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REVIEW ARTICLE **OPEN ACCESS**

Assessing the Effect of Low Carbohydrate High Fat Diet on HbA1c: A Systematic Review

Rahul Dev Choudhury[1]*, Dr. Neelam K Sharma[2], Nihar Jyoti Thakururia[3], Manish Acharjee[4]
[1]*Assistant Professor & Research Scholar, School of Physical Education, Lovely Professional University Jalandhar, Phagwara, Punjab 144001
[2]Professor, HoD & Deputy Dean, School of Physical Education, Lovely Professional University Jalandhar, Phagwara, Punjab 144001
[3]Research Scholar, Pondicherry University, Chennai, Kalapet, Puducherry 605014
[3]Research Scholar, Swarnim Gujarat Sports University, Vadodara - 391774, Gujarat, India
Correspondence author mail id: devrahul09@gmail.com

ABSTRACT
Diabetes mellitus, a metabolic disorder that elevates blood sugar levels, affects millions of people globally. The incidence of this phenomenon is increasing, leading to substantial challenges for affected individuals and healthcare systems. HbA1c is a crucial measure of glycemic control over an extended period in treating diabetes. This systematic review investigated the impact of a low-carbohydrate, high-fat diet on HbA1c levels in the context of obesity treatment. It aimed to assess the relationship between nutrition, obesity, and T2DM by measuring HbA1c. The PRISMA 2020 and PEDro score >3 was employed to search the literature. The PICO framework was utilized to construct a review question. After an in-depth search of articles, 13 articles were selected for review. The comprehensive literature review shows that a low-carb, high-fat diet, behaviour change, and regular exercise can lower HbA1c and improve glycemic management. The systematic literature review concludes that a low-carb, high-fat diet lowers HbA1c. This systematic review of published trials shows that a low-carb, high-fat diet can dramatically reduce HbA1c and enhance glycemic control.
Keywords: *HbA1C, LCHF diet, Ketogenic diet, PRISMA 2020, Ketogenesis, T2DM*

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INTRODUCTION

Millions of individuals worldwide suffer from diabetes mellitus, a metabolic disease that raises blood sugar. Its frequency is rising, causing significant problems for affected individuals and healthcare systems. HbA1c is a key indicator of long-term blood glucose control in diabetes therapy. Diabetes patients must maintain ideal HbA1c levels to avoid issues and improve their quality of life. The traditional diabetic diet has focused on lowering blood glucose levels by cutting carbs. However, other nutritional strategies have gained popularity recently. The low carbohydrate high fat (LCHF) diet is controversial but increasingly popular for diabetic blood glucose control. Carbohydrate reduction and fat intake are LCHF diet priorities. LCHF diets improve glycemic management, weight loss, and diabetes wellness. LCHF diets are becoming more popular for diabetes management, although more research is needed to assess their effects on HbA1c. This study addresses this dearth of knowledge by reviewing the literature and conducting a systematic review on LCHF diets and HbA1c levels. This article examines how LCHF diets may affect HbA1c. They are examined for insulin sensitivity, postprandial glucose reactions, and metabolic balance. A complete and updated overview of studies on dietary treatments for diabetes management is our goal. This will help healthcare professionals and diabetics understand LCHF diet's pros and cons.

Given the rising prevalence of diabetes, understanding how nutrition affects HbA1c and blood glucose control is vital. This study aims to determine how LCHF diets affect diabetes control and provide significant insights for future research, clinical practice, and public health recommendations. In the following sections, we will analyze our systematic review methodologies, analyze pertinent studies, and critically appraise the current understanding of how LCHF diets affect HbA1c. Low-carbohydrate, high-fat diets have recently gained significant attention as a potential alternative to managing diabetes and improving glycemic control. These diets, also known as ketogenic diets, involve reducing carbohydrate intake and increasing fat consumption. Using fat as the primary energy source, this diet aims to shift the body's metabolism from carbohydrate-based to fat-based. This shift in metabolism leads to the production of ketone bodies, which

can provide an alternative fuel source for the body. Several studies have suggested that low-carbohydrate, high-fat diets may benefit glucose control and HbA1c levels in individuals with type 2 diabetes [1]

THEORETICAL FRAMEWORK: NUTRITIONAL IMPACT ON BLOOD SUGAR CONTROL

Various theories have been proposed to explain the impact of low-carbohydrate, high-fat diets on blood sugar control and HbA1c levels. One theory suggests that reducing carbohydrate intake can lower blood glucose levels and improve insulin sensitivity.

