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Effectiveness of a Nutrition Education Program for Patients with Type 2 Diabetes Mellitus

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Abstract: Diabetes is a metabolic disease that is a major health problem globally. Dietary interventions contribute to the management of the disease and the improvement in patients' quality of life. The aim of the present study was to assess the effects of a nutrition and lifestyle education intervention on a sample of patients with diabetes. The duration of the intervention was 3 months, and it focused on the promotion of the Mediterranean diet through information pamphlets, diet plans and healthy lifestyle guidelines, which were provided in addition to patients' standard medical treatment. Patients were enrolled in the outpatient clinic of the University Hospital of Larissa (Greece). Anthropometric and biochemical parameters were recorded at baseline and follow-up using standardized equipment and methods. The intervention improved patients' body mass index, body composition, fasting glucose, postprandial glucose, triglycerides, HDL/LDL cholesterol and cholesterol. For smoking status, alcohol consumption and physical activity categorization, physical activity improved but not the other two indices. The results of this study show that patient education should be provided according to the nutritional recommendations for T2DM plus a more individually structured intervention. It is therefore necessary to direct the attention of doctors to the need for continuous and detailed discussions with patients in relation to both the standards of a healthy diet and the benefits it brings. Patients, for their part, need to commit to following an appropriate, healthy diet.

Keywords: diabetes; nutrition; weight loss; education

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1. Introduction

The prevalence of type 2 diabetes mellitus (T2DM) worldwide is increasing at epidemic proportions [1]. Chronic hyperglycemia is considered a major risk factor for cardiovascular and kidney disease, retinopathy and neuropathy [2]. The Center for Disease Control (CDC) estimates that almost 33% of adults in the U.S. have prediabetes; therefore, preventing or delaying T2DM is a public health imperative to help extend and improve the lives of millions of people [3].

The increase in the prevalence of T2DM is paralleled with the increase in overweight/obesity, and it has become particularly evident in the last decade [4]. Undoubtedly, as a person's body mass index (BMI) increases, the risk of developing T2DM increases in a "dose-dependent" manner. The prevalence of T2DM is 3–7 times higher in obese than in normal-weight adults [4], and people with a BMI > 35 kg/m^2 are 20 times more likely to develop T2DM than those with a BMI between 18.5 and 24.9 kg/m^2 [5]. Obesity also complicates the management of T2DM by increasing insulin resistance and blood

glucose concentrations [6]. Obesity is also an independent risk factor for dyslipidemia, hypertension and cardiovascular complications and cardiovascular mortality in patients with T2DM [2].

Attaining and maintaining a healthy body weight is a major therapeutic target in the management of T2DM. Governments are looking to identify the most effective services to support overweight/obese patients with T2DM to lose weight and improve their health status and quality of life [7]. Data from the Diabetes Prevention Program (DPP) showed that weight loss (7% of weight lost in the first year), increased physical activity (150 min of walking per week) and improvements in other lifestyle behaviors (e.g., dietary behavior) decreased the 4-year incidence of T2DM by 58% in men and women with glucose tolerance disorders [8].

Some strategies associated with successful long-term weight loss include lifestyle modification, specifically the adoption of low-caloric diets, frequent body weight monitoring, and participation in regular physical activity. Successful weight loss is accompanied by a reduction in the portion size of meals, foods and snacks, daily breakfast consumption, and 3 or less hours of screen-watching (television, computer, tablets/smartphone) per week on average [9,10]. The link between overweight and obesity and many non-communicable diseases is well known [11]. Weight loss has a major impact on improving glycemic control and reducing the risk of cardiovascular disease [12].

Dietary recommendations need to be based on personal choices, access to food and the patient's culture and ability to make behavioral changes [13]. Interventions in the patient's lifestyle to increase physical activity and reduce caloric intake aim to reduce body weight by 5%, as this can improve HbA1c and cholesterol and reduce cardiovascular risk [14]. The American Diabetes Association emphasizes the importance of educating the patient to make conscious food choices that take into account personal preferences, culture and religion and individualized metabolic goals. The diet patterns with the most beneficial effect on the metabolic profile have been mentioned as the Mediterranean diet and the vegetarian diet [15,16].

Long-term improvements to lifestyle, especially nutrition and physical activity, are challenging for most patients. The role of healthcare professionals working with diabetic patients is to encourage, monitor and support them in this effort [17]. Several techniques can be used to promote behavioral change. First, behaviors need to be screened, and personalized goals need to be set by the healthcare professional in agreement with the patient. Setting realistic and achievable goals allows patients to achieve success, which can be a starting point for further lifestyle change [18,19]. Strategies such as self-monitoring, avoidance of situations that trigger food intake and problem-solving (to the extent possible) may support self-regulation over time. Frequent communication and educational meetings (e.g., every fortnight) are associated with better long-term maintenance of weight loss [20].

