

Original article

# Evaluating the effect of Therapeutic Nutritional Interventions on Blood Sugar Control in patients with Type 2 Diabetes Mellitus

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## Abstract

Type 2 diabetes mellitus (T2DM) is considered one of the most common diseases. The etiology of T2DM is complex and is associated with irreversible risk factors such as age, genetics, race, and ethnicity, and reversible factors such as diet, physical activity, and smoking. The objective of this study is to examine the effects of two dietary interventions (intermittent fasting and calorie-deficient diet) on blood sugar control in patients with Type 2 DM. A cross-sectional approach was adopted, where participants diagnosed with T2DM were assessed before and after implementing dietary modifications. Data collection included anthropometric Weight, fasting blood glucose, HbA1c levels, and lipid profile. Statistical analysis was performed to compare pre- and post-intervention outcomes to determine the effectiveness of the applied strategies. The findings highlight the importance of early lifestyle modifications, medical nutrition therapy, and continuous monitoring as key elements in improving glycemic control and reducing the risk of complications in patients with T2DM. Results: Both dietary regimens (Intermittent fasting and calorie-deficient diet) demonstrated a significant reduction in FBS, RBS, triglycerides, total cholesterol, HbA1c, and body weight after 3 months. Intermittent fasting significantly reduced HbA1C and body weight more than calorie deficit diet. Most variables showed high statistical significance ( $P < 0.0001$ ), confirming the effectiveness of both regimens in improving metabolic outcomes. Although both approaches contribute to improving blood sugar control. However, intermittent fasting showed greater effectiveness in the short term for reducing HbA1c levels, while caloric restriction was more sustainable in the long term for maintaining weight and blood sugar control. Also, both regimens showed significant reductions in serum triglyceride levels and total cholesterol, reflecting a protective role of nutritional interventions in promoting cardiovascular health.

**Keywords.** Type 2 Diabetes Mellitus, Intermittent Fasting, Calorie Deficit Diet, Medical Nutrition Therapy.

## Introduction

Diabetes mellitus (DM) is one of the most prevalent chronic diseases worldwide and represents a major public health challenge in the 21st century. According to the International Diabetes Federation, the global number of individuals living with diabetes reached approximately 537 million in 2021 and is projected to rise to 783 million by 2045 [1]. In Libya, it is estimated that in 2024 there will be about 634,800 cases of diabetes among individuals aged 20–79 years, with nearly 570,000 cases classified as type 2 diabetes, representing approximately 90% of all recorded cases [2].

At the regional level, the Middle East and North Africa region has experienced a significant increase in diabetes prevalence, particularly type 2 diabetes, largely driven by lifestyle changes, rising obesity rates, and reduced physical activity [3,4]. This growing burden places considerable pressure on both individuals and healthcare systems, emphasizing the need for effective management strategies [5].

Type 2 diabetes is a chronic metabolic disorder characterized by impaired insulin secretion and/or reduced cellular responsiveness, resulting in persistent hyperglycemia [1]. In this context, medical nutrition therapy has emerged as a fundamental component in the management of the disease, given its role in improving glycemic control and overall health outcomes. Therefore, this study aims to evaluate the effectiveness of selected medical nutrition therapy approaches, specifically calorie restriction and intermittent fasting, in improving glycemic control and supporting weight management among patients with type 2 diabetes in the city of Gharyan.

## Methods

The study was performed in Gharyan city, Libya. Patients included in this study are following up at Gharyan Teaching Hospital and two of the local private clinics (Al Meezan centre for therapeutic nutrition and Al Ikhlis clinic). In this research, two methods were adopted: the descriptive method and the experimental method.

### Descriptive method

#### Questionnaire on the general and nutritional status of type 2 diabetic patients

This questionnaire was sent to and answered by 50 patients with type 2 diabetes. The questionnaire focused on age, gender, weight, height, medical history, dietary habits, blood sugar control, dietary intervention, physical exercise, social and psychological support, patients' knowledge about type 2 DM, medical follow-up, changes in dietary habits, and their compliance with those changes.

### **Questionnaire on the effect of nutritional therapy on type 2 diabetes**

Another questionnaire was sent to and answered by 24 patients aged 35-65 years who followed our designed dietary regimens, either the intermittent fasting regimen or calorie deficit diet regimen. The questionnaire focused on age, gender, effects of the two dietary regimens on blood sugar, psychological status, the difficulties facing patients while sticking to these dietary regimens, and their desire to continue or quit the dietary regimens.

### **Experimental method**

#### **Diet regimens used in this study**

Dietary management of type 2 diabetes requires the selection of carefully considered dietary patterns that are aligned with the nature of the disease and the patient's needs. Given the importance of achieving a balance between scientific effectiveness and ease of practical application, two diet regimens were adopted in this study: the calorie-deficient diet and the intermittent fasting diet. This chapter provides a step-by-step scientific description of both diets, in terms of their basic principles, biological mechanisms, and applications within a nutritional intervention plan.

#### **The Caloric Restriction Diet regimen**

This diet relies on reducing total daily calories by approximately 20% to 30% of an individual's normal requirement, while ensuring that essential protein, vitamin, and mineral needs are met without causing nutritional deficiencies. This diet regimen is based on the principle of achieving a delicate balance between the amount of energy consumed and the quality of nutritional components. It is recommended to focus on foods with high nutritional density, such as lean proteins, fibre-rich vegetables, healthy fats, and whole grains, while reducing simple sugars and saturated fats [30]. This dietary pattern promotes gradual and safe weight loss, contributes to reducing visceral fat, and improves the body's response to insulin, leading to more effective control of blood glucose levels [31]. It has also been found to have a positive effect on reducing triglycerides and total cholesterol in the blood [32]. This diet regimen is distinguished by its flexibility and the ability to tailor it to each patient's individual circumstances in terms of age, gender, weight, and physical activity level, making it a viable option in various settings [33].

The designed calorie-restricted diet regimen is as follows: in the morning (on an empty stomach), mix a cup of warm water with lemon juice, cinnamon, or organic apple cider vinegar. Also, drink three litres of water daily.

#### **The intermittent fasting diet**

This diet relies on regulating the timing of eating within a specific time frame during the day, with periods of structured fasting ranging from 12 to 16 hours, offset by periods during which balanced eating is permitted. The "16:8" pattern is one of the most common, where the individual fasts for 16 consecutive hours (including sleeping hours) and eats within an 8-hour window [34]. This diet aims to reduce the number of times a day one eats, which helps reduce frequent spikes in insulin levels and contributes to improved insulin sensitivity, thus supporting more efficient blood sugar regulation [35]. Intermittent fasting has also been observed to help with gradual weight loss, reduce visceral and hepatic fat, and improve blood lipid indicators such as low-density lipoprotein (LDL) cholesterol and triglycerides [36]. This regimen is not limited to meal timing alone. Rather, it is recommended during mealtimes to focus on healthy and balanced food choices, including proteins, vegetables, good fats, and complex carbohydrates, to ensure the body gets the nutrients it needs [37]. What makes it suitable is its simplicity and flexibility, as it can be modified to suit the patient's social and health conditions. It does not require precise calculations of daily calories, but rather relies on a structured lifestyle and healthy food choices [38].

