

The effect of the keto diet on lipid profile with type two diabetic patients

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Abstract

Introduction. In the developed world, among the main causes of disease and death is type 2 diabetes. It is a significant public health issue with rising prevalence, with more than 380 million patients estimated to be affected by 2025.

Aim. To evaluate the effect of ketogenic diets on glycemic control in patients with type II DM in Kirkuk and Mosul provinces.

Materials and methods. Patients with T2DM in both Mosul and Kirkuk cities were enrolled in this study to evaluate the effect of keto diet on HbA1c level and Lipid profile variations between 1/9/2022 to 1/4/2023.

Results and discussion. This study shows that the distributions of patients according to age and gender there was about 43.3 % female and 56.7 % male and the age variations, female with age above 56 years old was 30 % while male 60.7 %. A significant p value was shown in HbA1C variations before and after keto diet (0.0001), also in lipid profile of a significant p value before and after keto diet (0.001) regarding total Glyceride a significant p value highly was (0.002). Due to the large particle size of LDL-C, it has been hypothesized that this elevation in LDL-C would not likely cause cardiovascular problems. For individuals with type 2 diabetes, the low-calorie-ketogenic VLCK diet (<50 g of carbohydrates per day) is a safe, well-tolerated, and recognized medical nutritional therapy option when used in conjunction with an interventional weight loss program that offers support for lifestyle and behavioral modification over a 4-month period.

Conclusion. Diabetic and ketogenic diet there is a good clear relationship regarding the HbA1c and lipid profile. Further studies are required for larger numbers of patients and longer duration follow up.

Keywords: T2DM, VLCK, HbA1c, LDL-C

Conflict of interest. The authors declare that they have no obvious and potential conflicts of interest related to the publication of this article.

Contribution of the authors. Fadwa Ghassan – study conception and design. Ateka Mohammed, Zainab Kazim – data collection. Fadwa Ghassan, Ateka Mohammed, Zainab Kazim – analysis and interpretation of results. Fadwa Ghassan – draft manuscript preparation. All authors reviewed the results and approved the final version of the manuscript.

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Влияние кетогенной диеты на липидный профиль у пациентов с сахарным диабетом второго типа

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Резюме

Введение. Сахарный диабет 2 типа (СД2) входит в число наиболее распространенных заболеваний и основных причин смертности среди населения развитых стран. Это серьезная проблема общественного здравоохранения, и значимость ее растет: согласно оценкам, к 2025 году количество пациентов, страдающих этим заболеванием, превысит 380 миллионов.

Цель. Оценка влияния кетогенных диет на гликемический контроль пациентов с СД 2 типа в провинциях Киркук и Мосул.

Материалы и методы. С 01.09.2022 г. по 01.04.2023 г. в городах Мосул и Киркук проводилось исследование с целью оценки влияния кетогенной диеты (кетодиеты) на изменение уровня HbA1c и липидного профиля у пациентов с СД2.

Результаты и обсуждение. Исследование выявило следующее распределение пациентов по полу и возрасту: пациенты женского пола составили 46,3 %, мужского – 56,7 % от общего количества пациентов, при этом доля пациентов в возрасте старше 56 лет составила 30 % среди женщин и 60,7 % среди мужчин. *P*-значение в оценке изменений уровня HbA1c до и после применения кетодиеты оказалось существенным (0.0001), так же как и в оценке изменений липидного профиля до и после проведения кетодиеты (0.001); в отношении общего уровня глицеридов *p*-значение также было существенным и достигало величины 0.002. Принимая во внимание большие размеры частиц ЛПНП, нами была выдвинута гипотеза о том, что возникновение кардиоваскулярных проблем вследствие повышения уровня ХС ЛПНП маловероятно. Для людей с диабетом второго типа кетогенная диета с очень низким содержанием углеводов (VLCKD) (менее 50 г в день) является безопасным, легко переносимым и широко признанным видом диетотерапии, помогающим изменить образ жизни и поведенческие привычки в течение четырех месяцев при применении в сочетании с интервенционной программой по снижению веса.

