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Effect of Perceived Food Literacy on Eating Behavior Pattern, Glycemic Parameters, and Lipid Profile in Patients with Type 2 Diabetes: Structural Equation Modeling

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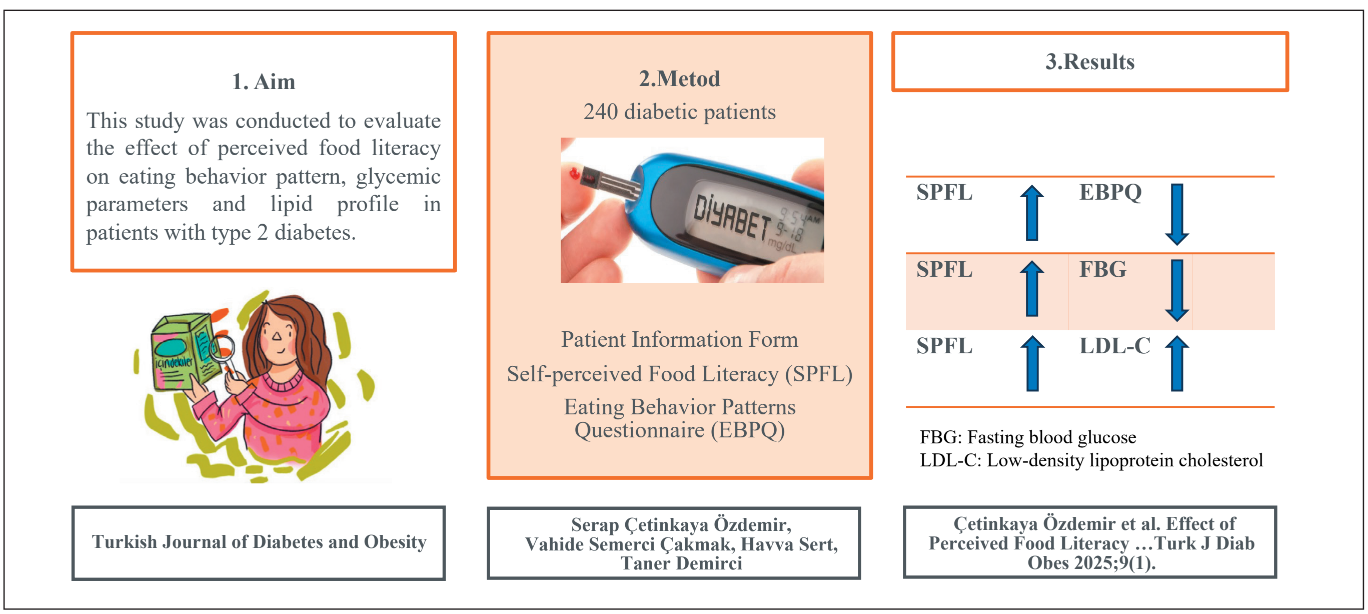
GRAPHICAL ABSTRACT



ABSTRACT

Aim: This study was conducted to evaluate the effect of perceived food literacy on eating behavior pattern, glycemic parameters and lipid profile in patients with type 2 diabetes.

Material and Methods: A descriptive and correlational study design was used in this study. This study included 240 patients with type 2 diabetes. Patient information form, self-perceived food literacy scale, and eating behavior patterns questionnaire were used in the study. Data were analyzed using descriptive statistics and structural equation path analysis.

Results: The self-perceived food literacy scale scores were negatively correlated with the eating behavior patterns questionnaire scores in patients with type 2 diabetes ($\beta = -0.233$; $p < 0.05$) and explained 5.4% of the variance in eating behavior. Self-perceived food literacy scale scores were negatively correlated with fasting blood glucose levels ($\beta = -0.176$; $p < 0.05$) and not significantly correlated with haemoglobin A1C levels ($p > 0.05$). On the other hand, perceived food literacy scale scores were positively correlated with LDL-C levels ($\beta = 0.162$; $p < 0.05$).

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Conclusion: Self-perceived food literacy appears to influence the eating behavior patterns of patients with type 2 diabetes. The findings indicate that food literacy has an effect particularly on fasting blood glucose levels; however, a similar effect was not observed in long-term glycaemic control parameters such as haemoglobin A1C. Moreover, as food literacy increased, the lipid profile deteriorated. In order to ensure optimal glycaemic control and lipid profile in individuals with type 2 diabetes, it is recommended that long-term follow-up interventions targeting the integration of this knowledge into sustainable healthy eating behaviours as well as increasing the level of food literacy are required.

Keywords: *Eating behavior patterns, Fasting blood glucose, Food literacy, Glycated hemoglobin A1c, Structural equation model, Type 2 diabetes*

Tip 2 Diyabetli Hastalarda Algılanan Gıda Okuryazarlığının Yeme Davranış Modeli, Glisemik Parametreler ve Lipid Profili Üzerindeki Etkisi: Yapısal Eşitlik Modeli

GRAFİKSEL ÖZET

1.Amaç

Bu araştırma, Tip 2 diyabetli hastalarda algılanan gıda okuryazarlığının yeme davranış modeli, glisemik parametreler ve lipid profilleri üzerindeki etkisini değerlendirmek amacıyla yapıldı.

2.Metod

240 diyabet hastası

Hasta Bilgi Formu

Algılanan Gıda Okuryazarlığı Ölçeği (AGOÖ)

Yeme Davranış Modeli Ölçeği (YDMÖ)

3.Bulgular

AGOÖ ↑	**YDMÖ** ↓
AGOÖ ↑	**AKŞ** ↓
AGOÖ ↑	**LDL-C** ↑

AKŞ: Açlık kan şekeri
LDL-C: Düşük yoğunluklu lipoprotein kolesterol

Türkiye Diyabet ve Obezite Dergisi

Serap Çetinkaya Özdemir, Vahide Semerci Çakmak, Havva Sert, Taner Demirci

Çetinkaya Özdemir et al. Tip 2 Diyabetli Hastalarda Algılanan Gıda …Turk J Diab Obes 2025;9(1).

ÖZ

Amaç: Bu araştırma, Tip 2 diyabetli hastalarda algılanan gıda okuryazarlığının yeme davranış modeli, glisemik parametreler ve lipid profilleri üzerindeki etkisini değerlendirmek amacıyla yapıldı.