The designed intermittent fasting regimen is as follows:

16-Hour Fasting Plan (from 8 PM to 12 AM): In this regimen, water, tea, coffee without sugar, cumin, and brewed herbs are allowed during fasting hours. These regulate blood sugar. Thus, both the calorie-deficient regimen and intermittent fasting emerge as effective nutritional options based on clear scientific foundations that contribute to improving the metabolic status of type 2 diabetes patients. The application of these two regimens within this study reflects an effort to find feasible nutritional strategies with a noticeable clinical impact, which will be analysed later through the results and conclusions of the interventions in the following chapters.

#### **Biochemical tests**

Blood samples were taken from the 12 patients following each regimen and sent for fasting blood sugar (FBS), random blood sugar (RBS), HbA1C level, serum triglyceride and cholesterol level, before and after a dietary intervention. Blood test analysis was performed in different laboratories. The dietary intervention continued for 3 months. The diet taken during these 3 months was either an intermittent fasting or a calorie-deficient diet. This diet regimen was low in carbohydrates. Weight was also measured for some of these patients before and after the intervention.

### Statistical analysis

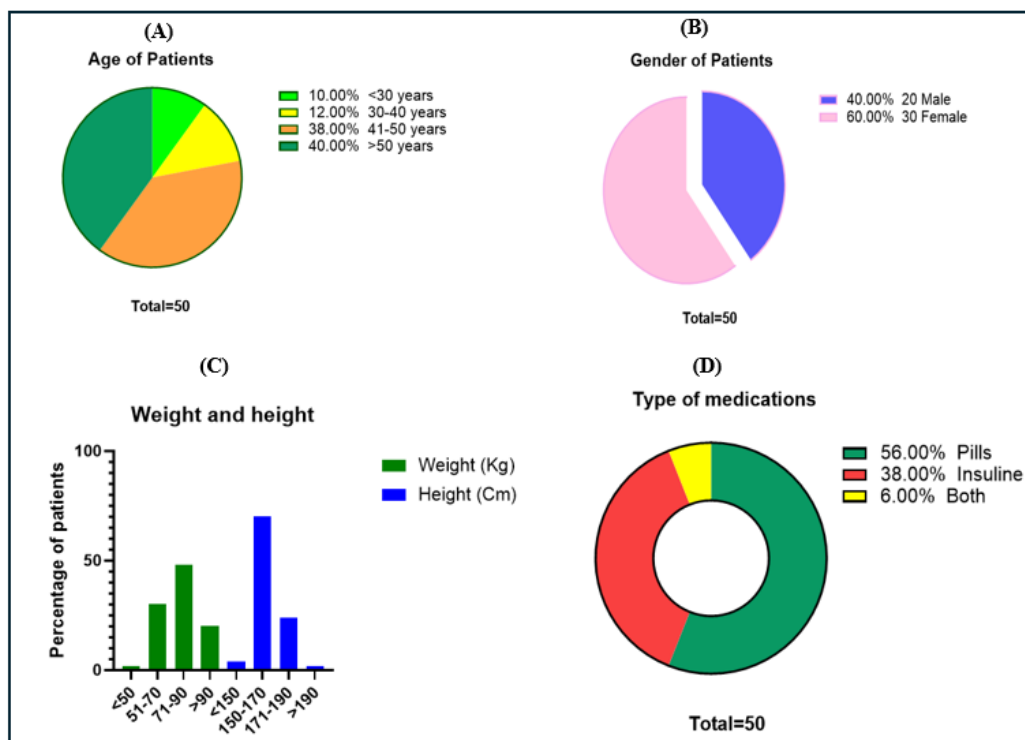
Blood test results of FBS, RBS, cholesterol level, HbA1C, and weight were compared before and after 3 months of dietary intervention in the case of intermittent fasting. Also, FBS, serum triglyceride level, cholesterol level, weight, and HbA1C were compared before and after dietary intervention in the case of calorie-deficient dietary intervention. All data were graphed using GraphPad Prism version 10. A paired Student's t-test was used to compare these data. All statistical analyses were carried out using GraphPad Prism version 10. Significance is indicated by ( $P<0.05$ ), ( $P<0.01$ ), ( $P<0.001$ ), ( $P<0.0001$ ). For the questionnaire results, data were graphed using GraphPad Prism version 10.

## Results

### General and nutritional status of type 2 diabetic patients (Questionnaire 1 results)

#### Age, gender, weight, height, and type of treatment

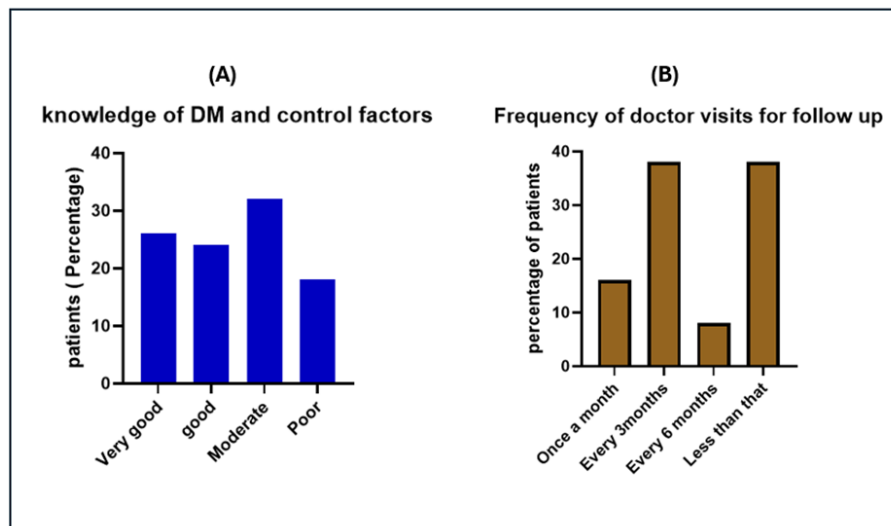
Analysis of the answers to a questionnaire answered by 50 patients. Most of the patients who answered the questionnaire were aged more than 40 years (about 40% aged 41-50 years, and 40% were more than 50 years). The majority (60%) of these patients were females. Half of these patients weighed between 70 and 90 kg, and about 20% were weighed more than 90, and about a third were between 51 and 70 kg. The height of the majority (75%) was between 150 and 170 cm, and approximately one quarter were between 171 and 190 cm, while a very small proportion exceeded 190 cm. All these patients were on medications. More than 50% were on oral hypoglycemic drugs, while 38% were on insulin therapy, and the others were on combination therapy (Figure 1).



