

The Effects of a Low-Carbohydrate Diet on Glycemic Control and Weight in Patients with Type 2 Diabetes Mellitus: Literature Review

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ABSTRACT

Type 2 diabetes mellitus (T2DM) represents a growing global health concern characterized by chronic hyperglycemia resulting from insulin resistance and impaired insulin secretion. Clinical management primarily focuses on achieving glycemic control and weight reduction through pharmacological and lifestyle interventions. This systematic literature review aims to synthesize current evidence regarding the effectiveness of low-carbohydrate diets (LCDs) in improving glycemic control—particularly HbA1c and fasting blood glucose—and reducing body weight in patients with T2DM. The findings indicate that LCDs are effective in promoting rapid metabolic improvements and weight loss in the short to medium term, especially within the first six months of intervention. However, these benefits tend to decline over longer durations (12–24 months). Patient adherence was identified as the most critical determinant of intervention success, with non-adherence significantly increasing the risk of poor glycemic control. In conclusion, although LCDs offer promising short-term therapeutic benefits, their long-term effectiveness largely depends on sustained adherence, family support, and continuous patient education.

Keywords: HbA1c, Dietary Intervention, Body Mass Index (BMI), Diabetic Management, Hyperglycemia.

INTRODUCTION

Type 2 diabetes mellitus (T2DM) is an escalating global health problem characterized by chronic hyperglycemia caused by a combination of insulin resistance and pancreatic beta-cell dysfunction (Hossain *et al.*, 2024). The increasing global incidence of T2DM leads to numerous microvascular and macrovascular complications, including cardiovascular disease, nephropathy, neuropathy, and retinopathy, placing a heavy burden on healthcare systems (Młynarska *et al.*, 2025). The primary goals of T2DM treatment are to achieve optimal glycemic control, delay or prevent the onset of serious complications, and improve patients' overall quality of life.

In addition to pharmacological interventions through oral medications and/or insulin therapy, comprehensive treatment strategies must incorporate lifestyle modifications, particularly diet and regular exercise (Carino *et al.*, 2025). Obesity and being overweight are among the most common comorbidities and significant risk factors for T2DM. Both conditions not only exacerbate insulin resistance but also accelerate the progression of the disease. Therefore, weight loss is crucial in the management of T2DM. Significant

improvements in glycemic control frequently accompany successful weight loss, indicating a close and mutually reinforcing relationship between the two (Choo *et al.*, 2026).

Various dietary strategies, such as the Mediterranean diet, low-fat diet, and low-carbohydrate diet (LCD), have been proposed and investigated for T2DM management (Yokose *et al.*, 2021). Among these, the LCD has garnered significant attention as a potential dietary intervention. A substantial decrease in carbohydrate intake, compensated by an increase in fat and/or protein consumption, is the hallmark of LCDs. Proponents of LCDs argue that reducing carbohydrate intake can directly and effectively improve blood glucose control by lowering the postprandial glycemic response (Cintya *et al.*, 2022).

Despite the growing popularity of LCDs, disagreements persist regarding their long-term safety and efficacy in individuals with T2DM. While early studies demonstrated promising results in improving glycemic management and weight loss, other studies have highlighted potential negative consequences or fluctuations in patient responses to these dietary changes over time (Sugandh *et al.*, 2023). These contradictory findings underscore the necessity for a more thorough and systematic analysis. An in-depth evaluation of the relevant literature is required to identify current research gaps, assess the consistency of findings, and synthesize the available evidence.

The main objective of this literature review was to systematically evaluate how low-carbohydrate diets (LCDs) affect individuals with T2DM. Hemoglobin A1c (HbA1c) and/or fasting blood glucose levels were utilized as primary metrics to precisely measure the effects of LCDs on weight change and glycemic management. To better comprehend the therapeutic advantages of LCDs, this review also discussed the underlying physiological mechanisms driving these effects. Finally, by analyzing prior studies, this review aimed to identify the limitations of current research and formulate recommendations for future studies and clinical practice in T2DM treatment.

