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The Impact of Various Diets on the Management of Patients with Type 1 Diabetes - systematic review

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Abstract

Introduction:

Type 1 diabetes (T1D) is a chronic autoimmune disorder characterized by the destruction of pancreatic β-cells, leading to absolute insulin deficiency. Given the increasing global incidence—especially among children and adolescents—growing attention is being paid not only to pharmacological treatment but also to the supportive role of targeted nutritional interventions.

Aim of the study:

This study aims to present and compare the effects of selected dietary models on glycemic control, the risk of complications, and the quality of life in patients with T1D.

Materials and Methods:

A narrative review was conducted based on scientific literature published between 2023 and 2025, sourced from the PubMed database. The analysis focused on five dietary patterns: plant-based, Mediterranean, gluten-free, ketogenic, and low-FODMAP diets.

Conclusions:

Diets rich in fiber, unsaturated fats, and low-glycemic-index foods may significantly improve glycemic stability, reduce inflammation, and positively influence gut microbiota composition in patients with T1D. Each dietary approach demonstrates distinct therapeutic potential and should be individually tailored. Dietary therapy should be recognized as an integral component of a multidisciplinary approach to T1D management.

Keywords: type 1 diabetes, plant-based diet, Mediterranean diet, gluten-free diet, ketogenic diet, FODMAP, nutritional therapy.

1. Introduction

Type 1 diabetes (T1D) is a chronic, progressive autoimmune disease in which the immune system targets and destroys pancreatic β-cells located in the islets of Langerhans, resulting in an absolute deficiency of insulin. Insulin is a key hormone for maintaining glycemic homeostasis, and its absence leads to hyperglycemia, increased catabolism, and activation of alternative metabolic pathways such as ketogenesis. In contrast to type 2 diabetes, T1D is driven primarily by autoimmune mechanisms rather than insulin resistance [1].

Clinical symptoms of T1D typically develop rapidly, particularly in children and adolescents. The classic triad includes polyuria, polydipsia, and weight loss, accompanied by fatigue, drowsiness, and, in more advanced stages, diabetic ketoacidosis (DKA)—manifesting as abdominal pain, nausea, vomiting, and a characteristic fruity breath odor. Without intervention, DKA can progress to unconsciousness and potentially death [1].

Diagnosis is based on the following criteria: a random plasma glucose ≥200 mg/dL with classical symptoms, fasting glucose ≥126 mg/dL, HbA1c ≥6.5%, or a 2-hour post-OGTT plasma glucose ≥200 mg/dL. The presence of specific autoantibodies—such as anti-GAD65, IA-2, ZnT8, or ICA—confirms the autoimmune nature of the disease [5].

Globally, more than 9 million people live with T1D, including approximately 1.5 million children [1]. In Europe, incidence rates vary widely—from 15 per 100,000 children annually in southern countries to over 60 per 100,000 in Finland, Sweden, and Norway. Recent years have seen a marked increase in the number of new T1D diagnoses, including in adults, often attributed to greater awareness and detection of latent autoimmune diabetes in adults (LADA) [5].

Therapeutic management of T1D centers on lifelong insulin therapy, designed to replicate physiologic insulin secretion. Primary treatment modalities include multiple daily injections (MDI) and continuous subcutaneous insulin infusion (CSII) via insulin pump. Technological advancements have enabled the use of continuous glucose monitoring (CGM), significantly improving metabolic control and reducing hypoglycemic episodes [2].

Evidence shows that children using CGM and insulin pumps achieve better glycemic outcomes and fewer hypoglycemic events, which is critical for maintaining cognitive development and emotional well-being [2][3]. Furthermore, chronic management of T1D impacts psychosocial functioning, including challenges at school, concentration difficulties, and an increased risk of mood disorders [4].

T1D care must be interdisciplinary, combining insulin therapy, education, psychological support, physical activity, and individualized nutritional planning. Growing research highlights the therapeutic potential of specific dietary models in improving glycemic control, minimizing complications, and enhancing quality of life. As such, dietetics is increasingly viewed as a foundational component of comprehensive T1D treatment.