**Figure 1. Age (A), gender (B), weight and height (C), and type of medications received (D) for patients with type 2 DM. Data was plotted and graphed in percentages using GraphPad Prism version 10 (N=50).**

### Patient's knowledge about DM and patients' medical monitoring

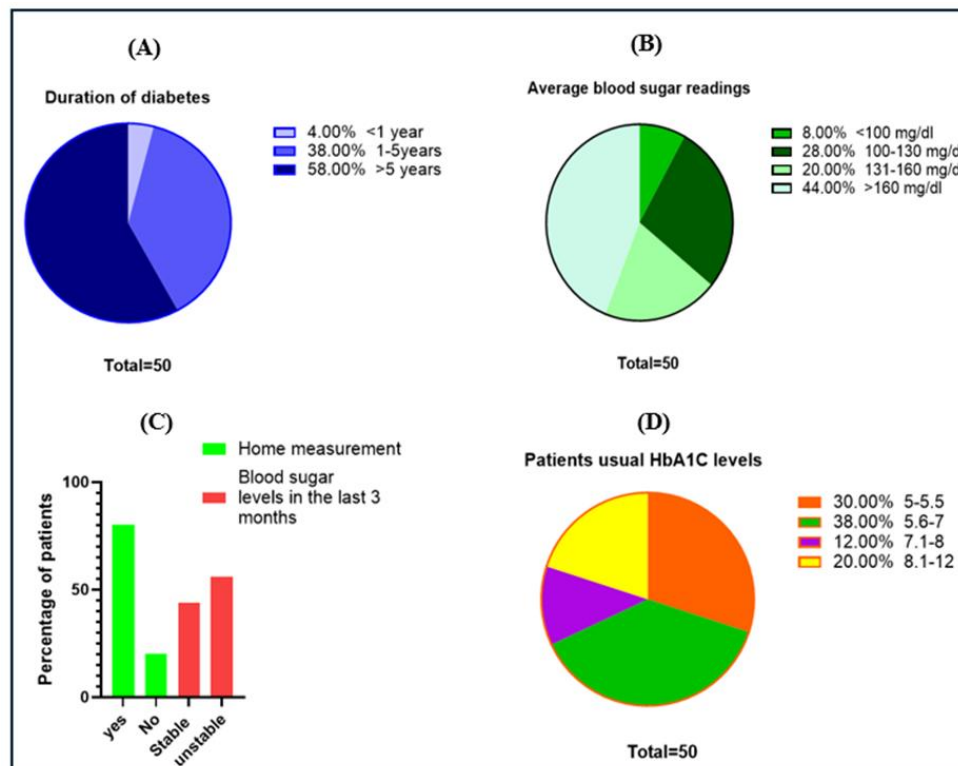
The patient's knowledge about diabetes control factors was moderate in more than a third of patients, and in about 25% were good, and in more than 25% were very good. Approximately 40% of type 2 diabetic patients were seeking medical advice from their doctors in their follow-up visits every 3 months. Similarly, 40% were seeing their doctors after more than 6 months (Figure 2).



**Figure 2. Patient's knowledge about DM and control factors (A). Frequency of follow-up visits (B). Data was plotted and graphed in percentages using GraphPad Prism version 10 (N=50).**

### Duration of DM and average blood sugar readings

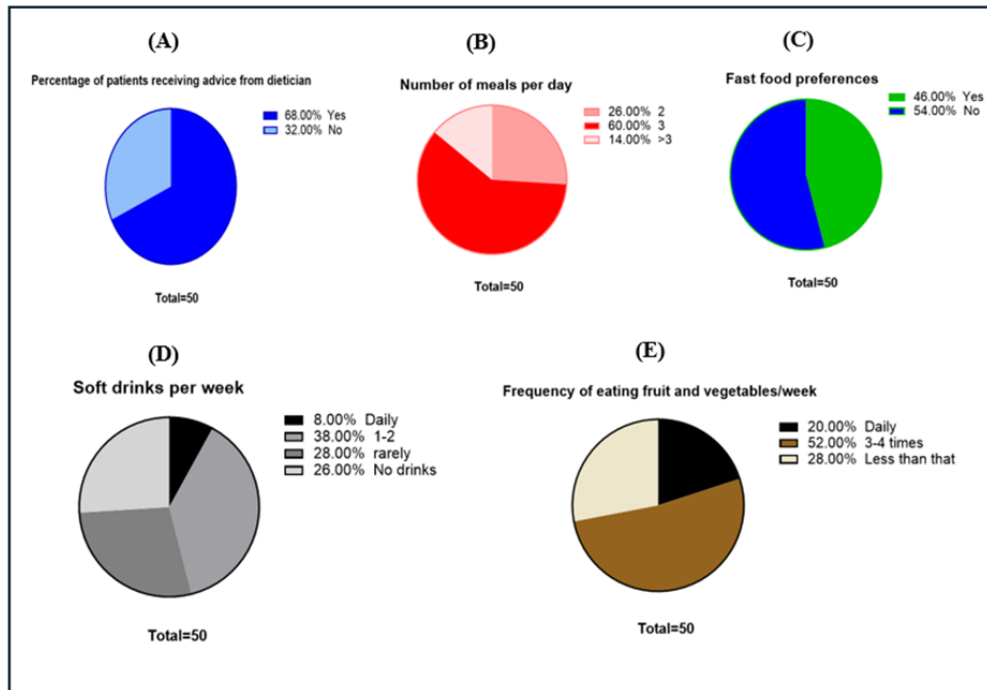
Most of the patients had DM for more than 5 years (58%). The minority had DM for less than a year (4%). Their random blood sugar readings for 44% of patients were more than 160 mg/dl, and for just a quarter of the patients were 100-130mg/dl. The majority were measuring their blood sugar at home (80%), and most of their blood sugar readings were unstable in more than 50 % of the patients. The average glycosylated Hb levels for more than two-thirds of these patients were between 5% and 7%, while the HbA1C for the fifth of these patients was very high (8.1%-12%) (Figure 3).



