels resulting from inadequate insulin production, poor insulin action (insulin resistance), or a combination of these factors [1, 2]. In 2024, an estimated 589 million individuals (aged 20–79 years) globally are affected by diabetes, representing approximately 11.1% of the adult population, or nearly 1 in 9 persons. More than 90% of these cases are T2DM, predominantly influenced by economic, social, demographic, environmental, and genetic variables [3]. A recent multi-centre, retrospective, cross-sectional research conducted in Türkiye indicated that the prevalence of T2DM among adults aged 18 years and older was 35.01% [4].

The Mediterranean diet, vegetarian diet, and food groups such as whole grains, fruits, and vegetables have demonstrated efficacy in the prevention and control of diabetes mellitus by enhancing insulin and glucose metabolism [5, 6]. In response to the increasing rate of diabetes both nationally and globally, there is a growing body of research examining the effects of healthy dietary practices focused on diabetes prevention.

The MIND diet, meaning Mediterranean-Dietary Approach to Stop Hypertension Intervention for Neurodegenerative Delay, is a novel dietary strategy that integrates components from both the Mediterranean diet and the Dietary Approach to Stop Hypertension Intervention diet. The MIND diet has 10 elements for cognitive health: green leafy vegetables, other vegetables, nuts, berries, legumes, whole grains, seafood, poultry, olive oil, and wine. It is advisable to restrict the intake of foods like red meat, butter, margarine, cheese, confections, fried items, and fast food [7, 8]. A systematic review showed that the MIND diet reduces the pace of cognitive deterioration. It shows advantages in obese individuals, enhancing working memory, language recognition, memory, and attention [9]. However, research examining its impact on T2DM is notably scarce. A study revealed that elevated MIND diet scores correlate with enhanced cardiometabolic profiles, diminished incidence of T2DM, and lowered all-cause and cardiovascular mortality in patients with T2DM [10]. The high bioactive chemical composition of the MIND diet could provide protection. Polyphenols improve insulin sensitivity via modulating glucose metabolism and maintaining β-cell function. Omega-3 polyunsaturated fatty acids enhance mitochondrial function, insulin sensitivity, and have antioxidant and anti-inflammatory properties. Plant-based anti-inflammatory diets diminish chronic inflammation and oxidative stress, as well as protect against metabolic and neurological disorders [11, 12]. This study aims to assess the correlation between adherence to the MIND diet and glycemic parameters for adults with T2DM.

Research Questions

The study aimed to address the following research questions:

1. Is there a correlation between the MIND diet score and glycemic parameters in individuals with T2DM?

2. Is there a significant difference in glycemic parameters between T2DM patients exhibiting low versus high adherence to the MIND diet?

Materials and Methods

Study Design and Participants

This cross-sectional study was performed from January to June 2024 via face-to-face interviews with 459 individuals diagnosed with T2DM. The research population comprised individuals aged 20-64 with T2DM who accessed treatment at family health centers associated with the Gümüşhane Provincial Health Directorate, in the northeast of Türkiye. The study was conducted with 459 patients with T2DM. The research defined exclusion criteria for participants with chronic kidney and liver diseases, parathyroid disorders, sleep disturbances, and psychiatric conditions, in addition to those utilizing corticosteroids, insulin, vitamin-mineral supplements, vitamin D replacement within the preceding six months, postmenopausal hormone therapy, and medications for osteoporosis treatment.

Ethical permission was obtained from the Gümüşhane University Scientific Research and Publication Ethics Committee (Meeting Number: 2023/6; Date: 13.12.2023). The research was conducted in compliance with the principles outlined in the Declaration of Helsinki. All participants provided informed consent.

Data Collection Tools

Data were obtained using the survey and a face-to-face interview with T2DM patients. The questionnaire consisted of six parts: 1. general information (gender, age, education level), 2. health information and nutritional habits (smoking, and alcohol consumption status, the number of meals eaten per day), 3. anthropometric measurements (body weight and height), 4. metabolic parameters, 5. MIND diet score. The patients with T2DM self-reported their height (cm) and body weight (kg). The BMI is determined by dividing body weight by the square of height and is evaluated based on the World Health Organization's BMI classification. The classification of BMS is outlined as follows: A value below 18.50 kg/m2 signifies underweight, while a range from 18.50 to 24.99 kg/m2 indicates normal weight. A value between 25.00 and 29.99 kg/m2 is classified as overweight, and a measurement exceeding 30.00 kg/m2 is categorized as obese [13].