The aim of this article is to provide a comprehensive comparative analysis of selected dietary models in order to identify which of them offers the greatest clinical benefit for patients with type 1 diabetes.

2. Pathophysiology of Type 1 Diabetes

Type 1 diabetes is a classic example of an organ-specific autoimmune disease, in which pancreatic β-cells are selectively destroyed by the host's immune system. This process generally progresses slowly and asymptomatically for months or even years before overt clinical symptoms emerge. The central pathogenic mechanism involves the loss of immune tolerance to β-cell antigens, resulting in their elimination by activated T lymphocytes [5].

The inflammatory cascade is likely initiated by environmental factors that activate antigen-presenting cells (APCs) such as dendritic cells and macrophages. These APCs process and present β-cell autoantigens in the context of MHC class II molecules, activating CD4+ and CD8+ T cells. The activated T cells secrete pro-inflammatory cytokines including IL-1β, TNF-α, and IFN-γ, which intensify the local inflammatory response and promote β-cell apoptosis. Furthermore, regulatory T cells (Tregs), responsible for suppressing autoimmune responses, exhibit both quantitative and functional impairments in individuals with T1D [6].

Concurrent with cellular immune responses, autoantibodies targeting β-cell antigens—such as GAD65, IA-2, ZnT8, and ICA—are often detected. Although not directly cytotoxic, these autoantibodies serve as biomarkers of ongoing autoimmunity and are essential in identifying individuals at high risk for developing T1D during the preclinical phase [5].

Genetic predisposition plays a pivotal role in T1D susceptibility. The most significant contributions come from specific HLA class II alleles—particularly HLA-DR3, DR4, and DQ8—that influence antigen presentation and immune tolerance. However, genetic predisposition alone is insufficient to cause disease; environmental triggers are also necessary. Key environmental factors include viral infections (e.g., enteroviruses), early exposure to cow's milk proteins, gut microbiota alterations, vitamin D deficiency, and oxidative stress [5][6].

Emerging evidence also highlights the role of immunometabolic dysfunctions. The PI3K/AKT/mTOR signaling pathway, critical for β-cell survival and function, becomes dysregulated under chronic inflammation and hyperglycemia. Dietary interventions such as the ketogenic diet may modulate this pathway, reduce oxidative stress, and protect β-cells from cytokine-induced apoptosis [7][8]. Experimental studies in cellular and animal models have demonstrated that ketone bodies possess protective properties against pro-inflammatory insults.

Moreover, the gut microbiome plays an increasingly recognized role in immune regulation and metabolic control. Through the production of short-chain fatty acids (SCFAs), gut microbes modulate inflammation and maintain intestinal barrier integrity. Dysbiosis—characterized by reduced microbial diversity and an overrepresentation of pro-inflammatory taxa—has been frequently observed in individuals with T1D [23].

Collectively, the pathophysiology of T1D reflects a complex interplay between genetic, environmental, and immunologic factors. Understanding these mechanisms opens the door to new preventive and therapeutic strategies, including antigen-specific immunotherapy, microbiota modulation, and tailored nutritional interventions.

3. Plant-Based Diet and Type 1 Diabetes

A plant-based diet, centered around unprocessed or minimally processed plant foods, is gaining increasing interest as a complementary component of type 1 diabetes (T1D) management. This dietary model emphasizes high consumption of vegetables, fruits, legumes, nuts, seeds, and whole grains, while minimizing or eliminating animal-derived products. Although traditionally studied in the context of type 2 diabetes, there is a growing body of evidence suggesting beneficial effects in T1D patients as well [9].

Recent studies involving young adults with T1D have shown that adopting a plant-based diet can reduce postprandial glycemic excursions, leading to improved glycemic stability and better overall metabolic control [9]. The diet is rich in soluble fiber, which slows carbohydrate absorption and moderates blood glucose spikes. Furthermore, plant foods contain phytochemicals—such as polyphenols and flavonoids—that exert anti-inflammatory and antioxidant effects, potentially contributing to improved glucose metabolism.