This is because carbohydrates are the primary source of glucose in the body, and reducing their intake can help stabilize blood sugar levels. Another theory focuses on the macronutrient composition of the diet. A low-carbohydrate, high-fat diet typically involves increased dietary fat and protein consumption while reducing carbohydrate intake. The macronutrient distribution can have varying impacts on carbohydrate metabolism pathways and the management of blood glucose, particularly in individuals with diabetes. [2]

Without glucose, the body metabolizes fat into fatty acids and glycerol, which can be utilized as an energy source by the cells but not by the brain. To fulfill the requirements of the brain, the fatty acids and glycerol undergo a process of conversion into sugar and ketones within the liver. Glycerol undergoes gluconeogenesis, a metabolic process that converts it into glucose. Ketogenesis is the process by which fatty acids are transformed into ketone bodies. Ketogenesis leads to the production of a ketone substance known as acetoacetate. Subsequently, acetoacetate undergoes conversion into two other forms of ketone bodies:

a. Beta-hydroxybutyrate (BHB) - Once the body has adapted to a ketogenic state, it will convert acetoacetate into Beta-hydroxybutyrate.

b. Acetone is occasionally converted into glucose by metabolism, although it is primarily eliminated as waste.

SIGNIFICANCE OF THE STUDY

The systematic literature review on the effect of a low carbohydrate high fat diet on HbA1c provides adequate knowledge during diet manipulation for controlling obesity. The comprehensive literature review emphasizes the significance of altering one's diet and its impact on glycated hemoglobin levels in order to decrease the prevalence of metabolic diseases in individuals with obesity. Ensuring a favorable HbA1C level can effectively manage significant health complications such as Type II diabetes mellitus (T2DM) and obesity-related cardiovascular illnesses.

OBJECTIVE AND REVIEW QUESTION

The review's objective is to analyze and evaluate the impact of a diet low in carbohydrates and high in fat on HbA1C levels.

AIM OF THE REVIEW

- To determine the efficacy of a diet low in carbohydrates and high in fats in reducing HbA1c levels during the treatment of obesity.
- To assess the impact of dietary alteration on treating obesity and Type II diabetes mellitus (T2DM) by evaluating the HbA1c status.
- To propose dietary adjustments for managing obesity and Type II diabetes mellitus (T2DM).

REVIEW QUESTION

"How does the LCHF diet help to control obesity and HbA1c relative health issues?"

Population	Intervention	Comparison	Outcome
The population is correlated with those experiencing obesity and type II diabetes.	The intervention is the LCHF diet.	The comparative group involves people with obesity and type II diabetes.	The result is linked to the management of obesity and the reduction of HbA1C levels.

TABLE 1. PICO framework is used to formulate a review question.[3]

METHODS

The PRISMA 2020 standards were followed for conducting this review.

LITERATURE SEARCH

The data were obtained by a systematic internet search strategy employing PubMed, MEDLINE, and Google Scholar. During the development of the search strategy for this publication, careful consideration was given to pertinent keywords and the current understanding of the subject matter. The keywords mentioned are

"Low Carbohydrate High Fats", "HbA1C", "Keto Diet", "Glycated Haemoglobin", and other related terms. The search was restricted to human studies comprising articles published in English between 2019 and 2023, encompassing a span of 5 years. Nevertheless, the list excludes editorials, commentaries, case studies, qualitative investigations, book chapters, and book reviews. After merging the results of the reviewed searches from the aforementioned databases, duplicate articles were removed in the second phase. Afterward, the studies were subjected to a quality assessment by carefully examining the titles, abstracts, and full text of the papers. At this juncture, research that failed to meet the specified inclusion criteria was excluded.

	PubMed Central	Google Scholar	MEDLINE
Keywords	Low Carbohydrate High Fats HbA1C Keto Diet Glycated Haemoglobin	Low Carbohydrate High Fats Glycated Haemoglobin Keto Diet HbA1C	Keto Diet HbA1C Low Carbohydrate High Fats Glycated Haemoglobin

TABLE 2. Keyword search

INCLUSION/EXCLUSION CRITERIA

A comprehensive literature review was conducted to find pertinent literature, using the specified criteria.