Biochemical Measurements

The metabolic parameters of patients who received

family health care in the past three months have been documented according to the values present in the system. Metabolic parameters included Hba1c, fasting plasma glucose (FPG), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), total cholesterol (TC), and triglyceride (TG) values.

The MIND Diet Score

The MIND score [7] consists of fifteen dietary elements. These are ten beneficial for brain health (green leafy vegetables, other vegetables, nuts, berries, beans, whole grains, fish, poultry, olive oil, and wine) and five detrimental items (red meats, butter/margarine, cheese, pastries and sweets, and fried/fast food). Olive oil consumption was given a score of 1 if it was utilized as the main oil. The frequency of intake for each food item related to all other diet score components was gathered and then given a concordance score of 0, 0.5, or 1. The overall MIND diet score was derived by adding the scores of the separate components. The components of the MIND diet and the scoring are listed in Table 1.

Statistical Analysis

The sample size was calculated by the researchers, based on a study conducted by [14], using the simple random sampling method, to determine the minimum sample size (power: 99%, $\alpha = 0.05$) to be 373 (http://www.raosoft.com/samplesize.html). The statistical analysis utilized the Statistical Package for the Social Sciences (version 26.0) (IBM Corp., Armonk, NY, USA). The distribution of the data was evaluated using visual methods such as histograms and probability graphs, along with analytical techniques like the Shapiro–Wilk test. For numerical data, descriptive statistics were displayed as mean and standard deviation, while for categorical variables, frequency and percentage were displayed. The MIND score cutoff was defined based on the median [15]. The median value of the MIND score was determined at 8.5, where scores ≤8.5 were categorized as low MIND scores, and those >8.5 were categorized as high MIND scores. An Independent t-test was used for the normal distribution of data, and the Mann–Whitney U test was used to test non-normal data. Relationships between numerical variables were given with the Pearson correlation. The results were statistically assessed at a level of significance of $p < 0.05$.

Results

Of the patients with T2DM, 58.60% were female, 41.40% male, and the mean age of the patients was 49.10±10.10 years. The major percentage of individuals are secondary school graduates (45.50%) and married (83.20%). The mean number of main meals per day is 2.60±0.50, whereas the mean number of snacks per day is 1.52±0.92. The mean BMI in patients was 30.62±5.48 kg/m², with about 90% classified as overweight or obese. The mean MIND diet score of individuals was 8.64±1.75. 52.90% of patients belonged to the low MIND diet group, whereas 47.10% were included in the high MIND diet group (Table 2).

The mean values for HbA1c, FBG, HDL-C, LDL-C, TC, and TG in patients with T2DM were 7.34±0.83 %, 159.00±50.00 mg/dL, 47.00±12.00 mg/dL, 158.00±27.00 mg/dL, 241.98±30.73 mg/dL, and 181.00±34.00 mg/dL, respectively (Table 3).

A significant difference was observed between HbA1c and FBG in the low and high MIND groups (p=0.000); however, no statistically significant difference was identified between the low and high MIND groups for HDL-C, LDL-C, TC, and TG levels (p> 0.05) (Figure 1). A significant negative correlation was found between HbA1c (r=-0.528, p=0.000), FBG (r=-0.242, p=0.000), and MIND scores in patients (Figure 2).

Discussion

The study was conducted to evaluate adherence to the MIND diet, lifestyle characteristics, and glycemic parameters for Turkish adults with T2DM. The results indicated that over 90% of individuals with T2DM were either overweight or obese. The mean MIND diet score for individuals was 8.64±1.75 (52.90% low adherence to the MIND diet; 47.10% high adherence to the MIND diet). A significant difference was found between HbA1c and FBG in the MIND groups, as well as a substantial negative association identified among HbA1c, FBG, and MIND scores.