The purpose of this study was to investigate the effectiveness of a nutrition and lifestyle education intervention in patients with T2DM for a patient-approach medicine. At the same time, the level of nutritional knowledge of the patients was assessed and their problems in adopting appropriate nutritional approaches were recorded with the ultimate aim of improving them. Some small studies promote nutritional supplementation [21] or a diet that may affect postprandial glucose or other metabolic biomarkers [22–24] or alter the metabolic profile through intermittent fasting [25], but only a few have examined the impact of behavioral [26] and patient-centric therapeutic approaches [27] for diabetes, so original research could close the gap. This study aims to present multifaceted strategies compared with the clinical studies conducted in the last years, with diet playing a pivotal role in T2DM management, with a special focus not only on the Mediterranean diet but also on personalized dietary recommendations for patients and shedding light on the efficacy of a multidisciplinary team of health professionals.

2. Participants and Methods

2.1. Study Designed

The study was approved by the competent Bioethics Committee of the University of Thessaly (approval numbers 49162/13-10-2017 and 49161/13-10-2017), and it was in line with the Declaration of Helsinki. All volunteers signed a written informed consent prior to their participation in the study. The study period was from October 2017 to January 2018.

2.2. Participant Recruitment

Eighty-eight T2DM patients (forty males and forty-eight females, average age 51.4 years) were admitted to the Larissa General University Hospital, Greece, for 90.0 ± 3.3 days. Criteria for participation in the study were a diagnosis of diabetes established by hemoglobin A1C (HbA1c) or plasma glucose concentration. In addition, individuals with a recent diagnosis of T2DM (<3 months) and who were treatment-naive, 30–70 years of age, clinically and biochemically stable and without any acute metabolic complications of diabetes were also considered for the study. Individuals with history of recent alcohol use (<6 months), pregnant women and those in a severe comorbid state were excluded. The clinical samples for analysis were collected at the baseline (t = 0 months) and at the end (t = 3 months) of the study.

2.3. Data Collection and Measures

At baseline, patients filled out the questionnaire (demographic characteristics, personal information, complications of the disease), and data were recorded for biochemical indicators, including fasting glucose, blood glucose, HbA1c, total cholesterol, HDL cholesterol, LDL cholesterol and triglycerides, and also medications. Anthropometric data were also collected. Participants' weight was measured in light clothing and without shoes using a portable calibrated electronic weighing scale precision scale (TAN- ITA MC-780U Multi Frequency Segmental Body Composition Analyzer, Amsterdam, the Netherlands). Height was measured with portable measuring inflexible bars (Seca model 220, Seca, Hamburg, Germany). Waist (at umbilicus) and hip (at widest point) circumferences (WC and HC) were measured according to standard conditions using a measuring tape, and waist/hip circumference ratio (WHR) was calculated. Blood pressure was measured with a clever blood monitor (FYGB-869). All measurements were taken twice, and the average of the two values was reported, as suggested [28]. The follow-up was planned after 3 months and aimed to evaluate potential changes in the collected variables. Subjects recorded their physical activity using the International Physical Activity Questionnaire [29] and a validated diet recall Food Frequency Intake form [30].

Low-density lipoprotein cholesterol (LDL) was calculated according to the Friedewald formula [31]. Fasting glucose was calculated [32], and glycated hemoglobin (HbA1c) was measured by high-performance liquid chromatography (HPLC). All participants were evaluated for their changes in the collected variables.

2.4. Lifestyle and Nutritional Intervention

Each patient was allocated to one dietitian, a nutritionist, who was responsible for educating, measuring and adhering to the intervention. The intervention included one face-to-face meeting about nutrition under the direction of a dietician and the patient. During this visit, the patients were informed about the purpose of the study, answered the 24 h diet recall questionnaire [33] and were given an individualized nutritional plan (the energy requirements were calculated and personalized according to the preferences/needs of each patient) and detailed nutritional instructions, recommendations and advice, both for their diet and eating behavior. Patients were also educated regarding the choices of foods containing carbohydrates, with the aim of regulating sugar levels within normal limits as well as easily forming their daily diet. There were written specific nutritional recommendations: to have 5–6 meals per day, dividing the foods containing carbohydrates, to prefer foods rich in soluble fiber (legumes, fruits, vegetables, whole grains), to avoid the consumption of pure sugar and products containing it (sweets, cookies with sugar,

cakes, jelly, ice creams with sugar, candies, sugared drinks, etc.), to reduce salt consumption and to avoid the consumption of saturated fat contained mainly in red meat, cold meats, egg yolks (up to 3 times/week) and butter. Emphasis was given to the consumption of vegetable fats, mainly olive oil, and to replace red meat with fish as much as possible. All participants' diets were evaluated to assess their compliance with the Mediterranean diet and standards recommended by the American Diabetes Association [34] and the Hellenic Diabetes Association [35]. Some dietary recommendations were given by the dietician, such as reducing the intake of calories, total fat to <30% of daily energy intake and saturated fat (including trans fatty acids) to <10% of daily energy intake and increasing fiber intake (15g to 30g/day) [36]. The patients were given a form with the food categories mentioned above and an individualized nutritional plan (55% carbohydrate, 15% protein, and 30% fat) that they could follow for weight loss, as this was a key target of the intervention for those who were overweight or obese. They also received instructions for exercise. More precisely, participants were instructed to follow a Mediterranean-type diet and to perform at least 150 min of moderate-intensity exercise a week. Adherence to recommendations from dietitians was reported after the three-month intervention. Finally, the patients could communicate, either through calling, messaging or visiting the dietician during the three-month intervention, for questions or for support for their efforts.