Inclusion Criteria	Exclusion Criteria
'The journals and review literature published from 2019 onwards are covered.'	'Excluded from consideration are journals that contain literature published prior to 2019.'
'Both peer-reviewed publications and reputable online sources are considered reliable for academic research.'	'Non-peer-reviewed journals are excluded from the study.'
'Journals/articles in the English Language are included.'	'Journals/ articles published in other languages except English are excluded.'
'Texts containing pertinent and well-thought-out keywords are deemed significant in the field of literature.'	'Publications and written works without appropriate and carefully chosen keywords are easily disregarded.'
'The inclusion of articles published in journals is ensured.'	'The types of written materials include book chapters, book reviews, editorials, case studies, qualitative research, and conference proceedings.'
'Studies required to have a score >3 on the Physiotherapy Evidence Database Scale (PEDro)'	'PEDro scores lower than 3 are excluded.'

TABLE 3. Inclusion and Exclusion criteria[4]

DESCRIPTION OF ALL STUDIES AND RESULTS

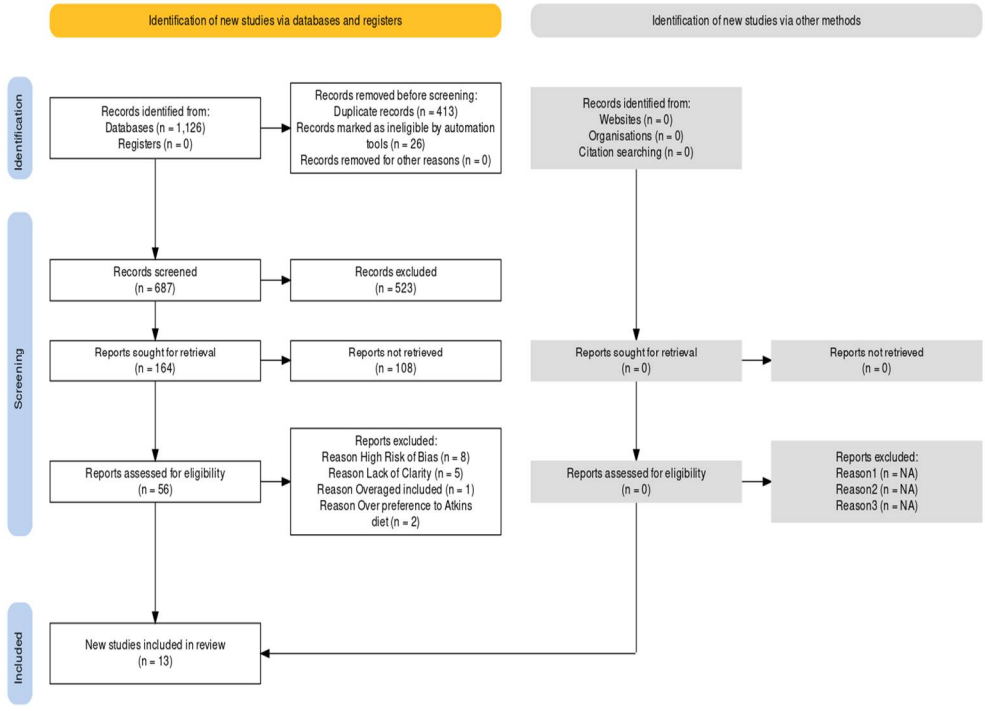

FIGURE 1. PRISMA flow chart 2020 [5]

This systematic review examines the selected papers investigating the efficacy and role of the LCHF diet on HbA1c. After doing a comprehensive search across three databases (PubMed, Google Scholar, and MEDLINE), a total of 1126 articles were identified as potentially relevant. However, after combining the results from the three databases and eliminating duplicate articles, the final number of articles remaining was 413. Out of the total, A total of 16 participants were eliminated from the study due to their failure to meet the specified inclusion criteria. After thoroughly examining the complete content of the remaining 40 publications, 13 studies satisfied the criteria for inclusion or exclusion.

RESULT AND DISCUSSION

Hussain and Thazhumpal found that the Low Carbohydrate Ketogenic Diet (LCKD) decreased blood glucose greater than the Low-Calorie Diet (LCD). Additionally, the diabetic LCKD group improved blood glucose levels significantly ($p < 0.0001$) compared to the LCD group, based on initial and final measures. HbA1c followed a similar pattern. When comparing the beginning (week 1) and last (week 24) results, the diabetic LCKD group normalized HbA1c better than the LCD group.[6]