The MIND diet is a nutritional strategy aimed at enhancing cognitive health, including elements from the Mediterranean and DASH diets. It highlights "brain-healthy" foods—such as green leafy vegetables, berries, whole grains, almonds, olive oil, legumes, chicken, and fish—while restricting detrimental items like red meat, butter, cheese, fried meals, and sweets [7, 16]. The diet was introduced by researchers at Rush University and Harvard School of Public Health in 2015 [17]. The MIND diet score ranges from 0 to 15, representing overall adherence based on 15 dietary components (10 healthy, 5 unhealthy). Each component is scored between 0 and 1, depending on intake frequency, with higher total scores indicating better concordance with the MIND diet (Table 1) [18]. The MIND diet primarily aims to enhance cognitive health, but accumulating data indicates it may also have substantial advantages in reducing cardiovascular disease, obesity, and diabetes. The extensive preventive potential arises from its integration of components from both the Mediterranean and DASH diets, which have demonstrated beneficial effects on several cardiometabolic risk factors [19, 20].

Obesity is frequent in adults with T2DM, with epidemiological studies indicating that 65% to 90% of patients are overweight or obese, a comorbidity that dramatically affects insulin resistance, cardiovascular risk, and total disease burden[21,22].

Table 1. MIND diet component servings and scoring (7)

MIND diet components	Scoring		
	0	0.5	1
Green leafy vegetables*	≤ 2 servings/week	>2 to <6 servings/week	≥ 6 servings/week
Other vegetables[α]	< 5 servings/week	5 to <7 servings/week	≥ 1 serving/day
Berries[β]	< 1 serving/week	1 serving/week	≥ 2 servings/week
Nuts	< 1 time/month	1 time/month to <5 times/week	≥ 5 servings/week
Olive oil	Not primary oil	-	Used as primary oil
Butter, margarine	> 2 teaspoons/day	1–2 teaspoons/day	< 1 teaspoon/day
Cheese	≥ 7 servings/week	1–6 servings/week	< 1 serving/week
Whole grains	< 1 serving/day	1–2 servings/day	≥ 3 servings/day
Fish (not fried)[γ]	Rarely	1–3 times/month	≥ 1 meal/week
Legumes[δ]	< 1 meal/week	1–3 meals/week	> 3 meals/week
Poultry (not fried)[¶]	< 1 meal/week	1 meal/week	≥ 2 meals/week
Red meats and products[§]	≥ 7 meals/week	4–6 meals/week	< 4 meals/week
Fried/fast foods[λ]	≥ 4 times/week	1–3 times/week	< 1 time/week
Pastries and sweets[φ]	≥ 7 servings/week	5–6 servings/week	< 5 servings/week
Wine	> 1 glass/day or never	1 time/month-6 times/week	1 glass/day
Total score	0	7.5	15

MIND: Mediterranean-DASH diet intervention for neurodegenerative delay

*Kale, collards, greens; spinach; lettuce/tossed salad

[α]Green/red peppers, squash, cooked carrots, raw carrots, broccoli, celery, potatoes, peas or lima beans, tomatoes, tomato sauce, string beans, beets, corn, zucchini/summer squash/eggplant, coleslaw, potato salad

[β]Strawberries

[γ]Tuna sandwich, fresh fish as main dish; not fried fish cakes, sticks, or sandwiches

[δ]Beans, lentils, soybeans

[¶]Chicken or turkey sandwich, chicken or turkey as main dish, and never eat fried at home or away from home

[§]Cheeseburger, hamburger, beef tacos/burritos, hot dogs/sausages, roast beef or ham sandwich, salami, bologna, or other deli meat sandwich, beef (steak, roast) or lamb as main dish, pork or ham as main dish, meatballs or meatloaf

[λ]How often do you eat fried food away from home (like French fries, chicken nuggets)?