2.5. Statistical Analyses

Statistical analysis was performed with the Statistical Package for the Social Sciences (SPSS 21). A frequency analysis was performed for each of the variables in the questionnaires. The Kolmogorov–Smirnov test was used to test the variables for a normal distribution. Data are presented as mean ± standard deviation (SD) or as median value (interquartile range). A paired *t*-test was used to compare parametric variables before and after three months of the nutrition education intervention; the Wilcoxon test was used for non-parametric data; and the chi-square test was used for categorical variables. *p*-values < 0.05 (two-tailed) were considered statistically significant.

3. Results

3.1. Study Population

Individuals with a history of recent alcohol use (<3 months) or in a severe comorbid state were excluded. The study population consisted of 48 females (mean age 50.1 ± 9.1 years) and 40 males (mean age 51.4 ± 6.8 years). The average interval between baseline and the end of the follow-up was 90.0 ± 3.3 days, and all participants completed the study. The study was explained to all the individuals initially considered. Only 88 of the initial 100 patients gave informed written consent and so participated in the intervention at the Hospital of Thessaly.

3.2. Socio-Economic Data, Nutritional Knowledge and Perception of T2DM Treatment

Although, risk factors for people with T2DM [3] are well known. it is therefore necessary to select socio-economic data and clinical characteristics of the T2DM patients.

More than half of the patients were treating diabetes with antidiabetic medication only (56.8%), with 3.4% injecting insulin and only 9.1% taking diabetic medications and eating a balanced diet (Table 1).

The amount patients spent on food each month was also checked for correlation with dietary guidelines. Most (52% of the sample) spent EUR 200–300, 32% spent EUR 300–400, 11% spent less than EUR 200 and just under 5% spent more than EUR 400.

As part of the interview, patients were questioned about their educational level. The results showed that almost half of the patients had a high school degree (42.5%), while only 4.6% had an elementary school degree. The rest of the patients had a university degree (Table 1).

No comorbidities were recorded in 25 patients; 57.5% had a family history of diabetes. The frequency of comorbidities for the remaining 63 patients is recorded in Figure 1.

Table 1. Socio-economic data and clinical characteristics of the T2DM patients (N = 88).

		%
Sex	Men	45.5
	Women	54.5
Education	Primary Education	4.6
	Secondary Education	42.5
	Higher Education	52.9
Financial budget per month for food	EUR < 201	11.4
	EUR 201–300	52.3
	EUR 301–400	31.8
	EUR > 400	4.5
Treatment of T2DM	Exercise and insulin	1.1
	Exercise. and medication	1.1
	Exercise and diet	1.1
	Diet, exercise and medication	6.8
	Diet and medication	9.1
	Insulin	3.4
	Medication	56.8
	Medication and insulin	20.5

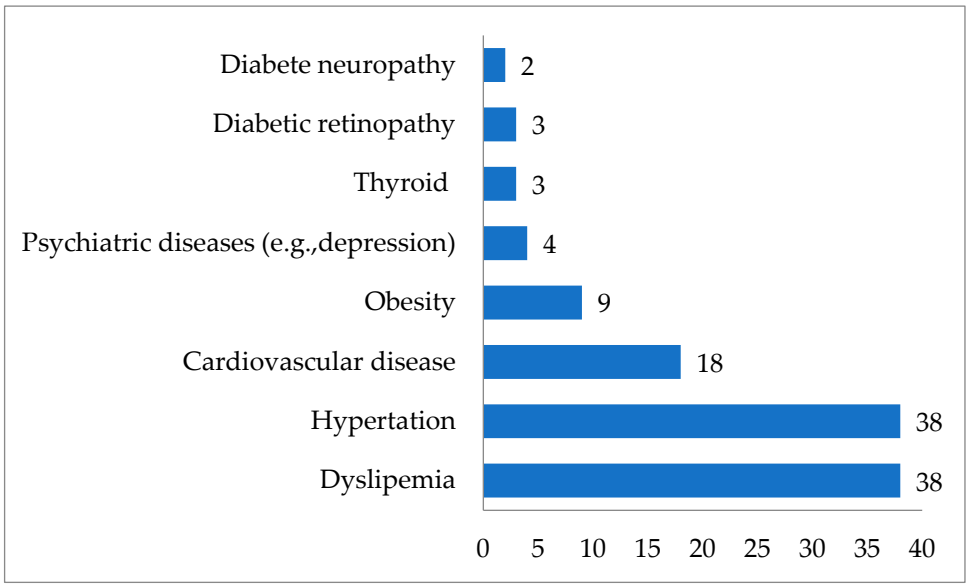

Figure 1. Comorbidity of the participants (%).

When asked about the frequency of blood glucose monitoring by the patients, 50% answered 1 time/day. After analyzing the patients' responses to the questionnaire, it was found that 90% of patients reported the frequency of their visits to the doctor for diabetes was every 3 months and 10% every year. A total of 89.8% of patients responded that they were not informed about the severity of the disease, while 10.2% of patients were informed. When asked if dietary instructions were given after the onset of the disease, the physician responded that it was the patient's responsibility. Almost half of the patients exercised every day. Finally, patients were asked if they smoked, and 25% of patients answered yes (Table 2).