Заключение. Прослеживается хорошо заметная связь между кетогенной диетой и такими показателями больных сахарным диабетом, как уровень HbA1c и липидный профиль. Предполагается проведение дальнейших исследований с увеличением числа пациентов и продолжительности наблюдения.

Ключевые слова: СД2, VLCKD, HbA1c, ХС ЛПНП

Конфликт интересов. Авторы декларируют отсутствие явных и потенциальных конфликтов интересов, связанных с публикацией настоящей статьи.

Вклад авторов. Фадва Гассан – концепция и дизайн исследования. Атека Мохаммед, Зайнаб Казим – сбор данных. Фадва Гассан, Атека Мохаммед, Зайнаб Казим – анализ и интерпретация результатов. Фадва Гассан – подготовка черновика рукописи. Все авторы рассмотрели результаты и одобрили окончательную версию рукописи.

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INTRODUCTION

In the developed world, type 2 diabetes mellitus is one of the main causes of diseases and death. By 2025, it is predicted that over 380 million people would have contracted the serious public health concern, which is becoming increasingly common [1]. Diabetes is a complicated chronic illness that causes hyperglycemia due to insufficient glucoregulatory control [2].

Individuals with type 2 diabetes are more likely to develop heart disease, diabetic neuropathy, retinopathy, and nephropathy, as well as have a shorter life expectancy than people without the condition [3]. The increasing worldwide impact of diabetes on individuals, families, and nations is evident from the data and statistics. IDF stands for the International Diabetes Federation. Based on data from Diabetes Atlas (2021), 10.5 % of adults aged 20 to 79 have diabetes, with nearly half of them being uninformed that they have the illness. The IDF predicts that 783 million adults, or 1 in 8 of them,

would have diabetes by 2045 – a 46 % rise from current estimates.

The ultimate objective of managing type 2 diabetes is keeping a patient's blood sugar within the target range, which is a glycated haemoglobin (HbA1c) of less than 7 % (53 mmol/mol)¹, as advised by clinical guidelines, or even to assist in reaching drug-free remission [4, 5]. By doing this, the risk of micro- and macrovascular complications related to diabetes is reduced [6].

After the DiRECT trial's publication [7, 8]. Low-carbohydrate or low-energy diets were the methods employed in these programs. Other food options must be provided, though, since not everyone wants to adhere to such a schedule.

A hypocaloric diet and increased physical activity, along with behavioral modifications, are the cornerstones of intensive lifestyle management for individuals

¹Type 2 diabetes in adults: management Available at: <https://www.nice.org.uk/guidance/ng28>. Accessed: 09.05.2024.

duals with type 2 diabetes (T2D). The ultimate goal is to reduce body weight by at least 15 kg, as this is associated with improved glucoregulatory control [9]. A growing number of people are using very low carb diets, or ketogenic diets, to improve their glucose control and reach remission. These diets can be used as an adjuvant or alternative therapy option to other dietary approaches and anti-diabetic medications [10].

As a result, substantial research is underway to find drugs and complementary treatments to lessen the disease's harmful impact on individuals [11]. The ketogenic diet is one of the therapy strategies being researched. A diet that is high in fat and low in carbohydrates is referred to be "ketogenic"¹. Popular ketogenic publications typically recommend consuming 70–80 % fat from total calories, 5–10 % carbs, and 10–20 % protein. Compared to other low-carb, high-protein diets, the protein intake on the ketogenic diet is kept reasonable since consuming too much protein can prevent ketosis. A ketogenic diet needs to contain adequate protein to retain lean body mass, including muscle, while still inducing ketosis since the amino acids in protein can be converted to glucose [12].

The basis of the ketogenic diet for weight loss is the theory that, by limiting the body of glucose – which is primarily produced by eating carbohydrates – an alternative fuel termed ketones – derived from stored fat – is produced. Hence, the word "keto"-genic. The brain requires the highest amount of glucose in a steady supply – roughly 120 grams per day – because it is unable to store it. When fasting or consuming minimal carbohydrates, the body first releases stored glucose from the liver and then momentarily breaks down muscle [13].