[φ]Biscuit/roll, pop tarts, cake, snack cakes/twinkies, Danish/sweet rolls/ pastry, donuts, cookies, brownies, pie, candy bars, other candy, ice cream, pudding, and milkshakes/frappes

Table 2. Sociodemographic characteristics of patients (n=459)

Variables		n	%
Sex	Female	269	58.60
	Male	190	41.40
Education level	Literate	34	7.40
	Primary school	52	11.30
	Secondary school	209	45.50
	High school	88	19.20
	University	76	16.60
Marital status	Married	382	83.20
	Single	77	16.80

Table 2 Cont. Sociodemographic characteristics of patients (n=459)

Variables		n	%
Employment status	Employed	150	32.70
	Unemployed	309	67.30
Smoking status	Yes	100	21.80
	No	359	78.20
Alcohol consumption	Yes	16	3.50
	No	443	96.50
		Mean	**SD**
Age (years)		49.10	10.10
Number of main meals		2.60	0.50
Number of snacks		1.52	0.92
MIND diet score		8.64	1.75
MIND diet score classification [n (%)]	Low (≤8.5)	243	52.90
	High (>8.5)	216	47.10
Body mass index (kg/m2)		30.62	5.48
Body mass index classification [n (%)]	Underweight	2	0.40
	Normal	55	12.00
	Overweight	178	38.80
	Obese	224	48.80

n: Count; %: Column percentage;
MIND: Mediterranean-Dietary Approach to Stop Hypertension Intervention for Neurodegenerative Delay; SD: Standard deviation

Table 3. Biochemical parameters of patients (n=459)

Parameters	Mean	SD
HbA1c (%)	7.34	0.83
FBG (mg/dL)	159.00	50.00
HDL-C (mg/dL)	47.00	12.00
LDL-C (mg/dL)	158.00	27.00
TC (mg/dL)	241.98	30.73
TG (mg/dL)	181.00	34.00

FGB: Fasting plasma glucose; HDL-C: High-density lipoprotein cholesterol; LDL-C: Low-density lipoprotein cholesterol; SD: Standard deviation; TC: total cholesterol; TG: Triglyceride

Iglay et al. showed that in individuals with T2DM, overweight or obesity is quite prevalent, with estimates indicating that over 78% of patients are affected—highlighting the need for weight control in comprehensive diabetes treatment [23]. In Türkiye, a study revealed that just 10% of those with T2DM had a normal BMI, whereas 31% were classified as overweight and 59% as obese [24]. In the results of our study, consistent with the literature, 87.60% of T2DM patients were identified as overweight or obese (Table 2). Obesity is a comorbidity closely associated with poor metabolic management and an increased likelihood of complications in people with T2DM.

A systematic review determined that adherence with the MIND diet is associated with enhancements in anthropometric measures, glycemic regulation, lipid profiles, and inflammatory markers; however, information concerning direct cardiovascular disease outcomes is not as specific [20]. In an adult population, greater adherence to the MIND diet was strongly correlated with decreased risks of overall obesity and an enhanced lipid profile—specifically lower blood triglycerides and increased HDL values [19]. A longitudinal cohort research revealed that people with T2DM who adhered to a high MIND diet demonstrated significantly reduced rates of all-cause and cardiovascular mortality (HR = 0.75 and HR = 0.50, respectively) in comparison to those with low adherence [10]. To our knowledge, there are no epidemiological or clinical studies in Türkiye regarding the MIND diet score, T2DM, and health outcomes. In our study, 47.10% of people with T2DM had high adherence to the MIND diet score (Table 2). HbA1c and FBG levels exhibited significant differences between the low and high MIND groups (Figure 1). Moreover, a statistically significant negative correlation was identified between the MIND diet score and HbA1c and FBG levels (Figure 2). The results suggested that increased adherence to the MIND diet among T2DM patients correlates with improved glycemic indicators.