**Figure 3. Duration of diabetes (A), Average blood sugar readings (B), and percentage of patients who measure blood glucose at home and status of their blood glucose levels in the last three months (C), and the patient's usual glycosylated Hb levels (D). Data was plotted and graphed in percentages using GraphPad Prism version 10 (N=50).**

### Dietary habits for DM patients

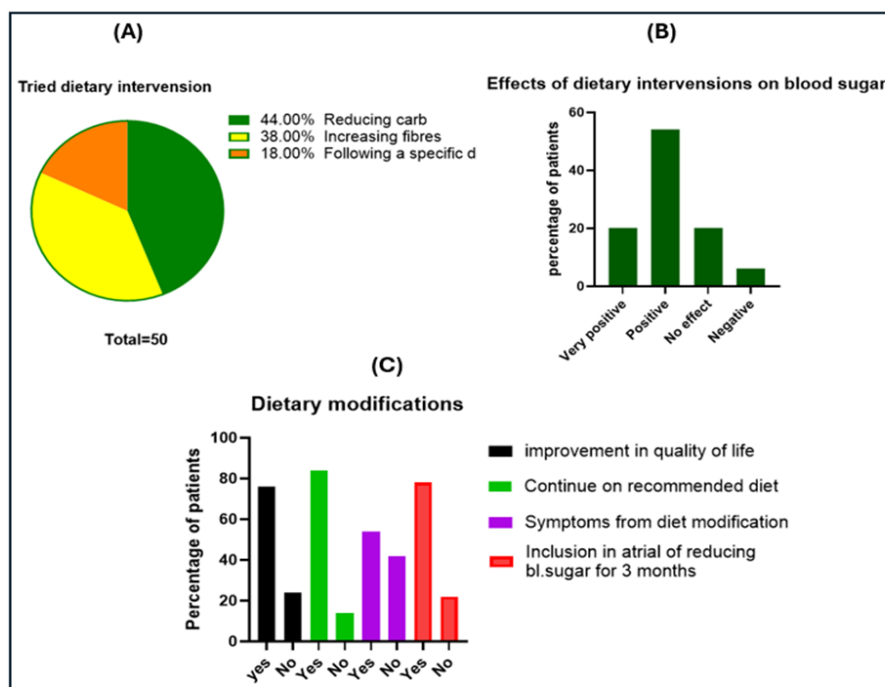
Most of the patients were receiving advice from a dietitian. About two thirds having 3 meals/day, while one fourth are having 2 meals/day. More than 50% of the patients did not prefer fast food, and more than a third of these patients had a soft drink two times a week. 20% of the patients are having fruit and vegetables daily, and >50% of them are having fruit and vegetables 3-4 times a week (Figure 4).



**Figure 4. Dietary habits for DM patients. Percentage of patients receiving advice from dieticians (A), Number of meals/ days (B), fast food preferences (C), frequency of having soft drinks (D), and frequency of having fruit and vegetables/week (E). Data was plotted and graphed in percentages using GraphPad Prism version 10 (N=50).**

#### **Dietary interventions and their consequences**

Reducing carbohydrate diet was followed by 44% of the patients, and a high fibre diet was followed by 38%, while the rest of the patients were on their usual diet. This dietary intervention was having a positive effect on blood glucose level in >50% of the patients, and 20% were having a marked reduction in their blood glucose level. These dietary changes showed a good effect on patients' quality of life in the majority of patients >75% and >80% of patients were intended to carry on these dietary modifications although >50 % experienced symptoms and health issues after following dietary changes and the majority of the patients agreed to follow a new dietary regimen aiming to reduce their blood sugar levels in the following 3 months (Figure 5).



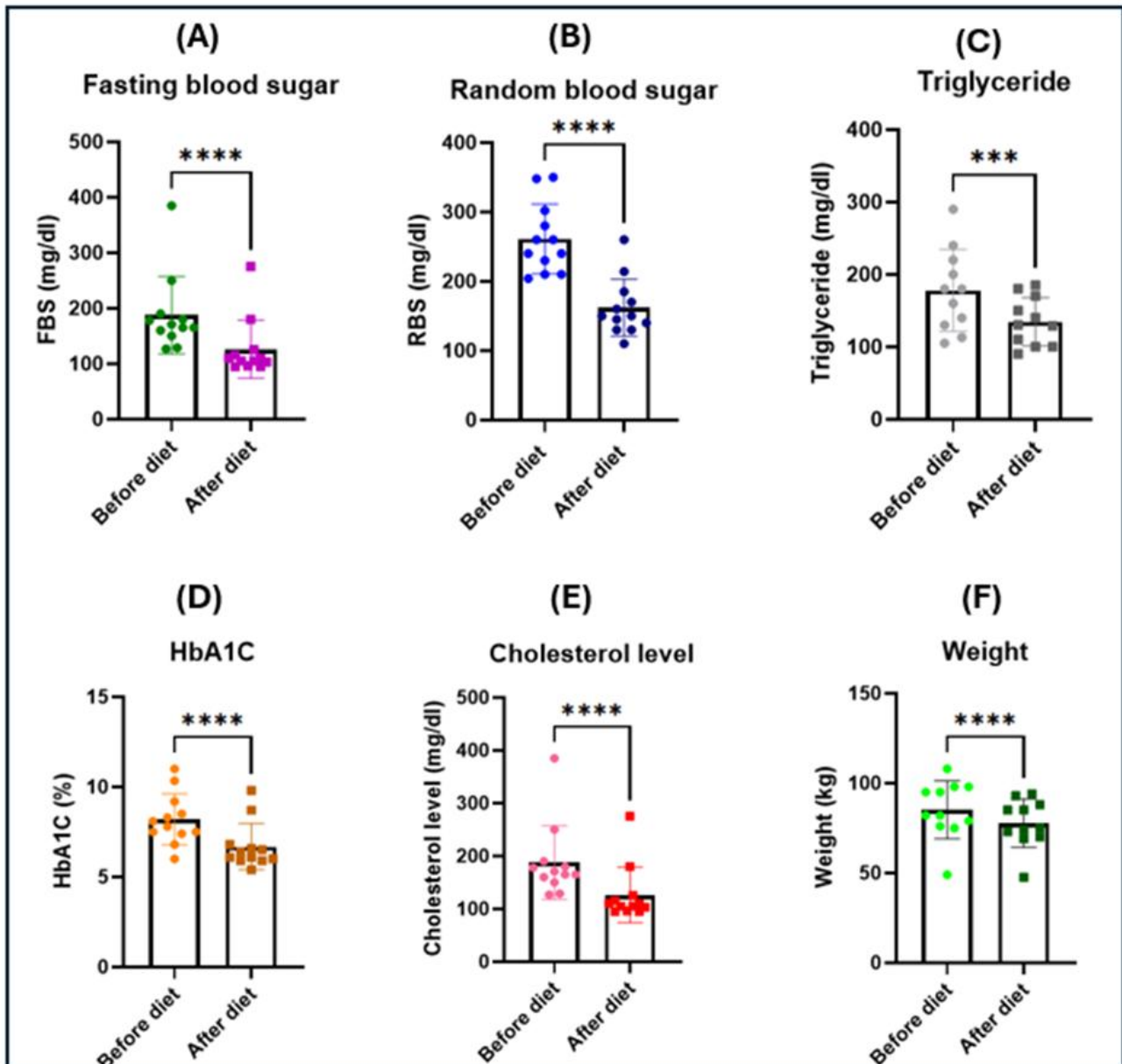
**Figure 5. Dietary interventions and their consequences. Dietary interventions that have been tried by patients (A) and their effects on blood sugar readings (B), Effects of dietary modifications and plan of trying a new dietary regimen in the next 3 months (C). Data was plotted and graphed in percentages using GraphPad Prism version 10 (N=50).**