The body will begin using fat as its primary fuel if this continues for three to four days and depletes its supply of stored glucose. Blood levels of an insulin-like hormone will also fall during this time. The liver may use fat to make ketone bodies, which it can use when glucose is not available [14]. Ketone bodies accumulate in the blood and cause ketosis. In healthful individuals, mild ketosis occurs spontaneously after periods of fasting (e.g., sleeping through the night) and intense physical activity. The ketogenic diet's proponents claim that while the brain will use ketones as fuel, healthy people usually create enough insulin to avoid too much ketones from accumulating. Blood ketone levels shouldn't rise to dangerous levels (referred to as "ketoacidosis") if the diet is properly maintained [15].

Multiple factors, such as body fat percentage and resting metabolic rate, influence the duration of ketosis and the quantity of ketone bodies that accumulate in the blood.

In the short term, the ketogenic diet has been demonstrated to result in positive metabolic alterations. In addition to the reduction of body weight, obesity-related health markers have improved, including insulin resistance, hypertension, elevated cholesterol, and triglycerides² [15]. Diabetes type 2 is becoming more and more common, and low-carb diets like the ketogenic diet are becoming more and more popular [15, 16].

Excessive restriction in carbohydrates can cause a variety of symptoms, including brain fog, constipation, migraines, low mood, hunger, and exhaustion. These symptoms might persist for several days or weeks. Long-term ketogenic diets side effects have been related to an increased risk of kidney stones and osteoporosis, as well as greater uric acid levels in the bloodstream (a risk factor for gout). It is crucial to include a daily intake of meats, fish, vegetables, fruits, nuts, and seeds in addition to high-fat foods to prevent potential nutrient deficiencies. This will help you get enough fiber, B vitamins, and minerals (iron, magnesium, zinc) [1].

This diet has been used in the past to treat children with refractory seizures. These days, a wide range of illnesses are being researched, including obesity, diabetes, Alzheimer's, Parkinson's, and cancer [3].

Prior to the discovery of insulin, ketogenic diets were a cornerstone of diabetic treatment for both type 1 and type 2 diabetes, with a long history of success in treating a variety of metabolic disorders, including drug-resistant epilepsy [17, 18]. But as a potential treatment option, they have only lately been added to the American Diabetes Association Guidelines for the first time [19]. Even so, there is still a great deal of debate over their application in clinical settings and their suitability for diabetics.

The American Diabetes Association (ADA) and Diabetes UK recently released general guidelines for managing diabetes in people with type 2 diabetes (T2D), with the primary goal being weight loss. This was necessary because there were no evidence-based dietary guidelines for managing diabetes. Interestingly, while weight loss in these cohorts improves glycaemic management, this advice was equally applicable to the 10 % of T2D individuals who are thought to be at a healthy weight (BMI 18.5–24.9 kg/m²) in people with T1D and gestational diabetes [20]. A agreement regarding the optimal dietary distribution for individuals with diabetes has not yet been reached [19], which has caused uncertainty among healthcare professionals when it comes to "prescribing" a certain dietary type or pattern as a therapeutic method for diabetes [21].

In 2021, the Scientific Advisory Committee on Nutrition (SACN) examined the available research on low-carb diets for individuals with type 2 diabetes [22]. A lower

¹ Diet Review: Ketogenic Diet for Weight Loss. Available at: <https://www.hsph.harvard.edu/nutritionsource/healthy-weight/diet-reviews/ketogenic-diet>. Accessed: 09.05.2024.

² Diet Review: Ketogenic Diet for Weight Loss. Available at: <https://www.hsph.harvard.edu/nutritionsource/healthy-weight/diet-reviews/ketogenic-diet>. Accessed: 09.05.2024.

carbohydrate diet clearly has positive short-term metabolic effects, but due to a lack of comprehensive long-term data, SACN reported inconsistent and inconclusive results for long-term therapeutic benefits. As a result, SACN concluded that a low-carb diet is neither superior nor inferior to other dietary patterns.