The literature has few studies evaluating the correlation between the MIND diet score and lipid parameters. Mohammadpour et al. examined the correlation between the MIND diet score and lipid parameters in individuals with metabolic syndrome and obesity. The MIND diet score is negatively correlated with the likelihood of decreased HDL, but no significant association was observed with

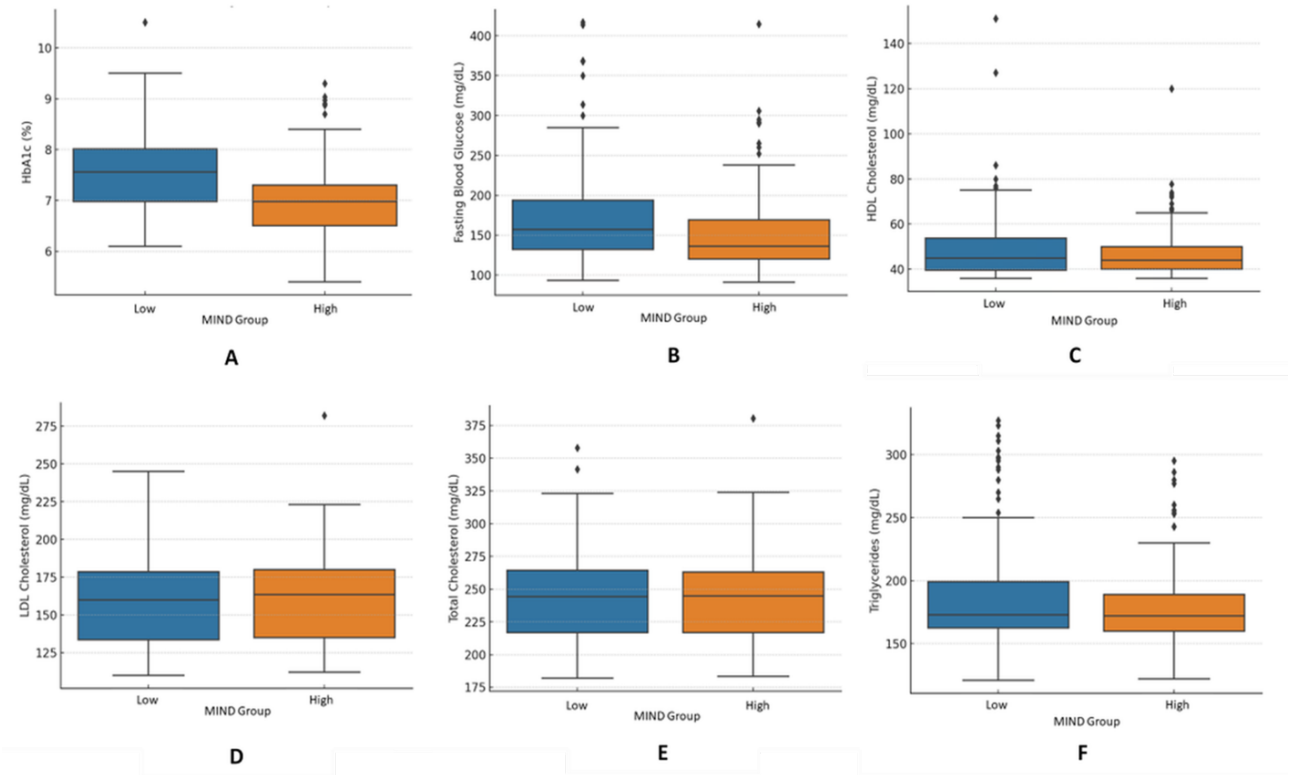

Figure 1. Glycemic parameters of patients categorized by MIND groups.
p<0.05

A. HbA1c in patients with low versus high MIND scores. B. Fasting plasma glucose in patients with low versus high MIND scores. C. HDL-C in patients with low versus high MIND scores. D. LDL-C in patients with low versus high MIND scores.
E. Total cholesterol in patients with low versus high MIND scores. F. Triglyceride in patients with low versus high MIND scores.