Gereç ve Yöntemler: Bu çalışmada, tanımlayıcı ve korelasyonel bir çalışma tasarımı kullanıldı. Bu çalışmaya 240 tip 2 diyabet hastası dahil edildi. Çalışmada hasta bilgi formu, algılanan gıda okuryazarlığı ölçeği ve yeme davranış modeli ölçeği kullanıldı. Veriler tanımlayıcı istatistikler ve yapısal eşitlik yol analizi kullanılarak analiz edildi.

Bulgular: Tip 2 diyabetli hastalarda algılanan gıda okuryazarlığı ölçeği puanları yeme davranış modeli puanları ile negatif korelasyon gösterdi (β = -0,233; $p < 0{,}05$) ve yeme davranışındaki varyansın %5,4'ünü açıkladı. Algılanan gıda okuryazarlığı ölçeği puanları, açlık kan şekeri düzeyleriyle negatif korelasyon gösterirken (β = -0,176; $p < 0{,}05$), hemoglobin A1C düzeyleriyle anlamlı bir korelasyon göstermedi ($p > 0{,}05$). Diğer taraftan, algılanan gıda okuryazarlığı ölçeği puanları, LDL-C düzeyleriyle pozitif bir korelasyon gösterdi (β = 0,162; $p < 0{,}05$).

Sonuç: Algılanan gıda okuryazarlığının Tip 2 diyabetli hastaların yeme davranışlarını etkilediği görülmektedir. Bulgular, gıda okuryazarlığının, özellikle açlık kan şekeri seviyeleri üzerinde bir etki sağladığını ancak hemoglobin A1C gibi uzun vadeli glisemik kontrol parametrelerinde benzer bir etkinin gözlemlenmediğini göstermektedir. Ayrıca, gıda okuryazarlığı arttıkça lipid profili bozulmuştur. Tip 2 diyabetli bireylerde optimal glisemik kontrol ve lipid profilinin sağlanması amacıyla, gıda okuryazarlığı düzeyinin yükseltilmesinin yanı sıra, bu bilginin sürdürülebilir sağlıklı beslenme davranışlarına entegrasyonunu hedefleyen uzun vadeli takip müdahalelerinin gerekliliği önerilir.

Anahtar Sözcükler: *Açlık Kan Şekeri, Gıda okuryazarlığı, Glikozillenmiş hemoglobin A1c, Lipid, Tip 2 diyabet, Yapısal eşitlik modeli, Yeme davranış modeli*

INTRODUCTION

Diabetes, a chronic disease that affects approximately 10.5% of the global population, requires continuous medical care with glucose management and multifactorial risk reduction strategies (1,2). The prevalence of diabetes in Türkiye increased from 8.1% in 2011 to 14.5% in 2021 (1). The increased prevalence of type 2 diabetes in recent years was attributed to unhealthy dietary patterns and rising obesity rates (3). Healthy nutrition is important for delaying and preventing acute and chronic complications in patients with diabetes. Food literacy is critical for developing healthy eating behaviors (4).

Food literacy is the knowledge, skills, and behaviors required to select, plan, manage, prepare, and eat foods to meet nutritional needs and determine food intake (4,5). Additionally, food literacy contributes to the maintenance of a healthy diet and the protection, development, and strengthening of diet quality (4). Increasing food literacy can improve the quality of life of patients and prevent nutrition-related diseases (6). Previous research found that higher levels of food literacy were associated with healthier food choices (7-10). Increasing food literacy in patients with diabetes contributed to the development of healthy eating habits, the selection of healthy foods, and the control of blood sugar levels (11-13). Food literacy is also an essential component in the effective management and treatment of type 2 diabetes (14). Additionally, food literacy is one of the factors affecting the self-care and management of patients with diabetes (13,15). One study reported that low food literacy was associated with poor glycemic control in patients with diabetes (12). Among patients with type 2 diabetes, food literacy was reported to be associated with favorable changes in the glycated hemoglobin A1c (HbA1c) level (16).

In particular, food literacy had a critical role in developing healthy eating behavior (17). The eating behavior model is a set of psychological and biological theories that examine issues, such as individuals' food choices, eating habits, and attitudes toward food (18). Limited studies examined the effect of food literacy on eating behavior (19,20). The effects of self-perceived food literacy (SPFL) on eating behavior patterns, glycemic parameters, and lipid profiles in patients with type 2 diabetes were not previously reported.

As nutrition literacy is important for effective diabetes management, health professionals must promote food literacy and healthy eating behavior among patients with diabetes. Clinical nurses can plan and develop interventions for the treatment and care processes of patients by promoting food literacy and favorable eating behaviors in patients with type 2 diabetes. This study aimed to examine the effect of food literacy on eating behavior patterns, glycemic parameters, and lipid profiles in Turkish patients with type 2 diabetes.

MATERIALS and METHODS

Study Design and Participants

This study was performed using a descriptive and relational survey model, conducted between July 2022 and August 2023. The study population comprised patients with type 2 diabetes who visited the diabetes outpatient clinic of a hospital in the Marmara Region of Türkiye. The sample size of the study was determined using the G*Power 3.1.9.7 program. The study by Solak et al. was used as a reference (16). Based on the assumption that the effect size was moderate, the minimum sample size of this study was calculated as 240 for a significance level (α) of 0.05 (95% confidence level) and a power of 0.95.

In this study, a convenience sampling method was employed, which involves selecting participants who are easily accessible to the researcher. First, the target population was defined according to the inclusion criteria. Then, individuals who visited the outpatient clinic during the data collection period and met the criteria were invited to participate. A total of 240 patients with type 2 diabetes who volunteered and met the eligibility criteria were included in the study (21). The inclusion criteria for this study were to have been diagnosed with type 2 diabetes for at least one year, to be 18 years of age or older, to be literate, to have no cognitive or communicative disability, to apply to the diabetes outpatient clinic, and to volunteer to participate in the study. Individuals diagnosed with other types of diabetes (type 1 diabetes, gestational diabetes, etc.), individuals with psychological disorders or who refused to participate in the study, and pregnant women were excluded from the study. In addition, individuals who did not use medication or dietary therapy in the treatment of diabetes were also excluded from the study.

Data Collection Tools

Patient information form, self-perceived food literacy (SPFL) scale, and eating behavior patterns questionnaire (EBPQ) were used to collect data in this study.