**Comparison of blood test results before and after dietary interventions.**

Blood test results for 12 patients in each of the two dietary regimens (intermittent fasting and calorie deficit) were compared before and 3 months after dietary intervention.

**Comparison of blood test results before and after an intermittent fasting regimen**

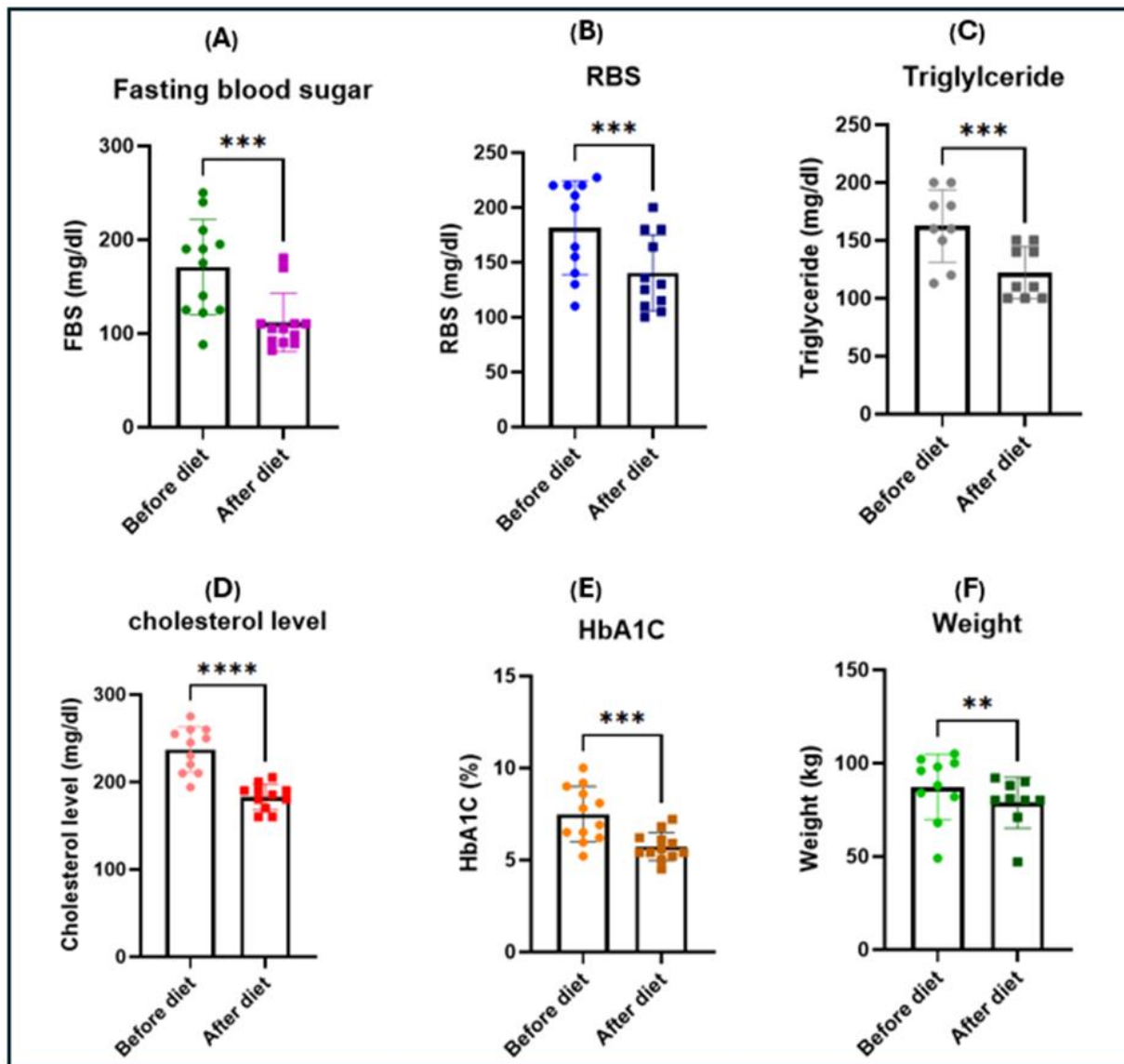
FBS, RBS, serum triglyceride, serum cholesterol, and HbA1C readings, as well as patients' weight readings, were significantly reduced after 3 months of following an intermittent fasting regimen ( $P < 0.0001$ ) and ( $P < 0.0001$ ) in case of serum triglyceride levels (Figure 6).



**Figure 6. FBS, RBS, triglyceride level, HbA1C, serum cholesterol levels, and weight of type 2 diabetic pre- and post-dietary intervention (intermittent fasting). A (FBS. N=12), B (RBS. N=12), C (triglyceride. N=10), D (HbA1C level. N=12), E (cholesterol. N=12), and F (Weight of patients N=11). Data was analysed by a paired two tailed student t test. Significance is indicated by \* ( $P < 0.05$ ), \*\* ( $P < 0.01$ ), \*\*\* ( $P < 0.001$ ), \*\*\*\* ( $P < 0.0001$ ).**