Figure 2 shows the percentage of participants who adhered to the dietary guidelines prior to the intervention. Before the intervention, half the patients had not received clear dietary guidelines related to treating their diabetes. The others had been given some kind of dietary plan by the research dietician. For the majority of patients (56%), reducing carbohydrate intake was the most important dietary goal; 20% of patients tried to increase their intake of fruit and vegetables; 42% chose to include low-fat foods in their diet; 27% of patients did not follow any

dietary guidelines. In terms of sodium consumption, only 5% restricted the consumption of processed foods, and 35% refrained from eating particularly salty foods.

Table 2. Therapeutic approaches and treatment of T2DM (%).

		N %
Frequency of blood glucose measurement	Occasionally	3.4
	Weekly	8.0
	1 time/day	50.0
	2–3 times/day	34.1
	>3 times/day	4.5
Frequency of doctor visits for type 2 diabetes mellitus	Once a year	13.6
	Once per 6 months	28.4
	Once per 3 months	35.2
	1 time/month	17.0
	2 times/month	5.7
Update on disease severity/consequences of non-regulation	No	89.8
	Yes	10.2
With the onset of the disease, were dietary instructions given (immediately)? If so, by whom?	No	11.4
	From the doctor	52.3
	By the dietitian with guidance from the attending physician	36.4
	From the dietitian during a visit on individual initiative	0.0
Reason for not visiting a dietitian	No answer	20.5
	Negligence	31.8
	The doctor is enough	36.4
	Cost	8.0
	No time available	3.4
Participation in physical activity	No	27.3
	Housework	6.8
	Outside work	2.3
	Walking	53.4
	Jogging	2.3
	Sport	8.0
Frequency of exercise	No answer	27.3
	1 time/week	2.3
	2 times/week	4.5
	3 times/week	10.2
	4 times/week	3.4
	5 times/week	5.7
	Every day	46.6
Smoking	No	75.0
	Yes	25.0

When asked about their knowledge of the proper diet for someone with diabetes, the largest percentage (57.5%) rated this as moderate, while 37.9% felt they were adequately informed. A small percentage of 3.4% felt that they had very good knowledge and 1.1% felt that they had no knowledge in this area.

3.3. Efficacy of the Nutrition Education Intervention

At the end of the dietary intervention period, changes were seen in all anthropometric and biochemical variables measured. Body weight and body mass index (BMI) decreased significantly, as did systolic blood pressure, fasting and mean glucose, total and LDL cholesterol and triglycerides (TGs) (Table 3). The most important outcome was the change

in body composition (average body fat and vascular fat percentage averages) and waist circumference (Table 3).

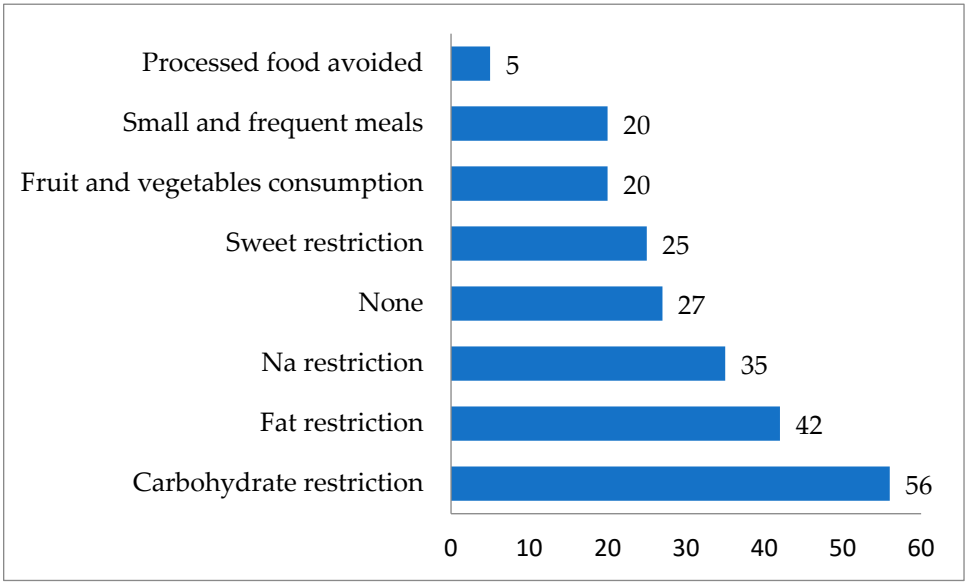

Figure 2. The participants who followed the nutritional guidelines before the intervention (%).

Table 3. Somatometric characteristics, biochemical variables and 24 h dietary recall results of the participants (N = 88) at baseline and after three months of the nutrition education intervention.