Patient Information Form: This form was prepared by researchers based on literature and comprised 18 questions, including those on sociodemographic characteristics and diabetes-related characteristics of patients. Additionally, anthropometric measurements (height and weight) were self-reported by the patients. The FBG, HbA1c, and LDL-C levels, which are routinely obtained from patients with diabetes, were obtained from the electronic hospital information system. Blood parameters in the electronic hospital information system were evaluated as follows. To ensure standardization and improve the reliability of the biochemical data, venous blood samples were collected from all patients in the morning after a minimum of 8 hours of fasting, and all collection, processing, and analysis procedures were performed in accordance with the standard protocols of the hospital's biochemistry laboratory. The samples were drawn into anticoagulant-free tubes and sent to the biochemistry laboratory. After the coagulation process was completed, the samples were centrifuged at 4000g for 10 minutes to separate the serum. Serum glucose and LDL-C levels were analyzed spectrophotometrically using a biochemical autoanalyzer. For the analysis of HbA1c levels, whole blood samples collected in EDTA tubes were analyzed using the high-performance liquid chromatography (HPLC) method.

SPFL Scale: This scale, which was developed by Poelman et al. was adapted into Turkish by Tarı Selçuk et al. (22, 23). The scale can be used to assess an individual's food literacy level as an indicator of healthy eating habits. Food literacy is defined as 'a set of interrelated skills and abilities that are key to planning, managing, selecting, preparing and eating foods correctly to ensure a balanced diet and improve psycho-physical well-being' (23, 24). This scale comprised eight sub-dimensions and 29 items. The sub-dimensions of the scale were food preparation skills, resistance and resilience, types of healthy snacks, social and conscious eating, examination of food labels, planning of daily nutrition, spending for healthy foods, and healthy food availability. The scale was scored on a five-point likert scale. A high score on the scale indicates a high level of food literacy. The total Cronbach's alpha coefficient for the Turkish version of the scale was 0.83, while the Cronbach's alpha coefficient for sub-dimensions was between 0.61 and 0.92 (23). In this study, the total Cronbach's alpha coefficient for the scale was 0.82, while the Cronbach's alpha coefficient for sub-dimensions was between 0.64 and 0.96.

EBPQ: This scale, which was developed by Schlundt et al., was adapted into Turkish by Yeşilkaya and Alphan (17, 25). It is very difficult for people to change the behaviour they have developed in nutrition over the years. For diabetes management, the person with diabetes may need to change their dietary behaviour. The scale can be used to determine the dietary behaviour of diabetic patients in terms of low-fat eating, snacking, emotional eating, planning, skipping meals and cultural/lifestyle behaviours (17). The Turkish version of the scale comprised nine sub-dimensions and 45 items. The sub-dimensions of the scale were low-fat eating, healthy eating, eating out, snacking, eating sweets and biscuits, emotional eating, planned eating behavior, skipping meals, and cultural lifestyle/behavior. A high score indicates an increased degree of behavior change. The total Cronbach's alpha coefficient for the Turkish version of the scale was 0.75, while the Cronbach's alpha coefficient for sub-dimensions was between 0.54 and 0.71 (17). In this study, the total Cronbach's alpha coefficient of the scale was 0.74, while the Cronbach's alpha coefficient for sub-dimensions was between 0.54 and 0.75.

Data Collection and Ethics

The study data were collected between July 2022 and August 2023. This study was approved by Sakarya University Faculty of Medicine Non-Interventional Clinical Research Ethics Committee (11.05.2022, approval number: E-71522473-050.01.04-128372-130). Written informed consent was obtained from the participants. The study was conducted according to the Declaration of Helsinki guidelines. A face-to-face survey was administered to the participants by researchers using data collection tools. The approximate time taken to complete the data collection form was 25–30 min.

Statistical Analyses

Statistical analyses were performed using IBM SPSS (v. 25) and Analysis of Moment Structures (AMOS) (v. 25) software packages. Differences were considered significant at $p < 0.05$. Analysis of the skewness and kurtosis of the data revealed a normal distribution with values between +2 and −2. Descriptive data were represented as mean ± standard deviation, min-max values, and number and percentage. The theoretical model for the correlation between SPFL, EBPQ scores, FBG levels, HbA1c levels, and LDL-C levels was examined using structural equation path analysis.

RESULTS

The clinical characteristics of the study participants were as follows: mean age, 58.04 years ± 11.07 years (min = 22 years, max = 91 years); the proportion of females, 55.4%; the proportion of literacy/primary school graduates, 65%. The descriptive characteristics of the participants and details on their diabetes status were shown in Table 1 and Table 2.

The mean SPFL Scale and EBPQ scores of patients with type 2 diabetes were 89.24 ± 13.36 (53–122) and 2.82 ± 0.30 (1.98–3.58), respectively. The mean subscale scores of the scales were given in Table 3.

The theoretical model for the correlation between SPFL Scale scores, EBPQ scores, FBG levels, HbA1c levels, and LDL-C levels was examined using structural equation path analysis. The AMOS output showing the parameters in the structural model was shown in Figure 1.

The goodness of fit criteria for path analysis were calculated. According to the confirmatory factor analysis index values,

Table 1: Descriptive characteristics of patients with Type 2 diabetes (n=240)

Identifying Information	Findings (n=240)	
Age (year±SD), min.-max.	58.04±11.07	22-91
Body Mass Index (BMI)	30.72± 5.10	18.61-45.20
BMI categories, n (%)		
18.50-24.99 kg/m²	33	(13.7)
25.00-29.99 kg/m²	81	(33.8)
30.00-34.99 kg/m²	76	(31.7)
35.00 kg/m² and over	50	(20.8)
Gender, n (%)		
Female	133	(55.4)
Male	107	(44.6)
Education level, n (%)		
Literate/primary school	156	(65.0)
Secondary school/high school	64	(26.7)
University	20	(8.3)
Income level, n (%)		
Low income	53	(22.1)
Middle-income/high-income	187	(77.9)
Smoking, n (%)		
Yes	65	(27.1)
No	175	(72.9)
Secondary diseases, n (%)		
Yes	166	(69.2)
No	74	(30.8)

BMI: Body Mass Index

Table 2: Diabetes characteristics of patients with type 2 diabetes

Identifying Information	Findings (n=240)	
Duration of diabetes (year±SD), min.-max.	9.97±7.84	(1-42)
FBG (mg/dL±SD), min.-max.	175.69±72.02	(61-397)
HbA1C (%±SD), min.-max.	9.35± 2.46	(4.70-16.70)
LDL-C (mg/dL±SD), min.-max.	135.45±36.31	(37-228)
Having diabetes in a first-degree relative, n (%)		
Yes	171	(71.3)
No	69	(28.7)
Treatment, n (%)		
OAD	119	(49.6)
OAD+Insulin	73	(30.4)
Insulin	25	(10.4)
Nutrition+OAD	23	(9.6)
Receiving nutrition education about diabetes, n (%)		
Yes	168	(70.0)
No	72	(30.0)
Hospitalisation due to hyperglycaemia, n (%)		
Yes	18	(7.5)
No	222	(92.5)
Hospitalisation because of hypoglycaemia, n (%)		
Yes	6	(2.5)
No	234	(97.5)