Rapid and effective weight loss is the most significant predictor of T2D remission, and this helps explain some of the therapeutic advantages of ketogenic diets, even though the exact physiological mechanisms are unknown [23]. The lowered metabolic adaptations that follow weight loss are proposed by proponents as the possible metabolic benefit of ketogenic diets in causing more significant and long-lasting weight loss than other traditional diets [24]. Conversely, studies on ketogenic diets have shown that they increase anorexigenic hormones such glucagon-like peptide 1 [25, 26], leptin [27], and cholecystokinin [28], and suppress the hormone that causes hunger, ghrelin [29]. As a result, participants experience increased satiety [25] and decreased appetite [29]. Some speculate that the anorexigenic properties of ketone bodies themselves may also be the cause of the greater efficacy. Supporting data indicates that exogenous ketone ester drink consumption, together with elevated blood ketone levels, led to larger decreases in hunger and ghrelin than did drinking of a dextrose drink [30]. Despite frequently better short-term results, there is now no convincing evidence that weight loss with this diet approach is superior over the long run¹.

Patients with diabetes benefit greatly from the ketogenic diet, which results in reduced body weight, better fasting glucose and insulin, lower cholesterol, and the elimination or reduction of diabetic drugs. Reduced consumption of carbohydrates is assumed to be the cause of this, as it lowers blood glucose and shifts energy metabolism from glucose to ketone bodies. Insulin resistance decreases as a result of this drop in blood glucose [11].

Numerous studies have demonstrated the ability of the ketogenic diet to aid in weight loss. Although both diets led to significant fat loss, patients on the ketogenic diet showed larger increases in high-density lipoprotein (HDL) cholesterol and lower serum triglyceride levels than those on the low-fat diet.

This result highlights the need for additional research into the benefits of the ketogenic diet and demonstrates that it can be used as a treatment for diabetes and obesity². The impact of carbohydrate restriction on type 2 diabetes was reexamined in four studies that were published between 2003 and 2005. A low-carb diet was

found to improve hemoglobin HbA1C more than a low-fat, calorie-restricted diet during a one-year period in the first experiment, which included 54 diabetic patients out of 132 total participants [31, 12]. A 5-week crossover feeding study comparing diets was conducted with eight individuals who had type 2 diabetes as part of the second experiment. More improvement in glycohemoglobin levels was observed in persons following a low-carb diet than in those following an equicaloric low-fat diet [13].

Ten type 2 diabetes patients were included in an inpatient feeding regimen for the third study. In just 14 days, the percentage of hemoglobin A1c decreased from 7.3 percent to 6.8 % [14].

Ten type 2 diabetes patients were included in an inpatient feeding regimen for the third study. In just 14 days, the percentage of hemoglobin A1c decreased from 7.3 percent to 6.8 %. In the third research, ten patients with type 2 diabetes were placed on an inpatient feeding regimen. The hemoglobin A1c level dropped from 7.3 to 6.8 % in just 14 days [14].

Subsequently, Feinman and associates provided coherent data endorsing the low-carb diet as the primary treatment strategy for type II diabetes and as the most potent supplement to medication in type I diabetes [15]. In order to better understand the connection between type II diabetes and kidney disease (KD), Farés and his team employed systems biology techniques in 2010. They specifically developed and analyzed cell networks that represent the metabolic state. They found a strong connection between the major ketosis pathway and the insulin resistance pathway, which may account for the benefits shown in previous clinical trials³. Low-carbohydrate diets, which are the first line of treatment for type II diabetes in obese individuals, are a current source of worry when it comes to low-calorie-ketogenic (VLCK) diets [32].

The increasing popularity of the ketogenic diet has sparked questions regarding how it should be used in weight-loss regimens. Additionally, consuming a low-fat diet was found to raise levels of high-density lipoprotein cholesterol (HDL-C) and decrease levels of triglycerides and blood glucose [33].