Characteristics *	At Baseline (t = 0 Months)	After Intervention (t = 3 Months)	*p*-Value
Body weight (Kg)	81.8 ± 17.2	77.8 ± 16.3	<0.001 *
BMI (kg/m^2)	28.8 ± 5.0	27.1 ± 5.4	<0.001 *
Waist circumference (cm)	107.4 ± 26.0	103.4 ± 25.5	<0.001 *
Hip circumference (cm)	96.8 ± 24.0	94.5 ± 23.6	<0.001 *
Waist–hip ratio	1.2 ± 0.1	1.1 ± 0.1	<0.001 *
HbA1c (%)	7.2 (6.4–8)	7.6 (6.7–7.7)	0.672 *
Postprandial blood glucose (mg/dL)	161.6 ± 36.0	131.9 ± 26.7	<0.001 *
Fasting glucose (mg/dL)	110.7 ± 19.5	99.5 ± 13.9	<0.001 *
Total cholesterol (mg/dL)	183.0 ± 41.1	165.8 ± 26.8	<0.001*
LDL-c (mg/dL)	96.2 ± 35.4	89.4 ± 20.0	0.002 *
HDL-c (mg/dL)	48.2 ± 15.5	47.1 ± 6.5	0.443 *
TG (mg/dL)	154.7 (150.7–154.7)	119.7 (69.7–120.7)	<0.001 **
SBP (mmHg)	14.2 ± 11.4	11.8 ± 0.9	0.056 *
DBP (mmHg)	8.8 ± 7.9	8.0 ± 0.4	0.342 *
Atherogenic index	4.1 ± 1.3	3.5 ± 0.5	<0.001 *
Uric acid (mg/dL)	6.5 ± 1.7	6.2 ± 1.4	0.0001 *
Body fat (%)	32.9 ± 7.8	29.2 ± 7.6	<0.001 *
Visceral fat (%)	11.8 ± 0.1	10.2 ± 0.1	<0.001 *
Muscle mass (%)	88.7 ± 4.3	83.1 ± 5.8	0.331 *
Daily calorie intake (kcal)	1659.7 ± 285.9	1631.4 ± 267.3	0.002 *

BW: body weight, BMI: body mass index, WC: waist circumference, HC: hip circumference, WHR: waist-to-hip ratio, HbA1c: glycated hemoglobin, BGP: blood glucose postprandial, FBG: fasting blood glucose, TC: total cholesterol, HDL: high-density lipoprotein cholesterol, LDL: low-density lipoprotein cholesterol, TG: triglycerides, SBP: systolic blood pressure, DBP: diastolic blood pressure, AI: atherogenic index, UA: uric acid, BF: body fat, VF: visceral fat, MM: muscle mass, DCI: daily calorie intake. Data are mean ± standard deviation (SD) or median value (interquartile range). * *p* values for the comparison with baseline by paired *t*-test. ** *p* values for the comparison with baseline by Wilcoxon test.

The atherosclerotic index and uric acid also decreased significantly at the end of the study period, while no significant changes occurred in HbA1c, HDL cholesterol, diastolic blood pressure and muscle mass (Table 3).

Based on the 24 h reminders at the beginning and end of the study, 73.4% of patients reduced their daily calorie intake and 5.9% increased their consumption of high-fiber foods by the third month, a large percentage (from 67.8% at the first visit to 59.8% in the third month) reduced their alcohol consumption, 5.9% opted for plant-based foods in place of meat, chicken and fish, while 5.2% made no changes to their dietary habits (Figure 3). Regarding patients' participation in physical activities, the percentage increased slightly by the third month, such as brisk walking, cycling or playing a friendly game of basketball or soccer (moderate to vigorous physical activity) (Figure 1). A significant percentage of patients skipped meals both at the beginning and at the end of the study (especially dinner (55.2%)) (Figure 4), although skipping breakfast and afternoon snacks was less frequent in the third month of the intervention and the differences were statistically significant ($p < 0.05$) (Figure 4). Lunch was the only meal that was not skipped by anyone.

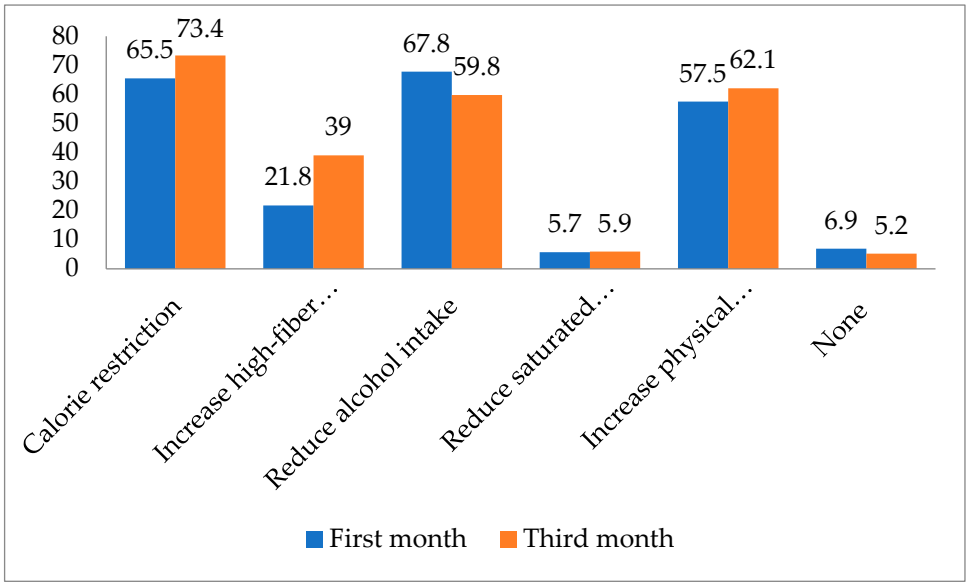

Figure 3. Percentage (%) of patients following the recommendations according to the ADA [22].

