

Effects of Ketogenic Diet on Glucolipid Metabolism

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Abstract. As a famous dietary pattern, the ketogenic diet was initially used to treat severe epilepsy. Today, the ketogenic diet is becoming the mainstream as a low-carbohydrate diet for weight loss. However, the impact of the ketogenic diet on glucolipid metabolism is still unclear. Thus, this study investigated the effects of the ketogenic diet on glucolipid metabolism, including obesity, and Type 2 diabetes. Results indicate that the ketogenic diet significantly improves glucolipid metabolism in people with Type 2 diabetes and it can significantly reduce their BMI and waist circumference and take on a specific role in insulin secretion, and reduce the risk of developing diabetes and related complications. However, the above experiments have shortcomings such as small experimental scope and short experimental time. Because long-term consumption of high-fat foods can also easily affect diseases such as blood lipids, this study provides information on the effects of a ketogenic diet on individuals who suffer from issues with glycolipid metabolism, particularly how it affects diabetes and obesity.

Keywords: Ketogenic diet; Glucolipid metabolism; Type 2 diabetes; Obesity.

1. Introduction

With the change in human lifestyle and eating habits, diseases related to glucose and lipid metabolism have developed into global chronic diseases. Glycolipid metabolism is further divided into glucose metabolism and lipid metabolism. Abnormal glucose metabolism refers to abnormalities in hormones or enzymes that regulate glucose, fructose, and other metabolism, or changes in tissues and organs, while abnormal lipid metabolism refers to abnormalities in lipids and their metabolites caused by congenital or acquired factors [1]. This disease tends to cause a variety of chronic diseases, such as obesity, followed by hypertension, hyperlipidemia, diabetes, and other metabolic diseases. These diseases pose a serious threat to human health, therefore, the factors causing obesity, how to effectively control weight, and reduce the occurrence of disease, have become a hot topic of concern [2]. At the same time, ketogenic diets have been noted for their ability to reduce weight in the short term. The diet lowers appetite and calorie intake without restricting fat consumption. As a result, the ketogenic diet is beneficial for lipid and glucose metabolism. In view of this, this article will concentrate on ketogenic diet and analyzes how it affects glucolipid metabolism, including type 2 diabetes, weight, and obesity.

2. Ketogenic Diet and Glucolipid Metabolism

2.1. Ketogenic Diet

Ketogenic diet, which is a diet that uses fat metabolism to produce ketogenic bodies (acetoacetic acid, acetone, and β Hydroxybutyric acid), thus replaces the dietary pattern of carbohydrate energy supply, and the use of ketones can reduce the incidence of epilepsy caused by insufficient glucose metabolism. The ketogenic diet is also known as a high-fat and low-carbon diet because, in the standard ketogenic diet, the ratio of the weights of fat and protein to carbohydrates is typically 4:1[3,4].

For this reason, the ketogenic diet was originally used to treat epilepsy. As research continues, the ketogenic diet is being widely used to treat people with obesity and diabetes [5]. According to research, ketogenic diets can improve insulin sensitivity and blood sugar control in people with type 2 diabetes, in addition to helping obese people lose weight and control the body's glucose and lipid metabolism.

2.2. Ketogenic Diet and Obesity

When the energy is stored, fat cells expand, producing the typical pathology of obesity [6]. Also, obesity can even cause more disease in the middle and later stages and these diseases are associated with an increase in mortality. These diseases include type 2 diabetes (T2DM), metabolic syndrome, cardiovascular disease, hyperlipidemia, hypertension, etc [7]. The body mass index of an individual is used to categorize obesity (BMI). As WHO warns, 1.9 billion people were overweight and more than 650 million of these people classified as obese in 2016 [8]. It is horrible number.

One experiment demonstrated the relationship between ketogenic diets and obesity, the normal diet of ordinary diabetes was given to the control group, while the low carbon ketogenic diet was given to the intervention group. According to the data in table1, the difference in BMI indicators in before and after the intervention is about 6.03kg/m², and the difference in waist circumference is 18.63cm. After the intervention, the average level of BMI and waist circumference data is lower than that of the control group. These findings demonstrate that a low-carb ketogenic diet can notably lower a person's BMI, waist circumference, and even weight. Analysis of the reasons may be related to the low carbohydrate diet, which plays an essential role in controlling the patient's body mass and fat, this dietary pattern increases the intake of protein through the diet, thereby increasing the body's sense of fullness at mealtimes, using fatty foods instead of sugars in carbohydrate foods as the main source of energy, and reducing patients' excessive intake of food and carbohydrates. By reducing the patient's excessive intake of food and carbohydrates, thereby meeting metabolic needs, rapid weight loss. It follows that the keto diet is effective in weight loss [9].