Prospective observational studies have also demonstrated that patients adhering to healthy plant-based diets exhibit reduced coronary artery calcification and improved lipid profiles, suggesting a cardioprotective effect relevant to the elevated cardiovascular risk associated with T1D [10]. Additional benefits include improved body composition, blood pressure regulation, and inflammation reduction, all of which may contribute to a decreased incidence of microvascular and macrovascular complications.

Recent research has also highlighted the importance of carbohydrate quality and source. For instance, incorporating fermented plant-based products—such as bread enriched with Fuzhuan tea—has been shown to enhance nutritional value and digestibility, which may positively influence metabolic outcomes in T1D patients [11].

Importantly, plant-based diets are associated with favorable modulation of the gut microbiota, a key factor in immune system regulation and metabolic function. Increased intake of dietary fiber and prebiotic compounds promotes the production of short-chain fatty acids (SCFAs), which contribute to reduced inflammation and improved intestinal integrity.

In conclusion, a plant-based diet can be a valuable tool in the dietary management of T1D. However, its implementation requires careful planning to avoid nutrient deficiencies—particularly vitamin B12—and should involve collaboration with a diabetes care team to ensure optimal glucose management and nutritional adequacy.

4. Mediterranean Diet and Type 1 Diabetes

The Mediterranean diet, originating from the countries surrounding the Mediterranean Sea, has long been considered one of the healthiest dietary models. It is recommended both for cardiovascular disease prevention and diabetes management. This diet is characterized by high intake of vegetables, fruits, legumes, nuts, whole grains, and olive oil as the primary fat source, along with moderate consumption of fish, dairy, and red wine. In the context of type 1 diabetes (T1D), this model has gained growing attention due to its anti-inflammatory, metabolic, and cardioprotective properties [12].

Prospective studies among children and adolescents with T1D have shown that adherence to the Mediterranean diet is associated with improved glycemic control, lower HbA1c levels, and favorable anthropometric indicators such as body mass index (BMI) and waist-to-hip ratio [12][13]. Thanks to its high fiber content and emphasis on monounsaturated fats, the diet promotes slower carbohydrate absorption and reduces the risk of postprandial hyperglycemia.

Interventional trials in adolescents have demonstrated that the Mediterranean diet does not increase the risk of hypoglycemia while improving metabolic parameters and lipid profiles [14]. These findings are particularly relevant given concerns regarding the safety of higher-fat diets in individuals with T1D.

Additionally, nutrigenomic research has revealed that the Mediterranean diet may modulate gene expression associated with obesity and diabetes in children with high polygenic risk scores. Studies have shown that adherence to this dietary pattern reduces the expression of genes linked to excess adiposity and improves body composition, even in genetically predisposed populations [15].

A further advantage of the Mediterranean diet lies in its high acceptability and ease of implementation. Its ingredients are widely accessible, and its preparation methods—such as steaming, baking, and limiting saturated fats—promote health without requiring strict restrictions.

Due to its multifaceted effects—improved glycemic control, lipid regulation, body weight maintenance, and potential gene modulation—the Mediterranean diet can be considered a highly beneficial nutritional model for patients with type 1 diabetes, especially among pediatric populations.

5. Gluten-Free Diet and Type 1 Diabetes

Celiac disease and type 1 diabetes (T1D) are autoimmune conditions that frequently co-occur. It is estimated that 4% to 10% of patients with T1D also have celiac disease—a significantly higher prevalence compared to the general population. This association is largely due to shared genetic susceptibility, particularly the presence of HLA-DQ2 and HLA-DQ8 alleles. In such cases, adherence to a gluten-free diet (GFD) becomes not only advisable but medically necessary [16].

Clinical studies involving children and adolescents diagnosed with both T1D and celiac disease have demonstrated that a gluten-free diet significantly improves glycemic control, lowers HbA1c levels, reduces inflammatory markers, and enhances overall nutritional status [16]. Long-term adherence to a GFD also mitigates intestinal mucosal damage and prevents nutrient malabsorption, which can otherwise exacerbate glycemic variability and complications in individuals with T1D.