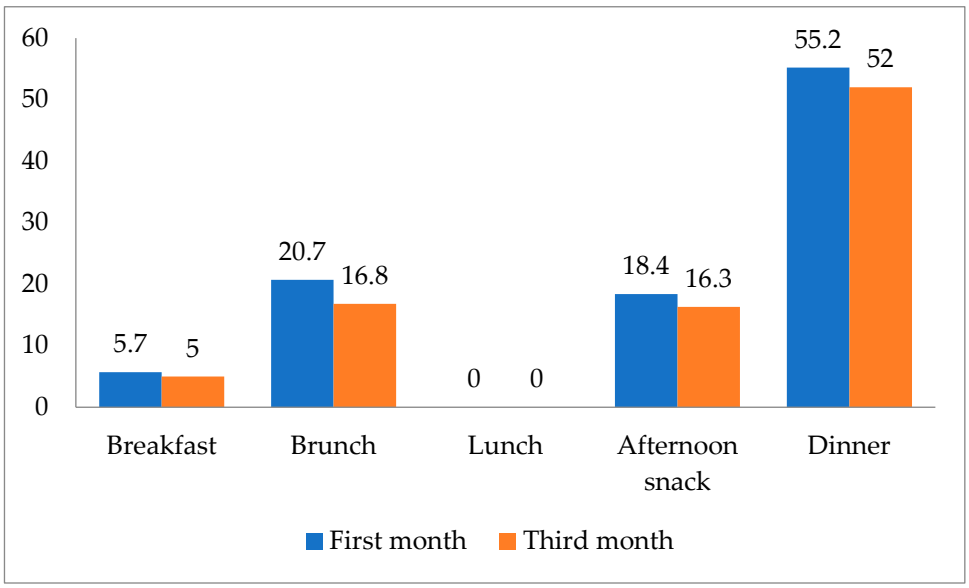

Figure 4. Percentage (%) of meal-skipping in participants.

Since dietitians should focus on individualized nutritional care to gain a holistic understanding of their patients, we recorded the frequency of patient communication with the dietitian during the three-month intervention and the results are shown in Figure 5.

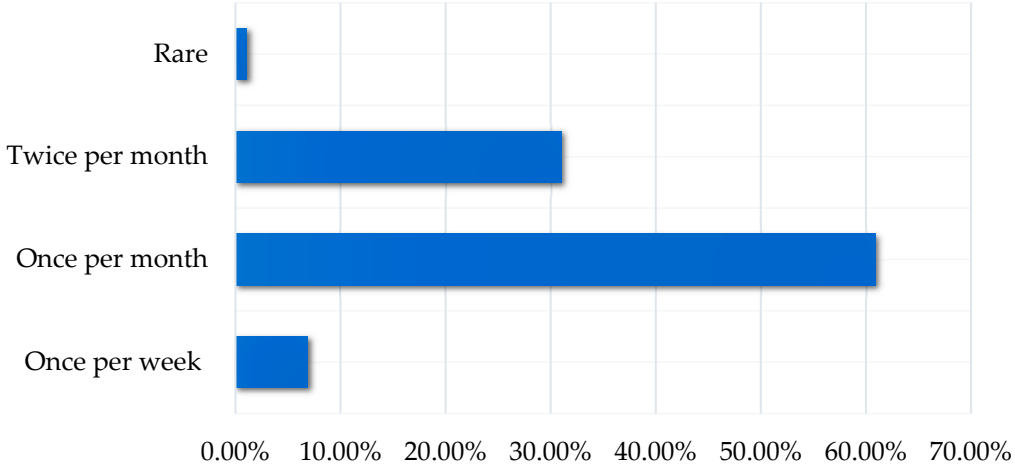

Figure 5. How often the patients communicated (either through calling, messaging or visiting) with the dietician during the three-month intervention.

4. Discussion

In this study, the nutritional and lifestyle recommendations given to diabetic patients appeared to cause significant changes in anthropometric characteristics and biochemical markers 3 months after a face-to-face meeting with a specialized dietitian. This is due to dietary instructions and changes in their physical activity (Tables 1 and 2). Main role in achieving and maintaining an appropriate body weight, preventing complications of the disease (Figure 1) and improving the overall clinical picture play also the appropriate dietary changes (Figure 2).

Other studies have also examined a similar research topic [37–39]. In most of them, a significant trend of a decrease in the recorded anthropometric characteristics and biochemical indices was observed [40]. In our study, body weight decreased from 81.8 to 77.8 kg after 3 months, and BMI also decreased from 28.8 to 27.1 kg/m^2. There was also a significant reduction in the average fasting blood glucose from 110.7 to 99.5 mg/dL and in the mean value of lipids (total cholesterol, LDL cholesterol, HDL cholesterol and triglycerides). The greatest change was observed in the mean total cholesterol and the mean triglyceride values. According to a recent study with a 3-month intervention to improve glucose control in individuals with type 2 diabetes through education, the HbA1c value was reduced by 1.1% [41]. In the ANODE study (2017), other secondary endpoints in the intention-to-treat analysis with web-based nutritional coaching were fasting blood glucose 1.46 mmol/L, total cholesterol 0.21 mg/dL, LDL-c 0.2 mg/dL, HDL-c 0.05 mg/dL, triglycerides 1.05 mg/dL and uric acid 45.45 μmol/L [42]. In our study, the changes in the other biomarkers were higher, with the exception of fasting blood glucose and uric acid, which were the same: fasting blood glucose 1.12 mmol/L, total cholesterol 17.2 mg/dL, LDL-c 6.8 mg/dL, HDL-c 1.1 mg/dL, triglycerides 35 mg/dL and uric acid 30 μmol/L. Other studies had positive results [41,42], as our study has. A possible explanation is the multi-layered strategies such as a personalized diet plan, written instructions with healthy food choices and personal contact with the dietician.