In 2021, 51 overweight PCOS patients were given ketogenic diet intervention for four weeks in Capital Medical University. Study by recording weight changes and comparing vitamin D and lipid metabolism indicators before and after. This study found that obese people generally lack vitamin D content in their bodies [10], and almost 90% of obese people also suffer from vitamin D insufficiency, and waist to hip ratio and vitamin D levels are highly inversely correlated. For obese patients, vitamin D supplementation alone is not effective without weight loss [8]. This is because most obese patients have little outdoor activity or poor dietary habits, such as being picky eaters. At the same time, obese patients have a low utilization rate of vitamins, which is due to the vitamin D is stored more in fat in obese patients, and the vitamin circulation level is lower compared to normal weight people [8]. That's because during the study, researchers found significant increases in vitamin D levels after the ketogenic diet weight loss intervention (Table 2). Body mass decreased by 5.79kg. Average BMI also showed a similar trend to body mass, with an average decrease of 2.12kg/m². In addition, waist-hip ratio decreased by 0.02 (P<0.01) (Table 3). Therefore, this study reached the same conclusion as at the beginning of this paragraph: After intervention with ketogenic diet, there is an obvious decrease in vitamin content, body fat rate, body mass, etc. The correlation between the patients' vitamin D levels and their BMI and body fat ratio was negative related.

Table 1. Comparison of BMI and waistline between the two groups of patients [9]

Index	Time	Intervention group	Control Group
BMI/(kg/m ²)	Before	30.12 ± 0.33	30.18 ± 0.36
	After	24.09 ± 0.21	26.22 ± 0.30
Waistline(cm)	Before	96.11 ± 0.65	96.05 ± 0.64
	After	77.48 ± 0.32	83.73 ± 0.45

Table 2. Vitamin D before and after the ketogenic diet intervention are compared (*p<0.01) [8]

Index		Baseline	Follow-up (4 Weeks)
Vitamin D/ (ng/ml) Vitamin D nutritional status	Normal	16.37± 5.67 9(17.65)	21.72 ± 6.64 28(54.90) *
	Under	33(64.70)	22(43.14) *
	Lack	9(17.65)	1(1.96) *

Table 3. Changes of body composition indicators in patients before and after ketogenic diet (*p<0.01) [8]

Body Composition Index	Baseline	Follow-up (4 Weeks)
Body Mass/kg	81.11±11.23	75.32 ± 10.58*
BMI/(kg/m ²)	29.87±3.79	25.75 ± 3.68*
Body Fat Ratio/%	40.77±4.70	37.88 ± 5.14*
Waist Hip Ratio	0.96 ± 0.05	0.94 ± 0.06*

BMI: Body Mass Index

2.3. Ketogenic Diet and Diabetes

Diabetes and obesity are connected diseases, and diabetes is one of the three main risk factors for early death globally [9]. Therefore, diabetes has been the focus of the medical community. In recent years, the incidence rate of type 2 diabetes is rising globally because of economic growth and increasing dietary and lifestyle improvements among people. Hyperglycemia and insulin insufficiency are the two main symptoms of type 2 diabetes, a prevalent chronic metabolic syndrome. This typically occurs because the patient's body is unable to create enough insulin or consume it properly. As a part of the body, if a patient does not receive timely and effective treatment, it is easy to cause a series of complications in the later stage of the disease, such as heart disease, stroke, visual failure, and even a series of kidney diseases [8,11]. Type 2 diabetes is the result of a typical disorder of glucose and lipid metabolism. Therefore, the earlier effective treatment is received, the better the health of type 2 diabetes patients will be. Drug treatment, lifestyle management, and exercise intervention are all used to treat diabetes clinically, but there is no complete and rapid solution to this disease in a short time. Despite this, following medical advice for medication is a popular and successful method of controlling patients' blood sugar levels among a range of strategies. Due to the increasingly depth research results in this field, researchers have begun to pay more attention to non-drug treatment to minimize the side effects and harm of drugs to the human body [12]. It's also led researchers around the world to become increasingly interested in the high-fat, low-carb ketogenic diet.

In fact, according to the analysis and interpretation of the experimental data, ketogenic diet does have a positive impact on the indicators of diabetes. A clinical study that was published in 2005 examined at how T2DM patients responded to a low-carb ketogenic diet. Twenty-eight overweight diabetic patients were placed on a ketogenic diet for sixteen weeks [13]. The results of the study showed that after 16 weeks of experimental intervention, the overall level of glycosylated hemoglobin (HbA1c) showed a downward trend. In addition, the percentage of glycosylated hemoglobin from 7.5% at baseline to 6.3% at week 16, hemoglobin decreased by 16%. (p<0.001). From 9.08 mmol/L at the start to 7.57 mmol/L at the 16th week, glucose dropped by 16.6%. The most dramatic decrease was in triglyceride, which decreased by 41.6%. Moreover, there is a negative trend in the data on uric acid, which proves that ketogenic diets also have a positive impact on cardiovascular disease. This reveals that low carbohydrate intake can stimulate a decrease in blood sugar levels, leading to a decrease in the rate of insulin production. Therefore, a ketogenic diet has a positive impact on the treatment of metabolic imbalances in insulin [13].