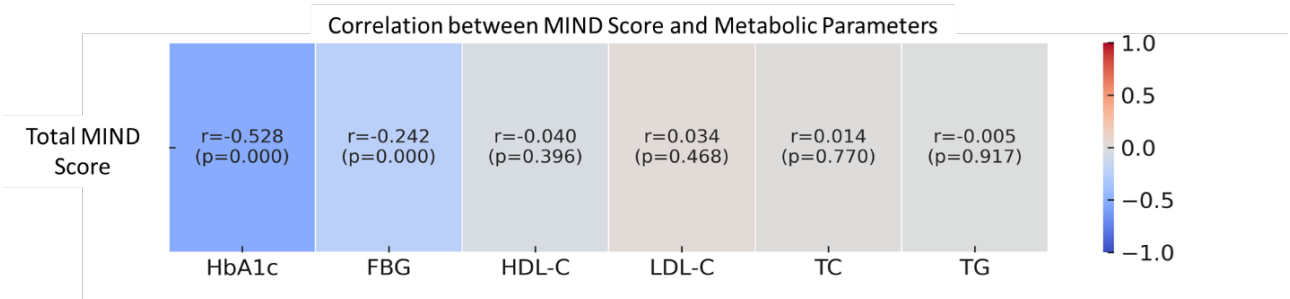

Figure 2. Correlation between MIND diet scores and glycemic parameters in patients.
p<0.05

FGB: Fasting plasma glucose; HDL-C: High-density lipoprotein cholesterol; LDL-C: Low-density lipoprotein cholesterol; TC: total cholesterol; TG: Triglyceride

triglycerides or other lipid metrics [13]. A systematic review indicated that specific randomized controlled trials demonstrated decreases in TC and LDL-C levels. In contrast, cross-sectional studies revealed a positive correlation with HDL-C and a negative correlation with the TC/HDL-C ratio [20]. Our study demonstrated no significant correlation between the MIND diet score and HDL-C, LDL-C, TC, and TG in individuals with T2DM (Figure 2). Multiple factors may affect the relationship between the MIND diet score and lipid parameters. Age and sex significantly influence lipid metabolism, as postmenopausal women demonstrate elevated levels of LDL-C and TC relative to premenopausal women, regardless of dietary intake [25]. Physical activity influences lipid profiles by enhancing TG clearance and elevating HDL-C synthesis, whereas its absence may diminish the lipid-modulating benefits of a high MIND diet score [26]. Energy balance and BMI are crucial, since high adiposity is significantly associated with increased TG and reduced HDL-C, thus obscuring nutritional advantages [27]. Genetic factors, such as metabolic syndrome and non-alcoholic fatty liver disease, might disrupt lipid metabolism and interact with dietary components, thereby reducing the lipid-enhancing effects of a high MIND diet score [28, 29].

Limitations and strengths of the study

Some limitations exist within our study. First,

measurements of the participants' height and body weight were recorded based on the self-reports. Second, acquiring data from a single city complicates generalization. Third, the duration of diabetes diagnosis in individuals was not inquired about. This study has notable strengths: this is, to our knowledge, the first research examining the correlation between adherence to the MIND diet, MIND score, and glycemic parameters in Turkish patients with T2DM. The large sample size makes our study results noteworthy. The comprehensive exclusion criteria have enhanced the consistency of our study.

Conclusion

This study demonstrates that, among Turkish patients with T2DM, higher adherence to the MIND diet is associated with improved glycemic control, as reflected by reductions in HbA1c and FBG levels. In contrast, no significant associations were observed with lipid parameters. The high prevalence of overweight and obesity identified in this study, consistent with prior research, underscores the importance of incorporating weight management strategies into diabetes care. Although accumulating evidence suggests that the MIND diet may exert beneficial effects on anthropometric, glycemic, and certain lipid parameters, the absence of significant lipid-related findings in our sample highlights the complex interplay of demographic, lifestyle, and clinical factors influencing these outcomes. Future longitudinal and interventional research—particularly within Turkish T2DM populations—is warranted to clarify the potential cardiometabolic benefits of the MIND diet beyond glycemic regulation. The MIND diet, with its emphasis on nutrient-dense foods, has been consistently associated with improvements in both metabolic regulation and psychological well-being. Accordingly, it may serve as a valuable adjunct to conventional diabetes management, offering potential benefits that extend beyond standard medical nutrition therapy.

Conflict of Interest

The authors declared that there is no conflict of interest.

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