The absence of a noteworthy correlation between energy consumption and HbA1c levels in Zhaleh et al. research could be recognized as the rise in carbohydrate intake resulting from high-calorie consumption. This increase in carbohydrate intake may counteract the impact of high-calorie intake on blood glucose regulation. Data analysis revealed that the thresholds for the impact of carbohydrate and total fat on HbA1c were 25 and 30 kcal/kg body weight, respectively. This can lead to alterations in insulin receptors and secretion, resulting in insulin resistance. Our work suggests high-carbohydrate meals can enhance peripheral insulin sensitivity and secretion while reducing liver glucose release. This effect is likely attributed to high fibre, fructo-oligosaccharides, resistant starch, and indigestible carbohydrates.[2]

After 3 and 6 months, the author found that patients on SGLT2 inhibitors experience genitourinary infections at rates of 2.37% and 21.78%, respectively. There is a significant disparity in the probability of genitourinary infection among the three drugs ($p=0.0019$). There is a correlation between genitourinary infection and elevated levels of HbA1c during the initiation of therapy, SUR, and the use of insulin. Men had the same number of factors whereas females, only the levels of HbA1c and eGFR at the initiation of SGLT2 inhibitor treatment were found to be associated with genitourinary infection.[7]

Charlene et al. concluded in their article that 57 women with type 2 diabetes who took metformin and ate a diabetic diet had an HbA1c of 9.3%. After moving to KD and IF, she achieved an HbA1c of 6.4 while off medication in just four months. The ketogenic diet (KD) combined with intermittent fasting (IF) is a long-term replacement for conventional type 2 diabetes care. Type 2 diabetics with normal weights can use KD and IF. Glycemic control does not require weight loss. This diet may be more beneficial than standard type 2 diabetes management since it minimizes or completely does away with the need for medication. A patient with high IF and KD adherence could not take any more oral hypoglycaemic medications while receiving standard care.[8]

The main analysis focused on a group of 33 participants who had all the necessary data. At the end of 12 weeks of the diet, there was no significant difference between the average HbA1c levels. The HbA1c readings showed no significant differences between the diet phases after 12 weeks. However, there was an improvement in HbA1c levels from the baseline on both diets, which can be attributed to multiple common dietary factors. The WFKD resulted in a significant reduction in triglycerides. Still, it also posed possible dangers due to increased LDL cholesterol levels and reduced intake of essential nutrients from omitting legumes, fruits, and whole, intact grains. Additionally, the WFKD was shown to be less maintainable. [9]

Małgorzata et al. examined the effects of a 12-week, carefully tailored LCKD on high blood sugar, insulin production, and lipid profiles in overweight or obese adult females. 91 female participants were assigned to two groups: an LCKD group ($n = 46$) that followed a hypocaloric ketogenic diet and CG ($n = 45$) that maintained a regular diet. HbA1c was measured, and HbA1c values averaged 5.87 ± 0.94, but after treatment, they were 5.38 ± 0.74. In contrast, the control group reported HbA1c readings of 5.86 ± 0.60 and 5.90 ± 0.74. All biochemical indicators showed significant changes when comparing the LCKD group with the CG. An adult female with glucose control issues and extra weight may benefit from a low-calorie ketogenic diet. [10]

Cooper discovered that adolescent girls who consumed a breakfast with a high glycemic index (GI) exhibited higher insulin levels than those who consumed a meal with a low glycemic index while consuming the same quantity of carbs. A separate study has established a correlation between glycemic load (GL) and metabolic syndrome in teenagers, with obesity being identified as the primary cause. The author employed six clinical trials to assess the efficacy of low-GI meals as indicators for glycemic control in individuals with type 2 diabetes. It was shown that a diet with a low glycemic index (GI) is more effective in regulating glycated hemoglobin and fasting blood glucose levels compared to a diet with a high glycemic index. [11]

Following KD intervention, there was an average decrease of 1.29 mmol/L in fasting blood glucose levels, and a decrease of 1.07 in glycated haemoglobin A1c levels, indicating improved glycemic management. The analysis examines the possible benefits of KD in managing diabetes and reducing weight. It utilizes fasting blood glucose and HbA1c as biomarkers to assess long-term glycemic control. HDL, LDL, TC, and TG values are evaluated to monitor alterations in glucose and lipid metabolism linked to metabolic diseases. Furthermore, the HOMA-IR model is employed to assess the reversal of insulin resistance.[12]

Patients in the VLCKD group had a noteworthy reduction in weight of 3kg at 3 months (T1) and 12 months (T2). However, patients in the LCD group did not see any meaningful alteration. The VLCKD group had a reduction of 0.69 ± 0.65% in HbA1c, whereas the LCD group had a reduction of 0.42 ± 0.01% after 3 months. The observed change was not statistically significant.[13]