There is less consistency in the effects of carbohydrate restriction and ketosis induction on total cholesterol and low-density lipoprotein cholesterol (LDL-C) [34].

Only a small number of research, meanwhile, have examined their effect on cardiovascular risk factors [35, 36].

According to this study, the ketogenic diet causes a considerable decrease in serum triglycerides in persons with a normal lipid profile, a slight increase in total and LDL cholesterol, and a moderate increase in HDL

¹ Low-carb diets position statement for professionals. Available at: <https://www.diabetes.org.uk/professionals/position-statements-reports/food-nutrition-lifestyle/low-carb-diets-forpeople-with-diabetes>. Accessed: 09.05.2024.

² Diet Review: Ketogenic Diet for Weight Loss. Available at: <https://www.hsph.harvard.edu/nutritionsource/healthy-weight/diet-reviews/ketogenic-diet/>. Accessed: 09.05.2024.

³ Diet Review: Ketogenic Diet for Weight Loss. Available at: <https://www.hsph.harvard.edu/nutritionsource/healthy-weight/diet-reviews/ketogenic-diet/>. Accessed: 09.05.2024.

cholesterol. For every kilogram lost, triglycerides decrease by 0.015 mmol/L and HDL cholesterol increases by 0.009, per another study [37].

High fasting triglyceride levels have been linked to an increased risk of cardiovascular disease [38].

Conversely, a wealth of research indicates that a diet heavy in carbohydrates increases insulin resistance, decreases HDL cholesterol, and increases triglycerides [39, 40].

Triglyceride and HDL level changes were reversed when carbohydrates were substituted for saturated fat [41–43].

High blood cholesterol levels can lead to difficulties, thus people often try to cut down unsaturated fat and cholesterol from their diets. In this instance, it is reasonable to assume that the best course of action is to let the cells use extra fat for energy, as this lowers obesity. Eating a diet high in fat and limiting carbohydrates, which are typically used to meet the body's energy needs, can condition the cells for this type of metabolism. When compared to other diet regimens, numerous studies have decisively shown how beneficial the ketogenic diet is in helping obese patients lose weight [44, 45].

Aim of study: to evaluate the effect of ketogenic diets on glycemic control in patients with type II DM in Kirkuk and Mosul provinces.

METHODOLOGY

This research about a group of patients with DM T2 in two cities Kirkuk and Mosul. The patients include in research are More than 18 Patients have DM T2 Men and women between 1/9/2022 to 1/4/2023.

• **The exclusion criteria:**

1. Children.
2. Pregnant.
3. Patients with DM Type 1 and other complication.
4. Cancer patients.

RESULTS

This study shows that the distributions of patients according to age and gender there was about 43.3 % female and 56.7 % male and the age variations, female with age above 56 years old was 30 % while male 60.7 %, as shown in table 1.

Table 1. Distribution the sample according to gender and age

Gender	Age classes			Total
	25–40	41–55	56>	
Female	6.7 %	6.7 %	30.0 %	43.3 %
Male	3.3 %	16.7 %	36.7 %	56.7 %
Total	10.0 %	23.3 %	66.7 %	100.0 %

The distributions of patients according to gender and Keto durations, female percentage according to duration of keto was 90 % in 5–8 days, while male distribution according to duration classes was highest in

5–8 days (23.3) % and female only (20) %, the same percentage was shown when the duration above 8 for male very sustain percentage for female. Table 2 shows the effect of keto diet on HP1C, Lipid profile, and total glycerides variations in males.

Table 2. Effect of Keto diet on different markers in female (mean + SD)

	Mean	SD	t value	Sig.
HbA 1c before	6.19	1.18	2.98**	0.011
HbA 1c after	5.68	1.04		
Lipid before	205.59	35.57	2.79*	0.016
Lipid after	170.53	46.05		
TG before	181.88	85.62	1.69 ^{NS}	0.116
TG after	131.20	63.44		

A significant *p* value was shown in HP1C variations before and after keto diet (0.0001), also in lipid profile of a significant *p* value before and after keto diet (0.001) regarding total glyceride a significant *p* value highly was (0.002). A significant *p* value was shown in HP1C and lipid profile only after keto diet as shown in figure 1, A and B.