FBG: Fasting blood glucose, **LDL-C:** Low density lipoprotein-Colesterol, **OAD:** Oral antidiabetic

the structural model showed a good fit (χ^2/sd = 2.93, goodness of fit index (GFI) = 0.97, adjusted GFI (AGFI) = 0.98, comparative fit index (CFI) = 0.99, root mean square of approximation (RMSEA) = 0.07, and root mean square residuals (RMR) = 0.01). The coefficients of the research model and the hypothesis test results of the structural model were shown in Table 4.

The SPFL Scale scores were negatively correlated with the EBPQ scores ($\beta = -0.233$; $p < 0.05$) and explained 5.4% of the variance in EBPQ scores.

The EBPQ scores were not correlated with the FBG levels ($p > 0.05$). The SPFL Scale scores were negatively correlated with the FBG levels ($\beta = -0.176$; $p < 0.05$). The EBPQ and SPFL Scale scores explained 3.5% of the variance in FBG levels.

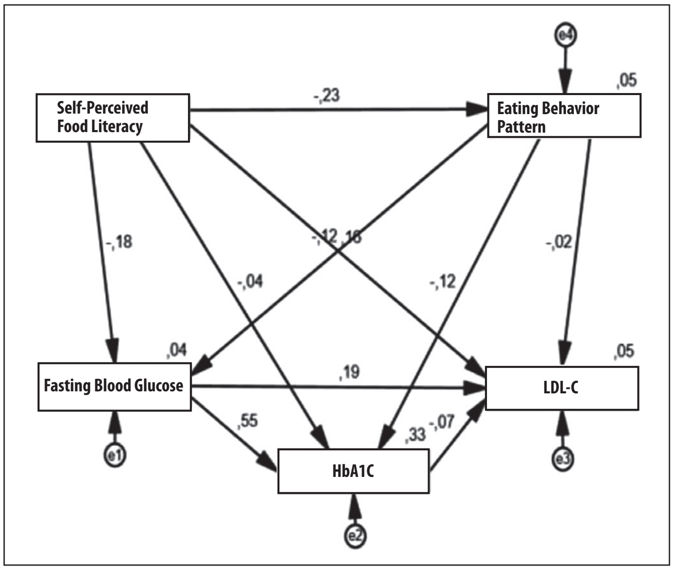

Figure 1: Path analysis

The EBPQ scores were negatively correlated with the HbA1c levels ($\beta = -0.122$; $p < 0.05$). The SPFL Scale scores were not correlated with the HbA1c levels ($p > 0.05$). The FBG levels were positively correlated with the HbA1c levels ($\beta = 0.548$; $p < 0.05$). The EBPQ scores, SPFL Scale scores, and FBG levels explained 33.2% of the variance in HbA1c levels.

Table 3: Perceived food literacy scale and eating behaviour model scale total and subscale scores of patients with type 2 diabetes

Scale and sub-dimensions*	Scale total and subscale scores (n=240)	
Self-Perceived Food Literacy (SPFL) Scale	90.98±12.94	53-122
Food preparation skills	18.71±5.57	7-30
Resistance and resilience	18.83±3.91	8-30
Types of healthy snacks	12.46±2.96	5-19
Social and conscious eating	11.21±1.74	4-15
Examination of food labels	3.43±2.06	2-10
Planning of daily nutrition	5.10±2.00	2-10
Spending for healthy foods	6.07±1.94	2-10
Healthy food availability	15.12±3.68	4-20
Eating Behavior Patterns Questionnaire	2.82±0.30	1.98-3.58
Low-fat eating	2.86±0.68	1-4.71
Healthy eating	2.42±0.89	1-4.67
Eating out	2.65±0.43	1.67-5
Snacking	3.30±0.97	1-5
Eating sweets and biscuits	2.42±0.75	1-4.25
Emotional eating	2.92±0.81	1-4.83
Planned eating behavior	2.03±0.58	1-4
Skipping meals	2.89±0.49	1.57-4.14
Cultural lifestyle/behavior	3.16±0.45	1.89-4.22

*Data are shown as scale total and subscale scores ±Standart Deviations, minimum –maximum values.

The EBPQ scores were not correlated with the LDL-C levels ($p > 0.05$). The SPFL Scale scores were positively correlated with the LDL-C levels ($\beta = 0.162$; $p < 0.05$). Additionally, the FBG levels were positively correlated with the LDL-C levels ($\beta = 0.191$; $p < 0.05$), whereas the HbA1c levels were not correlated with the LDL-C levels ($p > 0.05$). The EBPQ scores, SPFL Scale scores, FBG levels, and HbA1c levels explained 4.8% of the variance in LDL-C levels.

DISCUSSION

Nutrition and food literacy encompasses the knowledge, skills, and confidence to prepare healthy meals (26). In this study, the perceived food literacy of patients with diabetes was moderate. Rivera Rivero et al. reported that nutritional literacy among uninsured patients with diabetes was inadequate (12). Chronic diseases were reported to be associated with low health literacy in Greek adults (27). This study was conducted in the Turkish population. In the study population, most participants were from middle-income and high-income backgrounds and received education on nutrition.

In the eating behavior questionnaire, low-fat eating, healthy eating, eating out, snacking, eating sweets and biscuits, emotional eating, planned eating behavior, skipping meals, and cultural lifestyle/behavior were analyzed (26). In this study, the eating behavior of patients with diabetes was moderate. In contrast, one study reported that Ethiopian patients with diabetes exhibited poor eating behavior (28). Patients with diabetes were reported to frequently skip main and snack meals and obtained most of their daily calories from fat. Additionally, the amount of saturated fat consumed was above the recommended limit (29).