METHODS

This study employed a systematic review approach to identify, evaluate, and synthesize evidence regarding the effects of low-carbohydrate diets on glycemic control and body weight in patients with. A comprehensive literature search was conducted across PubMed, Google Scholar, and Mendeley databases (Yoshida *et al.*, 2021) using a combination of keywords, including "low carbohydrate diet", "ketogenic diet", "type 2 diabetes mellitus", "glycemic control", and "weight loss". The search included all relevant publications up to the date of the final search and was supplemented by a manual screening of the reference lists of relevant articles to identify additional studies. Articles were included in this review if they met the following criteria:

1. Study Design: Randomized controlled trials (RCTs), prospective cohort studies, or observational studies evaluating the impact of LCDs on T2DM patients.
2. Intervention: Diets explicitly defined as "low-carbohydrate diets" or their variants (e.g., ketogenic diet, very low-carbohydrate diet).
3. Outcomes: Reported primary outcomes had to include changes in glycemic control (HbA1c or fasting blood glucose) and/or body weight.
4. Population: Adults (>18 years old) formally diagnosed with T2DM.
5. Language: Publications available in Bahasa Indonesia or English.

RESULTS

This review synthesizes evidence from ten selected studies that met the inclusion criteria. The findings are summarized to highlight the effects of low-carbohydrate diets on glycemic

control and body weight among patients with T2DM; ten relevant articles were successfully identified and critically appraised, the summary of which is presented in Table 1.

Table 1. Summary of Literature Review on the Effects of Low-Carbohydrate Diet (LCDs) on Glycemic Control and Weight in Patients with Type 2 Diabetes Mellitus

No	Author, Year	Design	Method	Sample	Results	Duration
1.	(Sholehah <i>et al.</i> , 2025)	The pre-experimental design Two pre-post groups.	Purposive Sampling Method Data was collected through observation sheets and questionnaires .	33 adults or elderly people surveyed suffered from type 2 diabetes (DM).	In the intervention group, blood glucose levels decreased significantly from 296.63 mg/dl (pre-test) to 144.56 mg/dl (post-test), with an average reduction of 152.07 mg/dl, indicating that the combination of these measures was effective.	For those three weeks, the low-carbohydrate diet intervention was carried out through screening three times a week. In addition, AAROM therapy is given regularly three times a week for twenty minutes for those three weeks. Participants reported improvements in their overall mobility and energy levels, indicating a positive response to both the dietary changes and the therapeutic exercises. Follow-up assessments will be conducted to evaluate the long-term effects of these

No	Author, Year	Design	Method	Sample	Results	Duration
2.	(Khoiruni <i>et al</i> , 2023)	A quasi-experimental design with a group control and a pre-test and post-test.	The quasi-experimental design method with group design types before and after the test and control group is often utilized in educational research to assess the effectiveness of interventions.	The total sample size was 30 respondents, who were divided into two groups: intervention and control groups.	The intervention group experienced alterations in their blood sugar levels. 80% of the intervention group had abnormal blood sugar levels at the pretest, and 73.3% had normal blood sugar levels after the intervention. Significant dietary patterns also changed after the intervention: 66.7% of respondents had appropriate dietary patterns after the posttest, up from 20% at pretest.	interventions on their health outcomes. 6 Meetings.

No	Author, Year	Design	Method	Sample	Results	Duration
3.	(Novia <i>et al.</i> , 2023)	Cross-sectional analytic observational.	The purposive sampling method was used to select samples.	35 respondents	Compliance levels varied, with only 62.9% of respondents complying and 37.1% not complying. There is a relationship between compliance and blood glucose control, with 13 respondents who adhere to having controlled blood glucose levels and only 3 respondents who do not comply.	This study did not specify a duration.
4.	(Astuti <i>et al.</i> , 2024)	Comprehensive meta-analysis and review.	Until July 2023, a literature search was conducted from the PubMed, ScienceDirect, and Cochrane Library databases. A total of 7 relevant clinical studies were evaluated using Review Manager and R software.	7 clinical studies with 1395 Type 2 Diabetes Mellitus (T2DM) patients.	The Mediterranean diet consists of 45 percent CHO, 15 percent protein, and 40 percent fat. The Mediterranean diet has a low level of carbohydrates, with 35% carbohydrates and 45% fat (50% MUFA). The traditional Mediterranean diet contains carbohydrates [50–55 percent], fats [30%], and proteins [15–20	Each study analyzed had a different duration.