Table 3 showing the relationship between the gender and the biological markers as we can see there was no significant *p* value in both genders regarding HP1C and lipid profile and total glyceride.

Table 3. Comparing the traits decreasing % in both gender

	Gender	Mean, %	SD	t value	Sig.
HbA 1c	Male	12.75	9.17	1.20 ^{NS}	0.24
	Female	8.52	9.37		
Lipid	Male	11.17	12.65	0.69 ^{NS}	0.50
	Female	15.56	21.14		
TG	Male	20.41	36.73	0.47 ^{NS}	0.64
	Female	10.68	72.12		

Table 3 shows the improvement in HP1C and lipid profile and total glyceride according to age, also no significant *p* value was shown.

Table 4 shows the improvement in biological markers according to keto diet durations also no significant *p* value was shown.

Table 4. Improvement in the traits decreasing % in according to age

Age (year)	HbA 1c		Lipid		TG	
	Mean, %	SD	Mean, %	SD	Mean, %	SD
25–40	9.41	8.25	23.63	3.47	42.86	29.10
41–55	15.91	6.59	14.58	16.63	29.20	20.14
56>	8.24	10.06	11.94	17.18	5.40	60.69
Duncan test	NS		NS		NS	

Note. NS – refer to non-significant difference between groups.

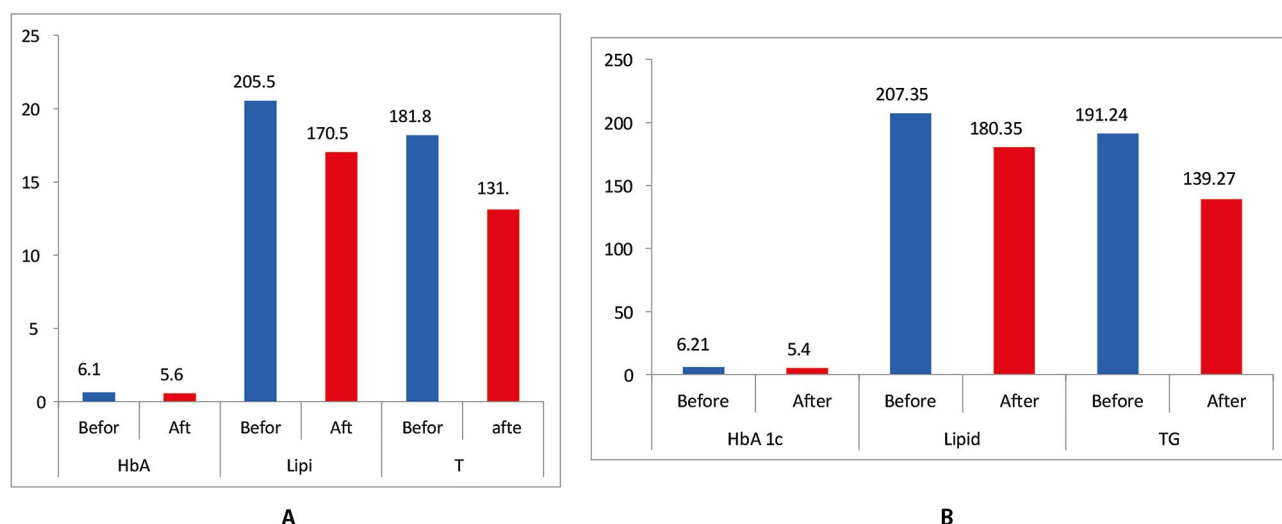


Figure 1. The relationship between HbA1c, Lipid Profile and Total Cholesterol before and after Keto diet