Considering the comparison between the goodness of fit values obtained for the structural model and the commonly accepted criteria in the literature, it can be said that the

Table 4: Path analysis regression coefficients

Hypotheses			β	Std. β	S.Error	t	p	R^2
Eating behaviour model	<---	Self-Perceived Food Literacy	-.005	-.233	.001	-3.705	**p<0.001**	.054
FBG	<---	Eating behaviour model	-28.290	-.118	15.637	-1.809	.070	.035
FBG	<---	Self-Perceived Food Literacy	-.977	-.176	.363	-2.689	**.007**	
HbA1C	<---	Eating behaviour model	-.998	-.122	.449	-2.225	**.026**	.332
HbA1C	<---	Self-Perceived Food Literacy	-.008	-.042	.011	-.767	.443	
HbA1C	<---	FBG	.019	.548	.002	10.189	**p<0.001**	
LDL	<---	Eating behaviour model	-2.979	-.025	7.966	-.374	.708	.048
LDL	<---	Self-Perceived Food Literacy	.453	.162	.185	2.450	**.014**	
LDL	<---	FBG	.096	.191	.039	2.479	**.013**	
LDL	<---	HbA1C	-1.009	-.069	1.136	-.888	.375	

model shows a good fit. The χ2/sd value calculated for the model is 2.93, and this value is at an excellent fit level according to the '$\chi 2/df \leq 3$' criterion in the literature. The CFI (Comparative Fit Index) value is 0.99, and when compared with the '≥0.95' criterion, it is seen that the model provides an excellent fit. GFI (Goodness-of-Fit Index) and AGFI (Adjusted Goodness-of-Fit Index) values are 0.97 and 0.98, respectively, and both values are '≥0.90', again indicating an excellent fit. The RMSEA (Root Mean Square Error of Approximation) value is 0.07 and although it exceeds the threshold of '≤0.05', it remains in the range of '≤0.10', indicating an acceptable level of fit. The RMR (Root Mean Square Residual) value was found to be 0.01, which is well below the '≤0.05' limit stated in the literature and indicates perfect fit. In line with all these findings, it can be concluded that the model generally shows a good and acceptable fit and the structural model is valid (30,31).

In this study, the SPFL Scale scores were negatively correlated with the EBPQ scores. Perceived food literacy is expected to positively affect eating behavior patterns (19,20,32). Mostafazadeh et al. reported that nutritional literacy explained 44% of the variance in eating behavior (19). High levels of perceived food literacy were also reported to be associated with unprocessed food consumption (20). Bastami et al. revealed the correlation of food literacy with dietary behavior and meat, fruit, vegetable, and fat consumption. However, food literacy was not significantly correlated with the consumption of dairy products, cereals, and legumes. A one-unit increase in food literacy improved food consumption behavior by 23% in the previous week (32). The reason for contrasting findings in this study may be because the participants were educated about healthy foods but did not practice healthy nutrition. Additionally, increased perceived food literacy may have resulted in stress, worry, information overload, confusion, and indecision about food among the participants. Thus, participants may have experienced anxiousness when making decisions about their food choices. Participants may be tempted to adopt strict dietary rules or restrictive eating habits. Reduced diversity in food consumption or malnutrition may adversely affect eating behaviors. Emotional eating and body shape anxiety may also influence eating behaviour. A structural equation modelling revealed that the effect of body shape anxiety on eating behaviour patterns is important. It was stated that an increase in body shape anxiety can directly cause a proportional increase in unhealthy eating patterns (33). In a structural equation modelling study different from our study, it was found that health anxiety and healthy eating behaviours were related and this was mediated by food choice motivations (34). Therefore, to better understand the mechanisms underlying the inverse relationship between food literacy and eating behaviour, future studies should consider incorporating mediators such as emotional eating, anxiety, and stress into the model.

In this study, the EBPQ scores were not correlated with the FBG levels. In contrast to the findings of this study, a healthy diet with frequent intake of whole carbohydrates, dairy products, white meat, fish, fruits, and vegetables was reported to decrease FBG levels in patients with type 2 diabetes (35). The quality of dietary fats and carbohydrates was reported to be more important than the quantity of these macronutrients. Whole grains, fruits, vegetables, legumes, and nuts decreased the risk of diabetes and improve glycemic control in patients with diabetes (36). For patients with type 2 diabetes, decreasing energy intake and matching insulin with planned carbohydrate intake were reported to be effective for glycemic control and other metabolic outcomes (37). One of the reasons for the lack of a significant relationship in this study was the short duration of the study. The lack of follow-up period made it difficult to observe the effects of changes in eating behaviour on glycaemic control. In addition, individual management of diabetes is affected by many variables such as physical activity level, compliance with medication, insulin regimen, comorbidities and lifestyle (38). These individual differences were not controlled in the study and may have caused the lack of a significant relationship. The SPFL Scale scores were negatively correlated with the FBG levels. Consistently, one study reported that nutritional literacy was negatively correlated with FBG levels in patients with diabetes (39). Inadequate nutritional literacy may have interfered with glycemic control. Low nutritional literacy was associated with poor glycemic control in uninsured patients with diabetes (12). The findings of this study were consistent with those reported in the literature. Thus, nutritional literacy can affect blood glucose levels.

In this study, the SPFL Scale scores were not correlated with the HbA1c level. A previous study also reported a negative correlation between HbA1c levels and food literacy scores in patients with diabetes (16). In patients with diabetes, the HbA1c level was negatively correlated with nutritional literacy (39). The lack of effect of food literacy on HbA1c in our study may be consistent with the fact that the effects of lifestyle changes on glycaemic control may take time. Long-term intervention studies in the literature suggest that a longer follow-up period may be required for such effects to occur (40, 41). For example; a study showed that a long-term lifestyle intervention revealed a small and significant change in HbA1c level after at least two years (40). In a different study, an increase in the duration of moderate to vigorous physical activity over a three-year period was associated with a decrease in HbA1c percentage in adults at high risk of type 2 diabetes (41). This suggests that the follow-up period of our study may have been insufficient to fully observe the effects of possible improvements in food literacy on HbA1c. Although we did not find a statistically significant association, this may mean that a longer follow-up period and possibly more holistic lifestyle approaches may be required for the behavioural changes we observed to have a clinically evident and statistically significant effect on HbA1c. Consistently, the HbA1c value was negatively correlated with the EBPQ scores in this study. A healthy diet with frequent intake of whole carbohydrates, dairy products, white meat, fish, fruits, and vegetables decreased the HbA1c levels in patients with type 2 diabetes (35). The HbA1c levels in patients with diabetes on a 6-month low-carbohydrate diet were significantly lower than those in patients with diabetes on a regular diet (42). Thus, the findings of this study were consistent with those reported in the literature.