The previous ketogenic diet and vitamin D intervention experiments, glucose and lipid metabolism indicators showed a decline [8]. As shown in Table 4, after a 4-week experiment, the patient's glucose metabolism, such as fasting blood glucose, decreased significantly, and the indicators of lipid metabolism, such as triglycerides, fasting insulin, and high-density lipoprotein, decreased significantly. However, the total cholesterol data are only slight changes, without significant changes [8]. The control group's measurements of lipid and glucose metabolism were all lower than those of the control group. This could indicate that a low carb ketogenic diet and vitamin D have important effects on glucose and lipid metabolism.

Ketogenic diet successfully improves glucose and lipid metabolism by effectively reducing weight and improving insulin sensitivity by human body, and there is a synergistic effect between vitamin D and glucose metabolism [8,13]. For patients with problems with glucose and lipid metabolism, the ketogenic diet offers a new treatment strategy as a straightforward and efficient dietary intervention.

Moreover, a ketogenic diet can not only benefit T2DM patients in the short term, but also ensure long-term efficacy. There was an experiment on type 2 diabetes (T2D) patients to improve blood sugar control and reduce weight by limiting carbohydrate and reducing drug use in 2005. This experiment was conducted by focusing on the body data of 262 T2DM patients receiving a low carbohydrate ketogenic diet for ten weeks. The study found a baseline HbA1c level of 7.6%, but after 10 weeks of the experiment, the researchers found a 1.0% decrease in HbA1c levels, and an average weight loss of 8 kg [14]. Moreover, experimental patients with HbA1c levels $\geq 7.5\%$ and between 6.5% and 7.4% have significant reductions in HbA1c levels [14]. Ketogenic diet has achieved success results in the treatment of T2DM patients. Not only that, during the experiment, but the dosage of diabetes drugs was also appropriated reduced. The experiment, among the 262 people, 112 patients had reduced their treatment medication the data showed a 1.2% drop in HbA1c. At the same time, another 21 people in the experiment even stopped using drugs for intervention, and in the HbA1c data, the data still decreased by 1%. Therefore, whether stopping or reducing drug intervention, HbA1c shows a significant downward trend. These results demonstrate the effectiveness of ketogenic diet in the control of diabetes, even when patients follow this low carbohydrate diet pattern to reduce drug use [14].

Table 4. Changes in indicators of glucolipid metabolism before and after KD intervention (*p<0.01) [8]

Indicators of Glucolipid metabolism	Baseline	Follow-up (4 Weeks)
Fasting Insulin/(μ IU/mL)	18.59 $\pm$ 8.86	11.43 $\pm$ 4.90*
Fasting Blood Glucose (mmol/L)	5.57 $\pm$ 1.90	4.90 $\pm$ 0.78*
(HbA1c) /%	5.70 $\pm$ 1.06	5.24 $\pm$ 0.63*
Total Cholesterol/(mmol/L)	4.98 $\pm$ 1.09	4.80 $\pm$ 0.91
Triglyceride/(mmol/L)	1.68 $\pm$ 0.86	1.07 $\pm$ 0.33*
High Density Lipoprotein (HDL) /(mmol/L)	1.22 $\pm$ 0.25	1.07 $\pm$ 0.21*
Low density Lipoprotein (LDL) /(mmol/L)	3.42 $\pm$ 1.02	3.27 $\pm$ 0.91

3. Conclusion

This study focuses on how patients with diabetes and obesity respond to the ketogenic diet in terms of their glucolipid metabolism. In summary, Glycolipid metabolic balance plays a crucial role in human motion, this study discovered that patients with Type 2 diabetes who follow a low-carbon ketogenic diet have significant improvements in their glycolipid metabolism, and it can significantly reduce their BMI and waist circumference and playing a certain role in insulin secretion, and reducing the risk of developing diabetes and related complications. However, the above experiments have shortcomings such as small experimental scope and short experimental time. Because long-term consumption of high fat foods can also easily affect diseases such as blood lipids. Therefore, the positive effects and potential disease risks of ketogenic diets on glucose and lipid metabolism need further experimental and research attention. Diet and disease are closely related to human life, and in this way can we find more perfect ways to treat disease and live a healthy life in the future. The conclusion of this study is that ketogenic diet is beneficial for glucose and lipid metabolism, but it is not limited to this. Therefore, in future work, researcher can expand the scope of research and conduct more in-depth research.

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