DISCUSSION

When comparing a ketogenic diet to the traditional "Plate Method", which is widely advised for the management of type 2 diabetes in those who are overweight, Saslow et al.'s small cohort ($n = 23$) randomised controlled trial from 2017 [46] offered supporting evidence. Those on a ketogenic diet experienced better weight loss and considerably reduced HbA1c levels after 32 weeks (less than 6.5 mmol/l for 55 % of participants). After completing a 12-month low-carb diet, 86 % of people with T2DM were able to cut back on or stop using insulin entirely, according to another study [47]. Long-term research on health outcomes comparing regular and ketogenic diets, however, is desperately needed. According to a recent systematic review and meta-analysis [48], individuals with type 2 diabetes benefit from low-carb and ketogenic diets when it comes to glucose control when compared to other diets. On the other hand, research indicates that ketogenic diets are far more effective in reducing HbA1c (-1.45 %) than low-carb diets (-0.27 %). The evaluation does not, however, consistently support the idea that ketogenic diets are better at reducing body weight than other diets; a pooled analysis found no significant difference in BMI reduction between ketogenic and control diets.

Studies show that 50 % of diabetics have high blood pressure, thus it's critical to draw attention to the ketogenic diet's additional benefits, which include lower blood pressure. But after a year, blood pressure did not alter, which could be related to the weight reduction plateau that occurs between 12 weeks and a year [49].

Significant improvements were observed in metabolic parameters, mental and physical functioning, and pain management in individuals with type 2 diabetes and obesity who were randomly assigned to either a conventional or an energy-restricted ketogenic diet for a duration of 12 weeks. The study indicated these be-

nefits [50, 51]. Because diabetes can have detrimental consequences on a patient's physical, social, and psychological well-being, which can all result in decreased self-care and consequent glycaemic control, health-related quality of life is highly important in managing diabetes [52].

In order to enhance glycemic control in a group of recently diagnosed type 2 diabetes participants, the goal of this manuscript is to report on the effectiveness of a short-term low-carbohydrate (LC) diet. The most significant finding was that in just ninety days, a low-carbohydrate ketogenic diet, with approximately 5 % of calories coming from carbohydrates, produced a significant drop in HbA1c from 8.9 %, which is the threshold associated with diabetes, to 5.6 %, the conventional level. In addition, other cardio-metabolic parameters such as blood pressure, triglycerides (TG), body weight, and BMI showed noteworthy changes as a consequence of the intervention. HDL ratio [53].

Our findings demonstrate that the low-calorie-ketogenic VLCK diet (<50 g of carbohydrates per day) is a safe, well-tolerated, and recognized medical nutritional therapy option for T2DM subjects when combined with lifestyle and behavioral modification support during a 4-month interventional weight loss program [53].

The main goal of the current study was to find out if a 3-week LCHF diet with >75 % fat would impair a healthy, young, normal-weight woman's lipid profile and reduce her ability to tolerate glucose. The study's second goal was to find out if an exercise session may mitigate any potential harm that an LCHF diet might do to one's ability to tolerate glucose [54].

After comparing the LC diet to an ER diet high in carbohydrates, we discovered that it was both acceptable and successful for short-term weight loss in Chinese women who were overweight or obese during the 12-week trial. Additionally, the HDL-cholesterol, to-

tal:HDL-cholesterol ratio, and TAG:HDL-cholesterol ratio showed more positive effects of the LC diet. There was similar adherence to both diets. It is the only feeding research that we are aware of that aims to ascertain how well Asian populations adhere to a low-carb diet and how it affects their ability to lose weight [55].

After just three weeks, KD lowers HbA1c, and the benefit appears to last for at least a year. This is connected to a decrease in drugs that lower blood sugar. A long-term diet appears to sustain the weight loss that was shown in a short amount of time. Sufficient assistance (psychosocial counseling, boosting good affect, and encouraging mindful eating) is required to produce a desired outcome and ensure compliance [56, 57].