Beyond metabolic benefits, a GFD contributes to better quality of life. Patient-reported outcomes indicate reduced gastrointestinal symptoms, improved well-being, and greater self-efficacy among individuals with T1D and celiac disease who adhere to the diet [17][19]. Nonetheless, effective implementation requires nutritional education and access to high-quality gluten-free products, which may differ in taste and texture from conventional food.

Advances in serological diagnostics have enabled earlier detection of celiac disease in individuals with T1D. Recent research suggests that updated threshold values for anti-tissue transglutaminase (anti-tTG) antibodies increase the sensitivity and specificity of celiac disease screening, allowing dietary intervention even before the onset of overt clinical symptoms [18].

It is important to emphasize that while a gluten-free diet is essential for T1D patients with diagnosed celiac disease, current evidence does not support its routine application in patients without enterocyte-specific autoimmunity. As such, dietary changes should always be guided by proper serological and histopathological evaluation.

6. Ketogenic Diet and Type 1 Diabetes

The ketogenic diet (KD) is a nutritional model characterized by very low carbohydrate intake (typically below 50 grams per day), high fat consumption, and moderate protein intake. Its primary goal is to induce a physiological state of ketosis, wherein the body utilizes ketone bodies as an alternative energy source in place of glucose. In recent years, the KD has garnered attention as a potential therapeutic adjunct in the management of type 1 diabetes (T1D), although its application remains controversial [20].

In theory, carbohydrate restriction leads to decreased postprandial glucose excursions and reduced insulin requirements, which may improve metabolic stability. Case studies have reported that implementation of a strict low-carbohydrate ketogenic diet has resulted in prolonged remission of clinical symptoms and excellent glycemic control with low insulin doses in some patients with T1D [21]. Additionally, improvements in triglyceride levels, blood pressure, and body weight have been observed.

Mechanistically, the KD influences several key metabolic pathways. One of the most important is the PI3K/AKT/mTOR axis, which plays a central role in β-cell proliferation, survival, and function. Under conditions of chronic inflammation and hyperglycemia—as seen in T1D—this pathway becomes dysregulated. Ketone bodies exhibit anti-inflammatory and antioxidative properties that may protect β-cells from cytokine-mediated apoptosis, as demonstrated in both cellular and animal models [7][8][22].

Nonetheless, there are notable risks associated with ketogenic diets in T1D. The primary concern is diabetic ketoacidosis (DKA), which may occur in cases of insufficient insulin and excessive ketogenesis. For this reason, the diet must only be followed under close medical supervision with regular monitoring of blood glucose and ketone levels. There have also been concerns about the diet’s impact on kidney function and electrolyte balance, necessitating ongoing biochemical assessment [20].

Despite these concerns, some patients report high satisfaction with metabolic outcomes while on the KD, and the number of clinical studies and systematic reviews addressing this diet continues to grow. Recent reviews suggest that while ketogenic diets may offer benefits in selected cases, long-term safety data remain insufficient and further research is needed [22].

In summary, the ketogenic diet may be considered a supplementary nutritional strategy in carefully selected patients with T1D who demonstrate high motivation, education, and the capacity for intensive self-monitoring. However, its application should always be individualized and integrated into a multidisciplinary diabetes care framework.

7. Low-FODMAP Diet and Type 1 Diabetes

The low-FODMAP diet (Fermentable Oligo-, Di-, Monosaccharides and Polyols) was originally developed for patients with irritable bowel syndrome (IBS). It involves reducing dietary intake of short-chain carbohydrates that are poorly absorbed in the small intestine and rapidly fermented by colonic bacteria, resulting in gas production and gastrointestinal symptoms. In recent years, interest in the low-FODMAP approach has extended to other clinical populations, including individuals with type 1 diabetes (T1D), who frequently experience gut-brain axis disturbances [23].