No	Author, Year	Design	Method	Sample	Results	Duration
					percent]. The Mediterranean diet contains many grains and vegetables, little red meat, more than 30% fat calories, between 30 and 50 grams of olive oil, and less than 50% carbohydrate calories. High-carbohydrate diet, low-fat diet, American Diabetic Association, and Chinese diet are some of the control diets available. These diets vary significantly in their macronutrient distribution, catering to different health goals and preferences. Understanding the unique benefits and potential drawbacks of each can help individuals choose a dietary approach that best suits their lifestyle and nutritional needs.	
5.	(Fitriani & Setiarini, 2024)	Systematic Review.	Research is gathered from online databases like Scopus,	1449 participants from 10 articles met the	Some studies have shown that fasting blood glucose, postprandial	The included studies varied from four weeks to five

No	Author, Year	Design	Method	Sample	Results	Duration
			PUBMED, and EMBASE in studies looking at how soluble fiber intake affects blood sugar control in patients with T2DM published from 2014 to 2023.	relevance and inclusion criteria.	glucose, and HbA1c levels have significantly decreased. Fiber supplementation can have gastrointestinal side effects, according to certain studies; however, there is no significant evidence of its safety. Several studies have not observed the effects of meeting fiber requirements in four weeks or less. Certain studies may exhibit bias due to their methodology or sample characteristics. In addition, 9 out of 10 studies showed a positive association between soluble fiber intake and better glycemic control in people with type 2 diabetes mellitus. This suggests that while supplementation can pose challenges, particularly in gastrointestinal health, the overall benefits of soluble fiber	years.

No	Author, Year	Design	Method	Sample	Results	Duration
					for managing blood sugar levels cannot be overlooked. Further research is necessary to clarify these findings and establish clearer guidelines for effective fiber intake.	
6.	(Goldenberg <i>et al.</i> , 2021)	Systematic review and meta analysis.	To perform a search, use CENTRAL, Medline, Embase, CINAHL, CAB, and literature. To estimate risks, random effects meta-analysis was used.	1,357 people participated in 3 trials.	At six months, a low-carbohydrate diet (LCD) was associated with better remission. Patients on LCD gained approximately 32% compared to the control diet (57% compared to 31%). However, clinically significant weight loss occurred over six months, and the effect diminished over twelve months.	The trials analyzed lasted from three months to two years. Significant results were reported six months and twelve months later.
7.	(Ichikawa <i>et al.</i> , 2024)	Meta analysis and systematic analysis of randomized controlled trials (RCTs).	We conducted a literature search from PubMed, Embase, and Cochrane databases up to June 2023. This study included randomized controlled	Overall, there were 6 studies that met the inclusion criteria and involved 524 people with type 2 diabetes.	HbA1c: The control group and the group that followed a low carbohydrate diet for a long period of time did not have a significant difference in HbA1c. This	12 months. 24

No	Author, Year	Design	Method	Sample	Results	Duration
			<p>trials on low carbohydrate diet (LCD) interventions in adults with type 2 diabetes. The findings revealed significant improvements in glycemic control and weight management among participants following LCDs interventions. Additionally, adverse effects were minimal, suggesting that such dietary approaches may be a viable option for this population.</p>		<p>study found that a low carbohydrate diet was successful in treating dyslipidemia over a long period of time. However, this diet is not recommended for people suffering from type 2 diabetes to control their glycemic load.</p>	
8.	(Nursihhah & Wijaya, 2021)	Quantitative with cross sectional design.	Univariate and bivariate analysis using statistical tests.	143 respondents were selected using proportional stratified random sampling method.	There is a significant relationship between dietary compliance and blood sugar control. Respondents who were not compliant with the diet had a 44.686 times greater risk of having uncontrolled blood sugar compared to respondents who were compliant with	No specific duration was mentioned.

No	Author, Year	Design	Method	Sample	Results	Duration
9.	(Anri, 2022)	Analytic study with case control design.	Sampling using purposive sampling.	100 respondents , consisting of 50 cases (patients with T2DM) and 50 controls (patients without DM).	the diet. Most respondents (69.2%) were not compliant in undergoing a diet. The study found that people who are obese have a 3.1 times higher risk of developing type 2 diabetes mellitus (DM) compared to people who are not obese. It was also found that people with an unbalanced diet had a 3.8 times higher risk of developing T2DM. And this study also found a person who rarely does physical activity has a 2.9 times higher risk of developing this disease.	No specific duration was mentioned.
10.	(Bangun <i>et al.</i> , 2020)	Prospective, Observational (Continuing Care Model).	Using total sampling technique.	A total of 48 respondents with type 2 diabetes mellitus.	Dietary Adherence: 56.3% of respondents were compliant with the diet program. Family Support: 47.9% of respondents had good family support. Relationship: There was a significant relationship between family	3 days.

No	Author, Year	Design	Method	Sample	Results	Duration
					support and dietary adherence. It can be concluded that family support is an important factor in DM patients' adherence to the diet program.	