**Comparison of blood test results before and after calorie deficit regimen**

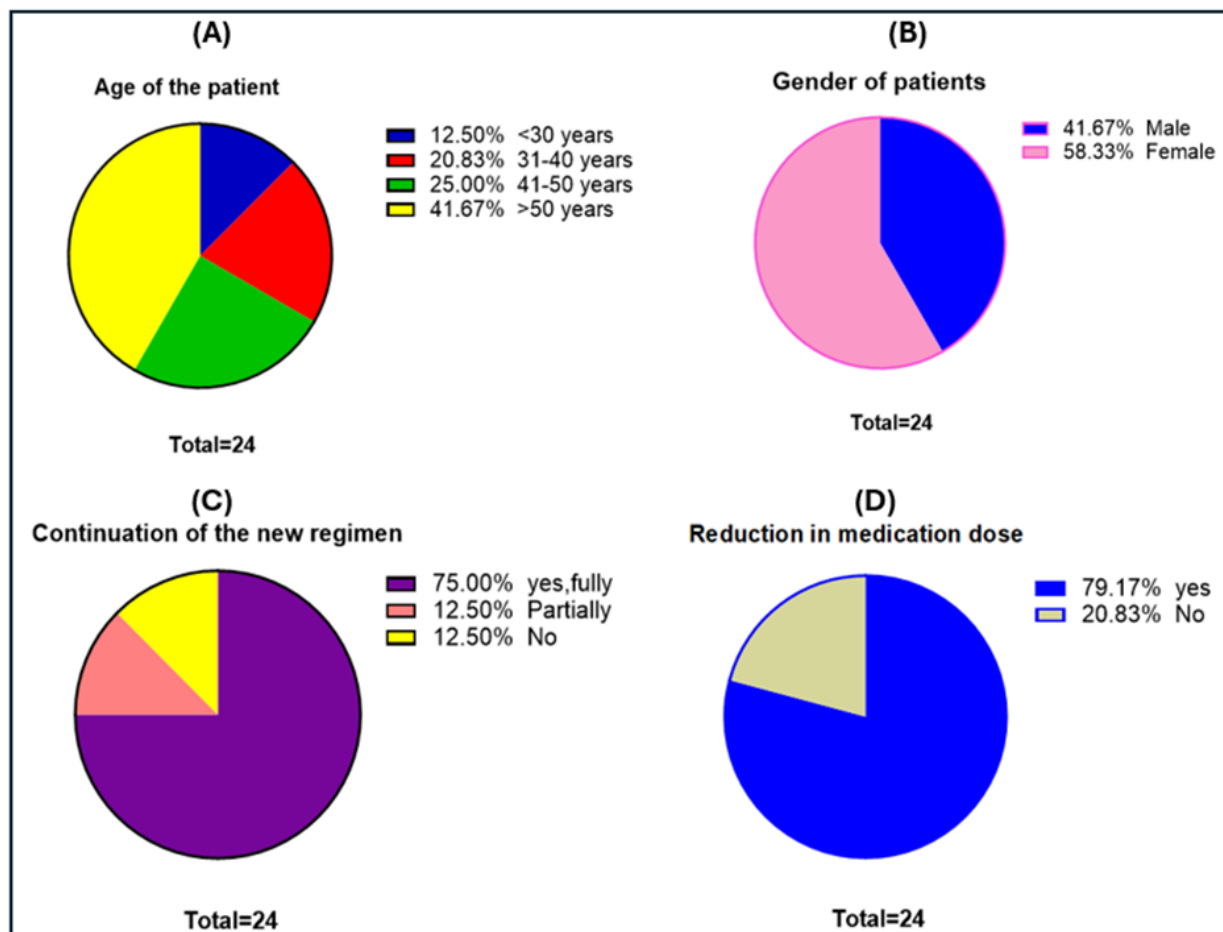
FBS, RBS, serum triglyceride, serum cholesterol, and HbA1C readings, as well as patient's weight readings, were significantly reduced after 3 months of following an intermittent fasting regimen ( $P < 0.01$ ) in the case of serum triglyceride levels (Figure 7).



**Figure 7.** FBS, RBS, serum triglyceride, serum cholesterol, and HbA1C levels, and weight of patients pre- and post-dietary intervention (Calorie deficit diet) in type 2 diabetic patients. A (FBS. N=12), B (RBS. N=11), C (Triglyceride. N=9), D (Serum cholesterol. N=11), E (HbA1C level. N=12) and F (Weight of patients N=10). Data was analysed by a paired two tailed student t test. Significance is indicated by \* (P<0.05), \*\* (P<0.01), \*\*\* (P<0.001), \*\*\*\* (P<0.0001).

**Age and gender of patients who followed a new regimen, and the changes in their medication doses**

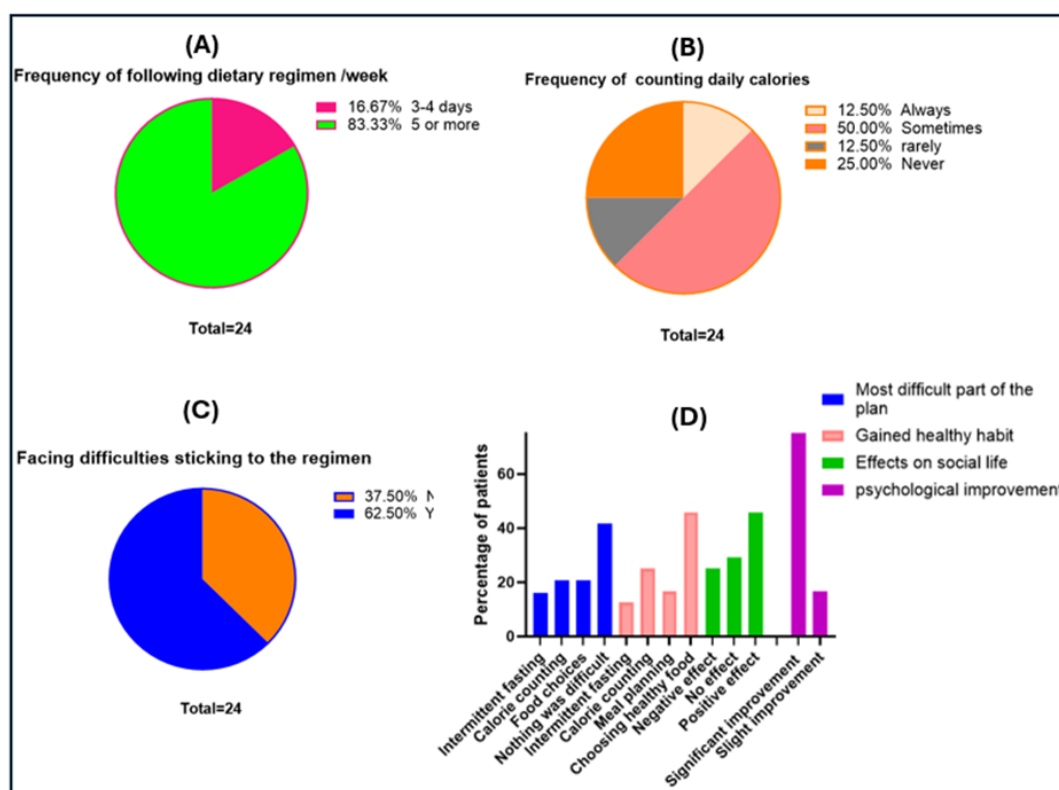
Most of the patients who followed the two regimens (intermittent fasting regimen and Calorie-deficient diet regimen) were above 50 years old (41.67%), while only 12.5% were below 30 years old. The proportion of females (about 60) was higher compared to males (41.67%). Regarding adherence to the new dietary regimen, 75% of the patients followed it fully, 12.5% adhered partially, and 12.5% did not continue. Concerning medication, most of the patients were able to reduce their treatment doses after following the dietary intervention, whereas 20.83% did not achieve this change (Figure 8).