Patients with T1D often report gastrointestinal symptoms such as bloating, abdominal discomfort, diarrhea, and altered food tolerance. These symptoms may result from autonomic neuropathy, microangiopathy of the intestinal mucosa, or gut dysbiosis. Studies indicate that a low-FODMAP diet can alleviate these symptoms by reducing colonic fermentation and gas production, thereby improving gastrointestinal comfort and quality of life [23][24].

Although direct research on the effects of the FODMAP diet in T1D is limited, emerging data suggest that dietary modulation of the gut microbiota may indirectly influence immune function and glycemic control. One key mechanism involves enhancing the production of short-chain fatty acids (SCFAs), which exhibit anti-inflammatory properties and help maintain intestinal barrier integrity and immune tolerance [25].

Another relevant aspect is the diet's potential impact on sleep quality, psychological stress, and depressive symptoms—factors frequently reported by patients managing chronic diseases such as T1D. By alleviating somatic discomfort, the low-FODMAP diet may contribute to improved mental health and self-management capacity.

It is important to note that the low-FODMAP diet is an elimination protocol requiring structured implementation in three phases: elimination, reintroduction, and personalization. Prolonged adherence to a restrictive, low-residue diet without professional supervision may lead to nutritional deficiencies and reduced gut microbial diversity.

In conclusion, while evidence remains preliminary, the low-FODMAP diet may serve as a supportive dietary strategy for T1D patients who experience significant gastrointestinal complaints. Further well-designed clinical trials are needed to establish efficacy and long-term safety in this specific population.

8. Conclusions

Type 1 diabetes remains an incurable condition that requires lifelong insulin therapy and strict metabolic control. Contemporary approaches to its management are evolving toward personalized, multidisciplinary care that not only addresses glycemic regulation but also aims to improve quality of life and prevent complications. A growing body of evidence suggests that appropriately selected nutritional strategies may play a therapeutic and modulatory role in immune, metabolic, and psychosocial domains.

The reviewed literature indicates that different dietary models offer distinct clinical benefits:

– Plant-based diets contribute to glycemic stability, reduce inflammatory markers, and support gut microbiota health. Their antioxidant and anti-inflammatory properties may reduce the risk of vascular complications and enhance patient well-being.

– The Mediterranean diet is among the most comprehensively studied patterns, improving glucose regulation, lipid profiles, and body composition while possibly influencing gene expression associated with metabolic risk.

– The gluten-free diet is essential for T1D patients with coexisting celiac disease. It improves nutrient absorption, metabolic control, and gastrointestinal symptoms. However, its routine use in patients without diagnosed enteropathy remains unsupported.

– The ketogenic diet shows potential for reducing insulin requirements, improving lipid metabolism, and exerting anti-inflammatory effects. Nevertheless, it carries a higher risk of ketoacidosis and must be carefully monitored.

– The low-FODMAP diet may improve gastrointestinal symptoms and emotional well-being in T1D patients with concurrent gut complaints, although long-term safety data are still lacking.

In summary, no single universal dietary model is suitable for all individuals with T1D. Nutritional therapy should be individualized based on age, lifestyle, comorbidities, patient preferences, and educational readiness. When combined with insulin therapy, technology, and structured education, diet becomes a cornerstone of effective long-term diabetes care. Further high-quality clinical trials are warranted to establish standardized dietary recommendations for people living with type 1 diabetes.

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Authors 'contribution:

Conceptualization: Mateusz Kacalak
Methodology: Mateusz Kacalak
Software: Mateusz Kacalak
Check: Mateusz Kacalak
Formal Analysis: Mateusz Kacalak
Investigation: Mateusz Kacalak
Resources: Mateusz Kacalak
Data curation: Mateusz Kacalak
Writing-Rough Preparation: Mateusz Kacalak
Writing-Review and Editing: Mateusz Kacalak
Visualization: Mateusz Kacalak
Supervision: Mateusz Kacalak
Project Administration: Mateusz Kacalak

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