In this study, the EBPQ scores were not correlated with the LDL-C levels. In contrast to our study, Sarmento et al. reported that a healthy diet reduced LDL-C levels in patients with type 2 diabetes (35). Sarmento et al. analysed the dietary habits and eating patterns of patients with diabetes in detail. In their study, they made a more comprehensive evaluation by classifying the patients according to their physical activity level and smoking status. In addition, a food frequency questionnaire covering the last 12 months was administered to measure food intake more objectively. The aforementioned study specifically aimed to investigate the impact of eating behaviours on individuals with diabetes in more depth. The present study aimed to monitor the impact of eating behaviours in a more specific way (35). Ley et al. demonstrated that whole grains, fruits, vegetables, legumes, and nuts improved the blood lipid profile of patients with diabetes (36). In this study, the eating behavior pattern did not affect the LDL-C level because more than half of the patients with type 2 diabetes were obese. In a study in the literature, it was reported that the nutrition and exercise programme did not have a significant effect on LDL-C levels (43). However, this finding indicates that studies with larger samples and long-term follow-up are needed to evaluate the effect of dietary behaviours on LDL-C. Indeed, we believe that monitoring the long-term effects of dietary behaviours may lead to significant changes in LDL-C levels. Therefore, it is important to conduct long-term studies that take into account the sustainability of individuals' dietary habits over time.

In this study, the SPFL Scale scores were positively correlated with the LDL-C levels. One study revealed the correlation of nutritional literacy with triglyceride and LDL-C levels in patients with diabetes (39). In this study, several factors may have contributed to LDL-C upregulation. Approximately 70% of patients had secondary diseases in this study. Some medications used to treat these secondary diseases may increase the LDL-C levels. Additionally, the mean age of the patients was 58 years. The ability of the liver to clear LDL-C decreases with aging, contributing to LDL-C upregulation in the blood (44).

This study is a pioneering study conducted using structural equation modeling to examine the effect of food literacy on eating behavior and biochemical indicators (FBG, HbA1c, LDL-C) in individuals with type 2 diabetes. The negative relationship between SPFL and EBPQ obtained in the study findings is striking, contrary to expectations in the literature. Previous studies demonstrated that food literacy positively affected eating behaviors (19,20,32). However, the negative relationship observed in the current study has been justified by psychosocial factors such as knowledge-practice mismatch, information overload, indecisiveness, stress, emotional eating, body perception, and body anxiety (33, 34). This situation can be explained by the fact that although individuals have knowledge about healthy eating, they cannot convert this knowledge into behavior. The findings of this study reveal that these relationships may be due to more complex factors. Psychosocial factors and individual motivations are thought to play an important role in this relationship, because having knowledge may not translate into healthy eating habits. In this context, the gap between knowledge and behavior can be better understood by examining the mediating role of psychosocial factors in detail in future studies. This study contributes to the literature by emphasizing that food literacy may not have an effect based solely on knowledge level and that environmental and psychological factors should also be taken into consideration.

Nurses, as one of the members of the multidisciplinary team, play a critical role in helping diabetic patients develop healthy eating habits. Nurses should provide training to individuals to develop their nutritional knowledge and eating behaviors in a healthy way in diabetes management. In addition, multidisciplinary team members can contribute to improving the glycemic control and lipid profile of diabetic patients by adopting a holistic approach to food literacy and nutrition education.

This study had limitation. The data were obtained using the convenience sampling method, which is associated with bias in sample selection. The data were based on self-reports of patients with type 2 diabetes. This study did not examine the duration of practicing the eating behavior in patients. In this study, variables such as duration of diabetes, medication use, physical activity and dietary habits were not controlled. Therefore, this may limit the generalisability of the results. Future studies are recommended to address the effect of these variables. Additionally, anthropometric measurements were self-reported by the patients. However, self-reported data may be subject to biases, such as recall inaccuracies, which could affect the accuracy of these measurements.

This study had some potential biases. The collection of data using convenience sampling resulted in the inclusion of only individuals who were accessible to the researcher, and participants were recruited from a single clinic. This means that the sample may not reflect a wider population of people with diabetes. In addition, in this study, the majority of the sample (77.9%) had middle and high income levels. This income distribution may create a potential bias because the small number of low-income individuals led the findings of the study to focus more on the food literacy and eating behaviours of middle- and high-income individuals. The limited participation of low-income individuals resulted in a sample that did not reflect the eating habits of this group. Future studies can reduce this potential bias and increase the generalisability of the findings to a wider population by creating a more balanced sample by income level.

The external validity of the study is also subject to limitations. As the research was conducted in a single hospital located in the Marmara Region of Türkiye, the findings may not be generalizable to individuals with type 2 diabetes in other geographical regions. Variations in lifestyle, dietary habits, cultural norms, and access to healthcare services across different regions may influence food literacy and eating behaviors. Future multicenter studies involving participants from diverse regions will help enhance the external validity and generalizability of the findings.

To ensure the generalisability of this model to larger and more diverse patient populations, further studies should examine how it performs across different subgroups defined by age, gender, ethnicity, socioeconomic status, diabetes duration, treatment type, physical activity level, and dietary habits. It is also important to test the model across different clinical settings and geographic regions, which may reflect variations in healthcare access and lifestyle. Such studies would contribute to understanding whether the model maintains its predictive validity and structural consistency across heterogeneous populations.

This study revealed that SPFL in individuals with type 2 diabetes has an effect on eating behaviors and some metabolic parameters. While nutritional literacy was found to be particularly related to fasting blood sugar levels, no similar relationship was found in HbA1c levels, which are indicators of long-term glycemic control. In addition, as nutritional literacy increased, lipid profile deterioration was observed. This suggests that individuals have difficulty implementing healthy eating behaviors despite their increased food literacy knowledge. In order to improve glycemic control and lipid profiles of individuals with type 2 diabetes, it is recommended that not only food literacy levels be increased, but also interventions that will support the transformation of this knowledge into healthy eating behaviors and the long-term sustainability of these behaviors be implemented. Therefore, it is important for multidisciplinary health professionals such as dietitians, nurses, physicians and psychologists to work in collaboration. This team should create training, support programs and personalized nutrition plans to improve not only the individuals' level of knowledge about food, but also their ability to transform this knowledge into healthy eating behaviors and to maintain it. In addition, it is recommended that patients be monitored long-term to see the development of food literacy and eating behaviors.