**Figure 8. Age and gender of patients who followed a new regimen and the changes in their medication doses. Data was plotted and graphed in percentages using GraphPad Prism version 10 (N=24).**

#### **Frequency of sticking to the new regimen and counting daily calories, difficulties facing patients, and effects of the new regimens**

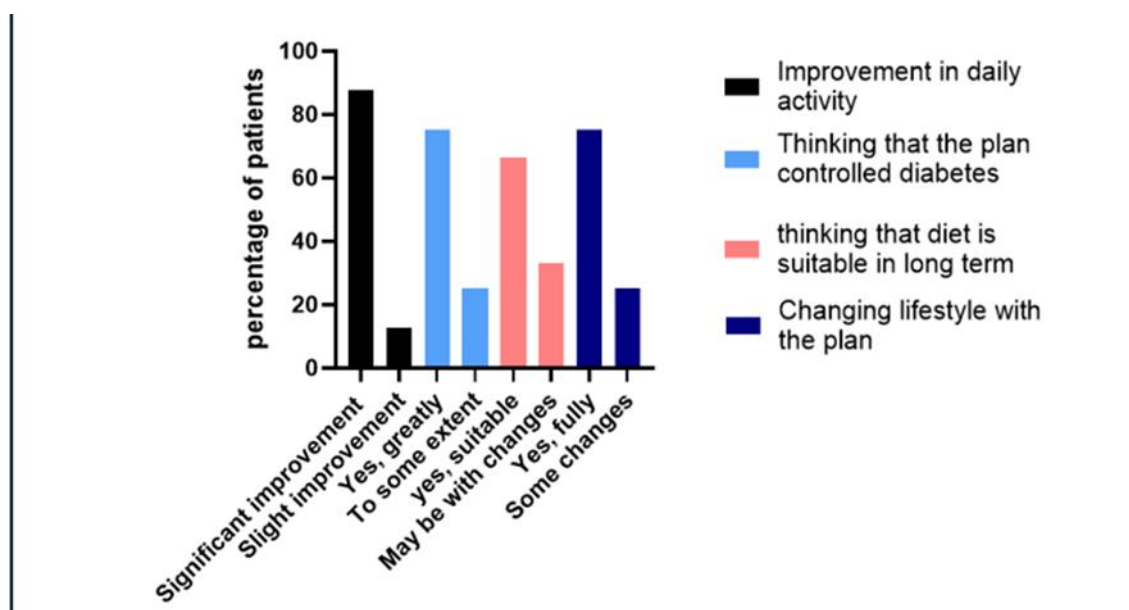
The majority of patients (83.33%) were following the plan for 5 or more days per week, while only 16.67% were able to follow it for three to four days, indicating good overall adherence to the plan. When assessing the frequency of calorie counting, only 12.50% of patients reported doing it always, while 50% stated that they do it sometimes. On the other hand, 25% of patients never counted their daily calories. More than half of the patients (62.50%) faced difficulties in sticking to the dietary regimen, whereas 37.50% of patients did not face such difficulties. Regarding the hardest part of following the diet plan, 18% mentioned that intermittent fasting was the most challenging aspect. At the same time, an equal percentage of patients (20%) reported that calculating calories and food options was difficult for them. Additionally, 42% of patients indicated that they did not find any part of the system particularly difficult. Concerning the healthy habits they had acquired and planned to continue, 15% reported adopting intermittent fasting, while 25% indicated that they would practice calorie counting. Furthermore, 20% of patients reported meal planning as a new habit, whereas the highest proportion (40%) chose to focus on selecting healthier food options. Regarding the impact on social life, more than 40% of patients reported a positive effect, while a smaller percentage indicated either no effect or a negative impact. The psychological outcomes were quite good, with more than 80% of patients experiencing significant psychological improvement and about 20% reporting slight improvement (Figure 9).



**Figure 9. Frequency of sticking to the new regimen and counting daily calories, difficulties facing patients, and effects of the new regimen. Data was plotted and graphed in percentages using GraphPad Prism version 10 (N=24).**

#### **Patients' perceptions of the dietary plan and lifestyle modifications.**

Most patients with type 2 diabetes reported a notable improvement in their daily activities after adhering to the dietary plan (85%). Nearly three-quarters of the participants perceived the plan as effective in controlling their diabetes. Approximately two-thirds of the patients also considered the diet to be practical and sustainable for long-term adherence. Furthermore, around three-fourths indicated that they had introduced lifestyle modifications in alignment with the dietary plan, either partially or fully (Figure 10).