Some studies found varying effects of nutritional education [43–45]. For example, one study of 100 patients with type 2 diabetes found no significant effects on BMI or daily intake of fruit and vegetables, but there were positive changes in fasting blood glucose and HbA1c as well as weekly consumption of fruit and vegetables. Weekly moderate physical activity also improved [46]. Awareness about diabetes complications and consequent improvements in dietary knowledge, attitude and practices lead to better control of the

disease [47]. Different medications may also have different effects [48] and it is important to provide appropriate motivation for physical activity [49]. Our study did not find any significant change in HbA1c values, although significant changes occurred in fasting blood glucose levels. The biggest change was found in those who followed the dietitian's nutritional advice.

Our results agree with other studies that both dietary guidelines and nutritional interventions contribute to the reduction in anthropometric characteristics and biochemical indicators of people with type 2 diabetes. Following specific dietary interventions also gives better results for weight loss than are found in people who follow more general dietary recommendations [50].

Our sample consisted of patients admitted to the hospital due to uncontrollable diabetes. It is possible that being admitted to the hospital and being given information about the possible complications that can occur if T2DM is not controlled contributed to their more positive attitude toward making changes in their behavior, both in terms of diet and physical activity (Figure 3). The intervention in the 88 adults with T2DM played an important role in their overall health.

Multiple supportive connections in community settings can also help people lose weight.

A study by Pellegrini and colleagues [47] aimed to evaluate the effectiveness of a technology-based system (TECH) on weight loss when used alone or in combination with a 6-month, in-person, behavioral weight loss intervention [47]. In another study of 212 patients [48], biomarkers such as fasting glucose, postprandial plasma glucose, triglyceride and HbA1c were lower at each follow-up meeting with the dietitian, which highlighted the improved patients' knowledge and behavior using the mobile interactive system as a helpful tool [49].

Nutrition is unquestionably important in the progression of T2DM, but most people rely more heavily on medication to manage their disease. In our study, the majority of the patients managed their diabetes by taking medicinal tablets (26.4%) or by combining antidiabetic drugs with appropriate nutrition/diet (27.6%). One review of 22 studies of overweight adults with type 2 diabetes [51] found that the most successful weight loss occurred with multicomponent interventions, including more intense physical activity and very low-calorie diets or low-calorie diets [51].

Programs delivered in primary care can produce meaningful weight loss. In our study, the average weight loss was 4 Kg. It is reported that a 5% to 10% weight loss is associated with health benefits, including lower systolic blood pressure along with reduced triglyceride and glucose levels, which may impact cardiac health [52]. In addition to weight control, the first goal is macronutrient and micronutrient intakes at the right amounts according to national dietary recommendations, i.e., a high-quality diet [34]. The proper dietary plan could be helpful for patients to follow the advice, as many do not realize that following the proper dietary rules prevents the occurrence of complications of the disease and improves the overall clinical picture of the patient [43]. In addition, more than half of the participants did not correctly identify alcohol as a factor that plays a role in the progression of the disease. Although abstaining from alcohol does not "reverse" diabetes per se, it significantly improves glycemic control and reduces the likelihood of complications [53]. Our study also showed that the consumption of breakfast is a factor in better metabolic biomarkers (Figure 4). This concurs with findings from a study of adults in families at high risk of T2DM in six European countries [54]. Another important finding of our study, as shown in the initial interviews of the patients with the dietitian, is that patients ignore the basic parameters of the disease. Although they know the importance of regulating blood glucose concentrations, they consider that reducing the calories they consume is enough to protect them from adverse situations. Observance of the frequency of meals by diabetic patients is of particular importance, but there was also a number of patients who skipped meals. Finally, the Mediterranean diet is considered a well-formed diet plan. However, with all dietary changes, we know that institutions and organizations

need behavioral scientists to assist consumers in becoming more aware of healthy eating habits, nutritional labeling and checking overall health [27].

According to the Academy of Nutrition and Dietetics and the Endocrine Society, another factor that affects the success of a nutrition education program and may minimize the frequency of visits to a dietitian is the cost [55]. A potential solution could be for primary care to support the recommendations from the organizations through consultations with health professionals [56].

Other factors, such as emotional support as well as fast and effective access to care, have been found to be important [57]. A greater number of contacts between patients and providers led to greater weight loss (Figure 5). The dietitian in all the studies followed some strategies for weight loss (>1 kg/month) such as dietary plans with detailed diet information or advice on cooking and minimizing the frequency of eating out and some other support tools like a food exchange list. Some specifically list replacement foods organized by food groups and guidelines on healthy food choices or even healthy recipes [58].