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Author Contribution
Serap Çetinkaya Özdemir, Vahide Semerci Çakmak, Havva Sert, and **Taner Demirci** contributed to the conception of the article. **Serap Çetinkaya Özdemir, Vahide Semerci Çakmak, Havva Sert,** and **Taner Demirci** contributed to the data acquisition and preparation. **Serap Çetinkaya Özdemir, Vahide Semerci Çakmak, Havva Sert,** and **Taner Demirci** contributed to the data analysis and figure. **Serap Çetinkaya Özdemir, Vahide Semerci Çakmak, Havva Sert,** and **Taner Demirci** contributed to the interpretation of results. **Serap Çetinkaya Özdemir, Vahide Semerci Çakmak, Havva Sert,** and **Taner Demirci** contributed to the manuscript drafting and revisions. **Serap Çetinkaya Özdemir, Vahide Semerci Çakmak, Havva Sert,** and **Taner Demirci** had the opportunity to access and verify the data. All authors were responsible for the decision to submit the manuscript for publication.

Conflict of Interest
The authors declare no potential conflicts of interest.

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Ethical Approval
This study was approved by Sakarya Unıversity Faculty of Medicine Non-Interventional Clinical Research Ethics Committee (11.05.2022, approval number: E-71522473-050.01.04-128372-130). Written informed consent was obtained from the participants.

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REFERENCES

1. International Diabetes Federation (IDF). IDF Diabetes Atlas. 2021; 10th edition. Access address: https://diabetesatlas.org/idfawp/resource-files/2021/07/IDF_Atlas_10th_Edition_2021.pdf Access date:15.12.2024
2. ElSayed NA, Aleppo G, Aroda VR, Bannuru RR, Brown FM, Bruemmer D, Collins BS, Cusi K, Das SR, Gibbons CH, Giurini JM, Hilliard ME, Isaacs D, Johnson EL, Kahan S, Khunti K, Kosiborod M, Leon J, Lyons SK, Murdock L, Perry ML, Prahalad P, Pratley RE, Seley JJ, Stanton RC, Sun JK, Woodward CC, Young-Hyman D, Gabbay RA, on behalf of the American Diabetes Association. Introduction and methodology: Standards of care in diabetes-2023. Diabetes Care. 2023;46(Suppl 1):S1-S4.
3. Gilcharan Singh HK, Chee WSS, Hamdy O, Mechanick JI, Lee VKM, Barua A, Mohd Ali SZ, Hussein Z. Eating self-efficacy changes in individuals with type 2 diabetes following a structured lifestyle intervention based on the transcultural diabetes nutrition algorithm (tDNA): A secondary analysis of a randomized controlled trial. PLoS One. 2020;15(11):e0242487.
4. Aktas N, Ozdoğan Y. Food and nutrition literacy. Harran Journal of Agriculture and Food Sciences. 2006;20(2):146-153.
5. Vidgen HA, Gallegos D. Defining food literacy and its components. Appetite. 2014;76:50-9.
6. Carbone ET, Zoellner JM. Nutrition and health literacy: a systematic review to inform nutrition research and practice. J Acad Nutr Diet. 2012;112(2):254-65.
7. Boslooper-Meulenbelt K, Patijn O, Battjes-Fries MCE, Haisma H, Pot GK, Navis GJ. Barriers and facilitators of fruit and vegetable consumption in renal transplant recipients, family members and healthcare professionals-a focus group study. Nutrients. 2019;11(10):2427.
8. Razavi AC, Dyer A, Jones M, Sapin A, Caraballo G, Nace H, Dotson K, Razavi MA, Harlan TS. Achieving dietary sodium recommendations and atherosclerotic cardiovascular disease prevention through culinary medicine education. Nutrients. 2020;12(12):3632.
9. West EG, Lindberg R, Ball K, McNaughton SA. The role of a food literacy intervention in promoting food security and food literacy-OzHarvest's NEST Program. Nutrients. 2020;12(8):2197.
10. Duan DF, Liu M, Chen Y, Huang YY, Shi YY. Food literacy and its associated factors in non-dialysis patients with chronic kidney disease in China: A cross-sectional study. Patient Prefer Adherence. 2022;16:439-447.
11. Yıldırım M, Kızıltan G, Ok MA. What is nutritional literacy? Journal of Başkent University Faculty of Health Sciences. 2021;6(Beslenme Özel Sayisi):1-13.
12. Rivera Rivero B, Makarova A, Sidig D, Niazi S, Abddelgader R, Mirza S, Joud H, Urfi M, Ahmed A, Jureyda O, Khan F, Swanson J, Siddique M, Weare-Regales N, Mirza AS. Nutritional literacy among uninsured patients with diabetes mellitus: A free clinic study. Cureus. 2021;13(7):e16355.
13. Bastami F, Mardani M, Rezapour P. Development and psychometric analysis of a new tool to assess food literacy in diabetic patients. BMC Nutr. 2022;8(1):134.
14. Savarese M, Sapienza M, Acquati GM, Nurchis MC, Riccardi MT, Mastrilli V, D'Elia R, Graps EA, Graffigna G, Damiani G. Educational ınterventions for promoting food literacy and patient engagement in preventing complications of type 2 diabetes: A systematic review. J Pers Med. 2021;11(8):795.
15. Riccardi MT, Savarese M, Acquati G, Nurchis MC, Sapienza M, Mastrilli V, Damiani G. Promoting food literacy in type 2 diabetes: a systematic review. European Journal of Public Health. 2021;31(Supplement_3):ckab165-190.
16. Solak Y, Durmus H, Vural Solak GT, Altuntaş SÇ, Mustan AG. Changes in HbA1c values of patients with type 2 diabetes mellitus during the pandemic period and their relationship to food literacy. International Journal of Diabetes in Developing Countries. 2024;44(1):114-121.
17. Yeşilkaya B. Validity and reliability of the eating behavior patterns questionnaire and evaluation of quality of life in people with type 2 diabetes (Doctoral Thesis), Istanbul, Okan University, 2018, 1-139, (Access address: https://tez.yok.gov.tr/UlusalTezMerkezi/tezSorguSonucYeni.jsp and Access date:14.08.2024)
18. Ogden J. The Psychology of Eating: From Healthy to Disordered Behavior, West Sussex, Wiley-Blackwell, 2010.
19. Mostafazadeh P, Jafari MJ, Mojebi MR, Nemati-Vakilabad R, Mirzaei A. Assessing the relationship between nutrition literacy and eating behaviors among nursing students: a cross-sectional study. BMC Public Health. 2024;24(1):18.
20. Kabasakal Cetin A, Aksaray B, Sen G. The role of food literacy and sustainable and healthy eating behaviors in ultra-processed foods consumption of undergraduate students. Food Quality and Preference. 2024;119(1):105232.
21. Golzar J, Noor S, Tajik O. Convenience sampling. International Journal of Education & Language Studies. 2022;1(2):72-77.
22. Poelman MP, Dijkstra SC, Sponselee H, Kamphuis CBM, Battjes-Fries MCE, Gillebaart M, Seidell JC. Towards the measurement of food literacy with respect to healthy eating: the development and validation of the self perceived food literacy scale among an adult sample in the Netherlands. Int J Behav Nutr Phys Act. 2018;115(1):54.
23. Tarı Selcuk K, Cevik C, Baydur H, Meseri R. Validity and reliability of the Turkish version of the self-perceived food literacy scale. Progr Nutr. 2020;22(1):671-677.
24. Palumbo R. The effects of food literacy on sustainability of well-being. Agric Agric Sci Pro. 2016;8:99-106.
25. Schlundt DG, Hargreaves MK, Buchowski MS. The eating behavior patterns questionnaire predicts dietary fat intake in african american women. J Am Diet Assoc. 2003;103(3):338-45.
26. Itzkovitz A, Maggio V, Roy-Fleming A, Legault L, Brazeau AS. Nutrition and food literacy among young Canadian adults living with type 1 diabetes. Diabet Med. 2022;39(11):e14921.