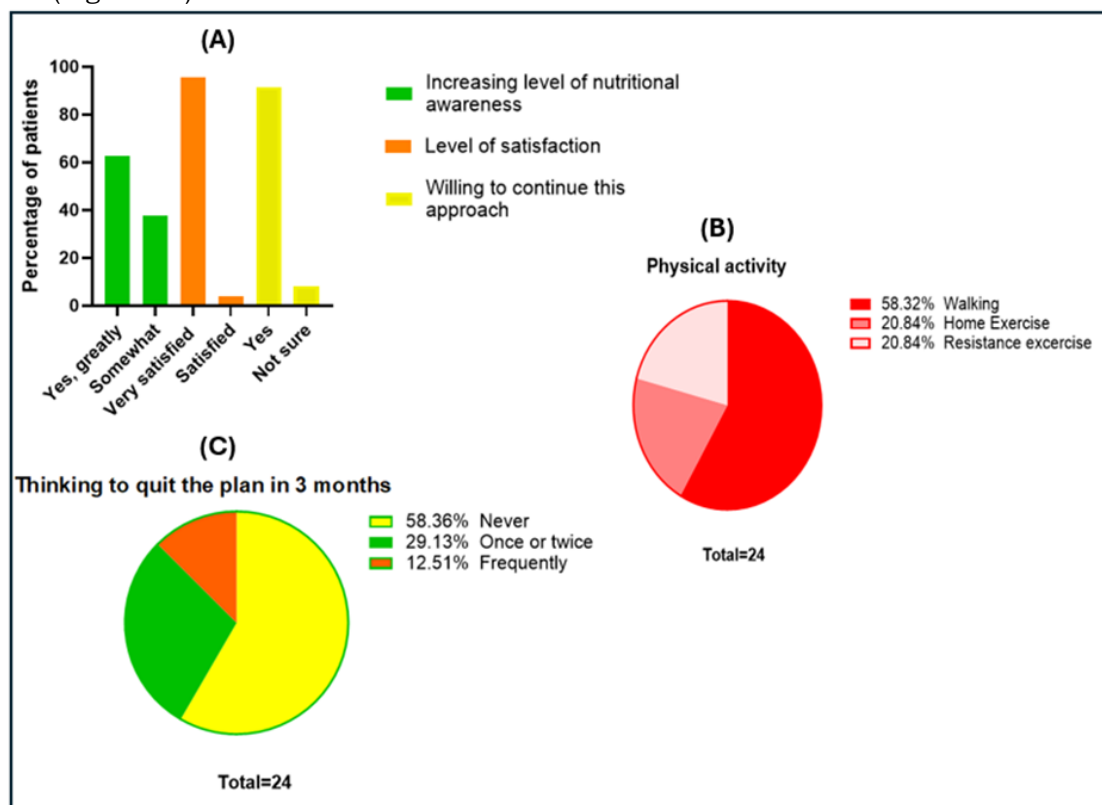


**Figure 10. Patients' perceptions regarding the effectiveness of the dietary plan and lifestyle modifications. Data are presented as percentages and were analysed using GraphPad Prism version 10 (N=24).**

#### **Patients' nutritional awareness, physical activity, and continuation of the plan**

Summarizes patients' perspectives regarding nutritional awareness, physical activity, and their willingness to continue the dietary plan. A considerable proportion of patients reported an increase in their nutritional

knowledge, along with a high level of satisfaction and willingness to sustain the dietary approach. Regarding physical activity, walking was the most common practice (about 60%), followed by home-based exercises (20.84%) and resistance exercises (20.84%). Additionally, when asked about quitting the plan within three months, >50% of patients reported never considering discontinuation, and 12.51% reported frequent consideration (Figure 11).



**Figure 11. Patients' nutritional awareness, physical activity, and intention to continue the dietary plan. Data are presented as percentages and were analysed using GraphPad Prism version 10 (N=24)**

## Discussion

The results of the first questionnaire (n=50) showed that the majority of participants were older than 40 years; 40% were aged 41–50 years, and another 40% were above 50 years, reflecting the higher prevalence of diabetes among older age groups. Females constituted 60% of the sample, which aligns with some regional studies suggesting a higher prevalence among women due to lifestyle factors and lower physical activity levels. For example, Fatani et al. reported higher diabetes prevalence among rural women (5.9%) compared to men (2.9%) in Saudi Arabia [39]. However, Nordstrom et al. (2016) found a higher prevalence in men [40]. Regarding weight, 50% of participants were within the 70–90 kg range, while 20% exceeded 90 kg, indicating the significant role of obesity in diabetes risk. All patients were adherent to medical treatment, with more than half using oral hypoglycemic agents. Approximately 40% reported regular follow-up visits every three months. Despite this, more than half experienced unstable glucose levels in the preceding three months, suggesting suboptimal glycemic control. In addition, over one-third of patients demonstrated only a moderate level of knowledge about diabetes management, highlighting the need for improved health and nutritional education.

The majority of participants (80%) reported home blood glucose monitoring, which has been associated with better glycemic control in previous studies [41].

In terms of laboratory outcomes, both dietary interventions resulted in improvements in metabolic parameters, including fasting blood sugar (FBS), random blood sugar (RBS), HbA1c, triglycerides, total cholesterol, and body weight. However, intermittent fasting demonstrated greater effectiveness compared to a calorie-deficient diet, with higher statistical significance ( $P < 0.0001$  in most variables). The calorie-deficient diet produced significant improvements ( $P < 0.05$  to  $P < 0.01$ ), likely due to reduced energy intake leading to weight loss, decreased visceral fat, and improved insulin sensitivity. These findings are consistent with previous studies showing that weight reduction improves glucose utilization and lipid profiles [43,45].

Intermittent fasting showed more pronounced reductions across all measured parameters after three months. These findings are supported by Arnason et al., who demonstrated that intermittent fasting is a safe and effective intervention for improving body weight and glycemic control in type 2 diabetes [47]. Additionally, evidence suggests that intermittent fasting reduces insulin resistance, fasting glucose, and

lipid levels [48]. A randomized clinical trial further confirmed that time-restricted eating is effective for weight loss and HbA1c reduction compared to daily calorie restriction [49].

Both dietary approaches were associated with weight loss, which has been strongly linked to improvements in HbA1c and lipid profiles. Ganesan et al. reported that even modest weight loss (2–5%) leads to significant HbA1c reduction, while greater weight loss (5–10%) improves triglyceride and cholesterol levels [46]. Overall, these findings demonstrate that dietary interventions are not only effective for weight reduction but also play a critical role in improving metabolic control and reducing cardiovascular risk factors. The observed reductions in HbA1c, triglycerides, and cholesterol emphasize the importance of structured nutritional strategies in diabetes management [52]. However, individual responses to dietary interventions may vary depending on adherence, genetic factors, and concurrent medications. Furthermore, maintaining these improvements over the long term remains a challenge [53]. Supporting evidence from Deshpande et al. (2023) reported similar outcomes, including significant reductions in HbA1c, body weight, and lipid profiles following a low-calorie diet [54].

## Conclusion

The results demonstrated that medical nutritional therapy represents a fundamental pillar in managing type 2 diabetes, contributing to improved blood glucose control, reduced dependence on hypoglycaemic medications, and enhanced quality of life for patients. Although both intermittent fasting and calorie-deficient regimens showed improvement in metabolic outcomes in the form of reducing fasting blood sugar, random blood sugar, serum cholesterol, and triglyceride, HbA1C, the reductions were more pronounced in intermittent fasting compared to calorie deficit dietary regimen. Although both approaches contribute to improving blood sugar control. However, intermittent fasting showed greater effectiveness in the short term for reducing HbA1c levels, while caloric restriction was more sustainable in the long term for maintaining weight and blood sugar control. Results showed a notable decrease in triglyceride levels and total cholesterol, reflecting a protective role of nutritional interventions in promoting cardiovascular health. Both dietary regimens showed significant reduction in body weight and improvement in general health indicators, with slight differences in response speed depending on individual adherence and lifestyle patterns. This suggested a positive effect on reducing obesity, which is one of the risk factors of diabetes mellitus. Scientific evidence has shown that choosing the optimal diet for patients with type 2 diabetes should be based on nutrient balance, calorie control, and adopting nutritional strategies such as calorie restriction or intermittent fasting, according to the patient's individual condition.

**Conflict of interest.** Nil

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