DISCUSSION

The management of Type 2 Diabetes Mellitus (T2DM) inherently relies on addressing foundational risk factors, particularly unhealthy lifestyle habits. Regarding obesity as a risk factor, (Anri, 2022) conducted an analytical case-control study to investigate the risk factors associated with T2DM and obesity. Involving 100 respondents (50 T2DM cases and 50 healthy controls), the study revealed that individuals with an unbalanced dietary pattern had a 3.8 times higher risk of developing T2DM. Furthermore, individuals who lacked physical activity exhibited a 9 times higher risk of developing the disease. These findings reinforce the fundamental role of lifestyle factors—particularly diet and physical activity—in both the prevention and management of T2DM.

To address these behavioral risk factors, structured interventions are crucial, yet their implementation presents significant real-world challenges. (Khoiruni *et al.*, 2023) emphasized that while dietary and exercise interventions are beneficial for people with diabetes mellitus, success is largely dependent on adherence. Their observation that 80% of the intervention group exhibited abnormal blood sugar levels before the intervention, and 73% continued to have abnormal levels post-intervention, suggests that achieving optimal glycemic control remains a significant challenge despite lifestyle modifications. A 77% compliance rate among participants indicates that while most individuals adhered to the program, there is still room for improvement. This emphasizes the critical need for continuous education and tailored interventions to ensure better compliance and more satisfactory outcomes.

Within these tailored interventions, focusing on specific nutritional components such as fiber has proven to be highly beneficial. In a systematic review, (Fitriani & Setiarini, 2024) demonstrated that dietary fiber intake is highly crucial for patients suffering from diabetes mellitus. Data collected from 1,449 subjects across ten research articles revealed that optimal fiber intake significantly reduces fasting glucose, postprandial glucose, and HbA1c levels. However, they also noted a lack of robust evidence proving the safety of excessively high fiber intake, indicating that clear clinical guidelines are still necessary to mitigate potential gastrointestinal side effects.

Synthesis of Key Findings: Patterns of Consistency and Complexity While optimizing general macronutrients like fiber is important, adjusting the overall dietary pattern through Low-Carbohydrate Diets (LCDs) has emerged as a prominent strategy (Parker & Sikora, 2022). Overall, the compiled evidence consistently indicates that LCDs are a highly effective dietary intervention for producing rapid and significant metabolic improvements in patients with T2DM, particularly in the short to medium term. In a primary study, a brief three-week

intervention by (Sholehah *et al.*, 2025) showed a statistically significant reduction in blood glucose. A meta-analysis by (Goldenberg *et al.*, 2021) reinforces these findings, demonstrating that LCDs improve glycemic control and increase T2DM remission rates, with the most pronounced effects observed during the first six months.

However, this initial success masks a more complex underlying pattern, where the long-term efficacy of LCDs appears heavily influenced by intervention duration. (Goldenberg *et al.*, 2021) explicitly noted that intervention effects wane after six months, which closely aligns with the long-term RCT meta-analysis conducted by (Ichikawa *et al.*, 2024), who found that after 12 to 24 months, the difference in HbA1c levels between the control group and the LCD group was no longer statistically significant.

As highlighted earlier regarding general lifestyle modifications, patient compliance emerges as the dominant factor dictating these long-term outcomes. Observational studies by (Novia *et al.*, 2023) and (Nursihhah & Wijaya, 2021) provide robust empirical evidence of a direct correlation between adherence levels and glycemic control. (Novia *et al.*, 2023) showed that among the 62.9% of respondents who strictly adhered to the diet, over half successfully controlled their blood sugar, whereas only a small fraction of non-compliant individuals (37.1%) achieved similar control. Notably, (Nursihhah & Wijaya, 2021) demonstrated that the risk of uncontrolled blood glucose is 25 times higher in non-compliant patients. Furthermore, (Bangun *et al.*, 2020) expanded this concept into the social domain, proving that external support—especially from family—is indispensable for sustaining patients' dietary motivation and behavioral changes.

Physiological Mechanisms and Short-Term Effects Before addressing how to overcome these behavioral barriers, it is necessary to understand why LCDs produce such rapid initial success. The short-term efficacy of LCDs can be explained by clear physiological mechanisms. By severely restricting the intake of macronutrients that are rapidly converted into glucose, LCDs significantly lower the postprandial glycemic load (Vlachos *et al.*, 2020). This directly alleviates the demand on the pancreas to secrete insulin, providing a state of "metabolic rest" that allows peripheral tissues to improve insulin sensitivity and beta cells to recover from glucotoxicity. Moreover, the heightened satiety induced by increased protein and dietary fat consumption naturally leads to a spontaneous reduction in caloric intake. Subsequent weight loss, particularly the reduction of visceral adiposity, has been independently proven to enhance insulin sensitivity and dramatically improve the overall metabolic profile (Abdullah *et al.*, 2025).