Based on earlier studies, it is widely recognized that a ketogenic diet improves lipid profiles and lowers cardiovascular risk factors including hypertension. However, recent studies have also revealed elevated levels of total cholesterol and low-density lipoprotein cholesterol (LDL-C) as a result of this diet. Because of the enormous size of the LDL-C particles, it has been hypothesized that this elevation in LDL-C would not likely worsen cardiovascular problems. In this case report, we describe a patient who was on a ketogenic diet who experienced a sudden spike in LDL-C, which was quickly corrected [58, 59].

People who are overweight or obese, who make up the majority of persons with type 2 diabetes, have participated in numerous studies examining the use of ketogenic diets for the management of diabetes [28]. Research on their impact, however, is scarce in the 10–15 % of T2D patients with healthy BMIs (20–24.9 kg/m²) who may not necessarily benefit from weight loss interventions. Due to the fact that the ketogenic diet is usually a caloric deficit diet in comparison to the typical "western diet", this raises the fundamental question of whether ketogenic diets offer additional benefits beyond weight loss (and independent of other macronutrient changes) or whether greater weight loss is the attributing factor for glucoregulatory improvement. This question is raised frequently in the scientific literature [23].

It is debatable whether the ketogenic diet should be advised because people with diabetes are already substantially more likely to develop cardiovascular disease and because the long-term effects of increasing consumption of saturated fat in the diet are still mainly understood [60, 61]. The impact of dietary saturated fat on LDL cholesterol (LDLc) and its consequent negative impact as a cardiovascular disease risk factor are well-established by Mendelian randomization studies [62], notwithstanding the paucity of data focused on ketogenic diets. Additionally, prospective studies utilizing carbohydrate intake quartiles showed that the highest risk of cardiovascular disease (RR 1.13), cancer (RR 1.08) and total mortality (RR 1.22) was associated with people with the lowest carbohydrate intake [63]. Recommending that care be used when starting such diets. Nevertheless, contradictory research indicates that ketogenic diets can improve the ratio of HDL to trigly-

cerides in the blood. Interestingly, in individuals with obesity (BMI > 35 kg/m²), a 24-week ketogenic diet significantly decreased total cholesterol, LDL cholesterol, and triglycerides while concurrently raising HDL cholesterol. These reductions occurred along with decreases in body weight and glycaemic levels [16].

Recommendations

To ensure optimal safety and proper management of any pharmacotherapies, it is imperative that patients with T2D who are taking medication first seek medical counsel for a personalized assessment prior to instituting any severe carbohydrate restricted diet. Nonetheless, it appears that carbohydrate restriction is safe for people using metformin, the most often recommended medicine [64].

CONCLUSION

Short-term metabolic benefits and weight loss are evident with ketogenic diets, and an increasing number of authoritative dietary guidelines are endorsing and highlighting these benefits. Likewise, our traditional recommendations lack long-term support because they are exceedingly expensive to sponsor and conduct. Long-term evaluation of the health effects of both traditional and ketogenic diets is clearly needed, although it is currently lacking. Notwithstanding, the sustenance of noteworthy weight reduction continues to be the primary catalyst for enhanced diabetic control, and medical practitioners need to recommend a nutritious eating regimen that personal adherence to is highest. It will be difficult to conduct clinical ketogenic diet implementation for the management of diabetes at the public health level due to the limiting issue of the lack of a clear definition of a ketogenic diet.

The following parameters were determined at the conclusion of this study:

1. An impressive decrease in HbA1c was observed in just 90 days, from a diabetic level (8.9 %) to the normal (5.6 %) on a low-carbohydrate ketogenic diet, wherein carbohydrates made up approximately 5 % of calories.
2. A substantial improvements across several cardio-metabolic parameters, including body weight, BMI, blood pressure, and the triglyceride (TG):HDL ratio.
3. Comparing the LC diet to an ER diet high in carbohydrates, Chinese women who were overweight or obese found it to be both acceptable and successful in helping them lose weight temporarily. Additionally, the HDL-cholesterol, total:HDL-cholesterol ratio, and TAG:HDL-cholesterol ratio showed more positive effects of the LC diet.

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