27. Michou MB, Panagiotakos D, Lionis C, Petelos E, Costarelli V. Health and nutrition literacy levels in Greek adults with chronic disease. Public Health Panorama. 2019;5(2-3):271-279.
28. Gebreyesus HA, Abreha GF, Besherae SD, Abera MA, Weldegerima AH, Kidane EG, Bezabih AM, Lemma TB, Nigatu TG. Eating behavior among persons with type 2 diabetes mellitus in North Ethiopia: a cross-sectional study. BMC Endocr Disord. 2021;21(1):99.
29. Kaynarpunar E, Akman M. Determination of nutritional habits, diet quality and eating behaviors of patients with type 2 diabetes. OPUS International Journal of Society Researches. 2021;18(40):2615-2637.
30. Hooper D, Coughlan J, Mullen MR. Structural equation modelling: guidelines for determining model fit. Electronic Journal of Business Research Methods. 2008;6(1):53-60.
31. Karagöz Y, Bardakçı S. Bilimsel Araştırmalarda Kullanılan Ölçme Araçları ve Ölçek Geliştirme, Ankara, Nobel Akademik Yayıncılık, 2020.
32. Bastami F, Haghi M, Mohammadi R, Taherian M, Khani Z, Zaedi P. An investigation of the relationship between food literacy and adherence to a healthy diet: Consumption of food groups in people with type 2 diabetes. Journal of Health Literacy. 2023;8(2):74-86.
33. Kheirollahpour MM, Danaee MM, Merican AFAF, Shariff AAAA. Prediction of the ınfluential factors on eating behaviors: a hybrid model of structural equation modelling-artificial neural networks. Scientific World Journal. 2020;2020:4194293.
34. Sun YH. Health concern, food choice motives, and attitudes toward healthy eating: the mediating role of food choice motives. Appetite. 2008;51(1):42-49.
35. Sarmento RA, Antonio JP, de Miranda IL, Nicoletto BB, de Almeida JC. Eating patterns and health outcomes in patients with type 2 diabetes. J Endocr Soc. 2017;2(1):42-52.
36. Ley SH, Hamdy O, Mohan V, Hu FB. Prevention and management of type 2 diabetes: dietary components and nutritional strategies. Lancet. 2014;383(9933):1999-2007.
37. Franz MJ. Diabetes nutrition therapy: Effectiveness, macronutrients, eating patterns and weight management. Am J Med Sci. 2016;351(4):374-9.
38. Türkiye Endokrinoloji ve Metabolizma Derneği. (TEMD). Diabetes Mellitus ve Komplikasyonlarının Tanı, Tedavi ve İzlem Kılavuzu (2024). Access address: https://file.temd.org.tr/Uploads/publications/guides/documents/diabetesmellitus2024.pdf
39. Güner TA, Günter T. The effect on the quality of life and metabolic control of nutritional literacy in ındividuals with diabetes mellitus. Online Turkish Journal of Health Sciences. 2022;7(1):19-26.
40. Sone H, Katagiri A, Ishibashi S, Abe R, Saito Y, Murase T, and JDC Çalışma Grubu. Yaşam tarzı değişikliklerinin tip 2 diyabetli hastalar üzerindeki etkileri: Japonya diyabet komplikasyonları çalışması (JDCS) çalışma tasarımı, başlangıç analizi ve üç yıllık ara rapor. Hormon ve Metabolik Araştırma. 2002;34(09):509-515.
41. McCarthy M, Edwardson CL, Davies MJ, Henson J, Gray L, Khunti K, Yates T. Change in sedentary time, physical activity, bodyweight, and hba1c in high-risk adults. Med Sci Sports Exerc. 2017;49(6):1120-1125.
42. Dorans KS, Bazzano LA, Qi L, He H, Chen J, Appel LJ, Chen CS, Hsieh MH, Hu FB, Mills KT, Nguyen BT, O'Brien MJ, Samet JM, Uwaifo GI, He J. Effects of a low-carbohydrate dietary intervention on hemoglobin A1c: A randomized clinical trial. JAMA Netw Open. 2022;5(10):e2238645.
43. Tezcan Cİ, Suna G, Karabulak A. Yetişkin bireylerde e-sağlık mobil uygulama destekli beslenme ve egzersiz programlarının vücut kompozisyonu ve bazı kan parametreleri üzerine etkisinin incelenmesi. Süleyman Demirel Üniversitesi Sağlık Bilimleri Dergisi. 2024;15(1):17-28.
44. Blood Cholesterol Causes And Risk Factors. Access address: https://www.nhlbi.nih.gov/health/blood-cholesterol/causes#:~:text=Eating%20a%20lot%20of%20foods,should%20come%20from%20saturated%20fats., Access date:17.12.2024
45. Image. Access address: https://www.bugday.org/blog/tag/etiket-okuma/, Access date:27.04.2025
46. Image. Access address: https://www.obezitecerrahi.com/seker-hastaligi-ameliyati-fiyatlari/, Access date:27.04.2025