Long-Term Challenges: Compliance and Diminishing Returns Despite these robust physiological mechanisms, the restrictive nature of LCDs creates significant sustainability issues over time. Adherence is the critical component that likely explains the discrepancy between short-term successes and long-term outcomes. Ketogenic and severely low-carbohydrate diets are difficult to sustain over long periods, particularly in social and cultural environments centered around carbohydrate-rich foods. Therefore, the diminishing returns reported by (Goldenberg *et al.*, 2021) and (Ichikawa *et al.*, 2024) over time may not represent a physiological failure of the diet itself, but rather a behavioral failure to sustain it. If adherence dictates success, interventions cannot rely solely on diet prescriptions; they must incorporate robust behavioral strategies, structured family support (Bangun *et al.*, 2020), and continuous nutritional education.

Dietary Modification Training and the Role of Soluble Fiber Directly addressing this critical need for ongoing education, research by (Khoiruni *et al.*, 2023) provides empirical evidence regarding the efficacy of dietary modification training on glycemic parameters. Following their training intervention, 73.3% of the intervention group achieved normoglycemia, driven by an increase in appropriate dietary patterns from 20% at baseline to

66.7% post-intervention. These findings suggest that structured education is vital in bridging the gap between dietary prescription and patient implementation.

A key aspect of this nutritional education involves teaching patients to select high-quality carbohydrates. The nutritional mechanisms underlying these glycemic improvements are further elucidated by the systematic review of (Fitriani & Setiarini, 2024) concerning soluble fiber. Their analysis demonstrated that soluble fiber intake significantly reduces fasting blood glucose, postprandial glucose, and HbA1c levels through enhanced satiety and the retardation of glucose absorption. Synthesizing these studies underscores that optimal T2DM management requires a dual approach: increasing nutritional literacy through training and prioritizing specific dietary components, such as soluble fiber, to meet metabolic targets.

The Broader Context of Diet and Lifestyle Factors Furthermore, this review highlights that if an LCD is too restrictive for a patient to maintain, it is not the only viable dietary option. As demonstrated by a meta-analysis conducted by (Astuti *et al.*, 2024), which compared LCDs with the Mediterranean Diet, alternative dietary modalities are equally effective. Although the Mediterranean diet contains a higher proportion of carbohydrates (around 50%), its emphasis on complex carbohydrates, healthy fats, and dietary fiber yields profound metabolic benefits. This proves that selecting carbohydrate sources with a low glycemic index that do not trigger severe blood sugar spikes is an essential part of T2DM dietary management.

Ultimately, dietary strategies—whether LCD or Mediterranean—must be integrated into a broader lifestyle approach. As supported by (Fitriani & Setiarini, 2024) research on fiber, and (Anri, 2022) findings on the dangers of physical inactivity, a holistic approach yields the best results. Additionally, (Akrimi & Brinkmann, 2022) successfully demonstrated the amplified benefits of pairing LCDs with regular exercise. Diet remains just one intricate element within the comprehensive management of T2DM.

Strengths and Limitations of the Review While the synthesized evidence provides comprehensive insights into these multifaceted approaches, the findings must be interpreted in light of certain limitations. A primary strength of this review is its broad methodological scope, ranging from real-world observational studies to RCT meta-analyses. However, significant heterogeneity among the included studies is a major constraint. The definition of "low carbohydrate" varies drastically across studies, ranging from ultra-strict ketogenic protocols to moderate approaches, making direct comparisons challenging. Second, the absence of a formal methodological quality assessment limits our ability to quantify potential biases within individual primary studies. Third, inherent publication bias cannot be completely ruled out.

CONCLUSION

The findings of this review confirm that lifestyle modification remains the cornerstone of effective T2DM management. Low-carbohydrate diets provide significant short- to medium-term benefits in improving glycemic control, promoting weight loss, and enhancing insulin sensitivity. However, the sustainability of these benefits is limited by challenges in long-term adherence. Therefore, effective management strategies should incorporate not only dietary interventions but also continuous education, behavioral support, and family involvement. Future research should focus on long-term interventions with larger sample sizes to better understand strategies that promote sustained adherence and improved clinical outcomes.

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