Both groups saw a reduction in BMI and HbA1c following the intervention. Nevertheless, it is crucial to acknowledge that the disparities in these decreases were not statistically significant. Specifically, in the KD group, HbA1c decreased from 8.74% to 7.82%, while in the diabetic diet group, it decreased from 8.69% to 8.42%.[10]

The proportion of patients in the LGID group declined from 8.3% to 7.8%. The LCKD group experienced a substantially larger reduction in weight (from 108.4 kg to 97.3 kg) compared to the LGID group.[9]

Patients in the VLCK group experienced a more significant reduction in body weight than those in the low-calorie diet group. The HbA1c levels in patients in the VLCK group showed a substantial decrease (from 6.9 to 6.0 %) compared to those in the low-calorie diet group (6.8 to 6.4 %).[14]

Following a 12-month intervention, individuals in the LCK group experienced a reduction in body weight of 8.3%. Patients in the LCK group experienced a more significant reduction in HbA1c levels than in the MCCR group.[15]

Diabetic patients in the LCKD group experienced a notable reduction in body weight. In contrast, patients in the low-calorie diet group saw a smaller decrease in weight. There was no statistically significant variation in BMI values between diabetes patients in the LCKD group and those in the low-calorie diet group.[6]

LIMITATIONS OF THE STUDY

Low-carbohydrate, high-fat diets can reduce HbA1c levels, but this systematic study identified disadvantages. The inherent prejudice in numerous studies restricts their scope. The absence of blinding among participants and study staff regarding the food intervention may have influenced the outcomes. The absence of blinding in the examination of food nutrition leads to bias. The research findings were potentially biased since the study methods were inadequately described. Future research should address these limitations to enhance the quality and validity of the findings. Challenges occur when analyzing studies on diets low in carbohydrates and high in fat. The absence of a standardized naming system makes comparing and drawing broad conclusions from research findings challenging.

Notwithstanding these constraints, the methodical inquiry revealed intriguing impacts of low-carb, high-fat meals on HbA1c levels. Low-carb, high-fat diets resulted in reduced HbA1c levels.

RECOMMENDATIONS FOR FUTURE RESEARCH

The limitations of this thorough evaluation necessitate some recommendations for future research on the impact of low-carbohydrate, high-fat diets on HbA1c levels: In order to examine the impact of low-carbohydrate, high-fat diets on HbA1c, it is necessary for future studies to address the limitations identified in this systematic review. In order to enhance statistical power and the capacity to apply findings to a broader population, it is advisable to conduct well-structured randomized controlled trials with larger sample sizes. These randomized controlled trials (RCTs) should employ rigorous blinding techniques in order to minimize bias and ensure the accuracy and reliability of the results.

CONCLUSION

The recent systematic review yielded valuable insights regarding the efficacy of behavior change methods in decreasing HbA1c levels. The importance of problem-solving, behavior feedback, goal-setting, and self-monitoring in reaching positive results was emphasized. These programs show potential in effectively managing HbA1c levels by utilizing known behavior change techniques, providing hope for individuals seeking effective strategies for diabetes treatment. Furthermore, physical activity played a vital role in preventing obesity and insulin resistance. High-intensity interval training has been identified as an efficient intervention for persons with type 2 diabetes.

Ultimately, the evidence reported in the systematic review firmly affirms the significance of behavior change strategies and lifestyle adjustments in enhancing glycemic control. The review's findings illuminate the potential advantages of diabetes health coaching, self-management support groups, and digital

applications in facilitating long-lasting dietary modifications. The utilization of peer support, goal setting, self-monitoring, and individualized tools can greatly enhance glycemic control and facilitate weight loss in patients diagnosed with type 2 diabetes and prediabetes. This highlights the growing importance of behavior change support in promoting self-care and improving the overall management of diabetes. Conclusively, the systematic literature review presents compelling evidence that adopting a low carbohydrate high fat diet, employing behavior change approaches, and engaging in regular exercise can benefit HbA1c levels and overall glycemic management. To summarize, the systematic literature review provides strong evidence that a low carbohydrate high fat diet is highly helpful in lowering HbA1c levels. The results of this comprehensive analysis of published studies offer strong evidence that a diet low in carbohydrates and high in fat can significantly affect HbA1c levels and improve glycemic control.

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