After the nutritional intervention, a change was observed in all biochemical indices and anthropometric characteristics studied. Therefore, the adoption of a careful dietary pattern based on the Mediterranean diet can lead to significant and long-term changes in metabolic profile due to minimizing ultra-processed foods, which are high in saturated fats and added sugars. Such changes protect against cardiovascular complications [59,60].

Diet advice via individual sessions as treatment has occurred in many studies [61]. A single dietary counseling session [62], as in our study and others, did not have the same results as can occur in more intensified interventions such as weekly [63], fortnightly [64] or monthly sessions [20].

Dietary patterns such as the Mediterranean diet as well as physical activity are crucial for improving the metabolic disturbances seen in patients with diabetes [65]. The primary goal is to reduce saturated and trans fatty acids. Dietary plans documented to reduce body weight at least by 5% in overweight and obese people should also reduce total fat to <30% of daily energy intake, reduce saturated fat (including trans fatty acids) to <10% of daily energy intake, increase fiber intake (14g/1000 Kcal) [66], minimize refined and processed foods [67] and increase omega-3 fatty acid intake [68]. Increasing the daily consumption of natural foods rich in dietary antioxidants (tocopherols, carotenoids, vitamin C, flavonoids, polyphenols), trace elements and vitamins by increasing vegetable and fruit intake to 400 g/day should be encouraged [69]. Educational meetings with the dietitian in primary care will possibly help patients better understand type 2 diabetes and show how they can control it with easy-to-apply lifestyle changes. The interaction and exchanges between different specialists, a friendly atmosphere of meetings, weight loss tips, including the latest research-backed strategies, healthy eating plans, smart nutritional secrets, meal-planning help and lifestyle strategies to help manage diabetes could help patients control diabetes. Moreover, effective social support with assistance and encouragement from family members, adequate self-management skills and self-efficacy (confidence) may reduce the risk of developing diabetes complications [70].

In our study, despite recommendations from health professionals to adopt a healthier lifestyle, many patients avoided exercising, while a high percentage of patients smoked. These practices are anything but helpful in controlling the disease. This finding should concern and activate health professionals to mobilize change in the behavior and habits of patients. Exercise seems to have a positive association not only with the regulation of systolic and diastolic blood pressure [71] but also with glycemic control [72] and variability, insulin sensitivity, lipid profile, oxidative stress/antioxidative capacity and/or chronic inflammation [73]. Although there is limited evidence, stopping smoking has been shown to have benefits in reducing or slowing the risk of cardiovascular morbidity and mortality in people with diabetes [74].

The nutritional intervention adopted by our patients was based on the principles of the Mediterranean diet [69]. The Mediterranean diet is considered to be a model of healthy eating. Its beneficial actions are generally accepted both in the general population and in

patients with T2DM [66]. It is a food pattern that satisfies all the conditions of a suitable diet for the regulation of the disease. It is therefore necessary to inform patients about the beneficial effects of this nutritional model in order to adopt it in their daily lives. Many people with diabetes initiate a conversation about diet with a health professional themselves [75]. The primary reason clinicians initiate a conversation about weight management is to avoid follow-on complications from T2DM [76]. A key strategic theme is to strengthen research-based understanding of T2DM and public health to improve the lives of young people and adults living with or at high risk of developing T2DM.

Therapeutic patient education for obesity or diabetes is a cost-effective intervention that improves patient outcomes [51]. The first step is to learn about the patient's circumstances and perspective, the second step is to help the patient identify their goals, the third step is to help the patient develop a plan (especially a dietary plan and oral health routine), the fourth step is to help the patient implement their plan and the fifth step is to review progress and adjust to changing circumstances. According to the most recently published WHO guidelines (2023), this review identified the factors that could be helpful for doctors, dietitians, nutritionists and other health professionals to promote health and prevent T2DM complications through education [27].

The main objective is to give health professionals better access to effective nutrition education for all people by identifying risk factors such as obesity, malnutrition, excessive sugar intake, weight, age, smoking, alcohol consumption and physical inactivity. A fundamentally different approach is then needed, one that emphasizes disease prevention and health management through a multidisciplinary, integrated and patient-centered approach to overall health [76].

The limitations of this study include the small sample size. The primary care physician was recommended and notified. Future research needs to be conducted using artificial intelligence and its applications to diabetes in order to detect and manage the disease and capture more data to be recorded for personalized healthcare with lower costs. A fully automated web-based program improves lifestyle habits and HbA1c in patients with type 2 diabetes and could be the next step for the researchers.

5. Conclusions

In conclusion, this study adds to the existing scientific evidence of the benefits of a nutrition education program for patients with type 2 diabetes mellitus by demonstrating relevant outcomes in both glycemic responses and dietary behaviors in a real-world setting. Overall, these data suggest that more frequent face-to-face contact with the dietitian may also be more helpful, and meal frequency and a daily breakfast followed by an afternoon snack of healthier foods may help to break down barriers and facilitate dietary self-management of diabetes. To achieve this, people with diabetes need education about their condition. They need to understand how to self-regulate their blood sugar not only in normal situations but also in stressful situations, such as intense physical activity, and when to seek early medical help. The earlier treatment begins, the better the prognosis.

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