



## A REVIEW: USE OF KETOGENIC DIET IN VARIOUS DISORDERS

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**ABSTRACT** The use of a ketogenic diet in various disease conditions is discussed in this article. The study's goal is to see how the ketogenic diet can help with different ailments. The keto diet is a high-fat, low-carb diet. It requires consuming significantly less carbohydrate and substituting it with fat. When carbs are removed, the body enters a metabolic state known as ketosis. While in ketosis, the body becomes extraordinarily efficient at burning fat for energy. Epilepsy, Parkinson's disease, Alzheimer's disease, obesity, diabetes, metabolic syndrome, Poly cystic ovarian syndrome (PCOS), and cancer are the disorders for which it could be extremely effective.

**KEYWORDS :** Ketogenic Diet, Parkinson's Disease, Alzheimer's Disease, Obesity, Diabetes, Metabolic Syndrome, Poly Cystic Ovarian Syndrome (PCOS), Cancer

**INTRODUCTION**

The ketogenic diet (or keto diet, for short) is a low-carb, high-fat diet. The ketogenic diet entails substantially lowering carbohydrate consumption and replacing it with fat. The body enters a metabolic state known as ketosis when carbs are reduced<sup>1</sup>. Ketosis is a metabolic state in which the body burns ketone bodies as a source of energy. The body becomes extremely effective at burning fat for energy while in ketosis. It also causes fat to be converted to ketones in the liver, which can be used to provide energy to the brain. Blood sugar and insulin levels can be drastically reduced on a ketogenic diet. Ketogenic diets may also have benefits in weight reduction, diabetes, cancer, epilepsy and Alzheimer's disease. The ketogenic diet is available in various forms, including: Standard ketogenic diet (SKD): It's a high-fat, low-carbohydrate, moderate-protein diet. It usually has 70 percent fat, 20 percent protein, and barely 10% carbohydrates. Cyclical ketogenic diet (CKD): This diet includes periods of high-carb refeeding, such as 5 ketogenic days followed by 2 high-carb days. Targeted ketogenic diet (TKD): This diet allows you to eat carbohydrates in between workouts. High-protein ketogenic diet: This diet is comparable to a traditional ketogenic diet, but with additional protein. Typically, the fat-to-protein-to-carbohydrate ratio is 60% fat, 35% protein, and 5% carbohydrates<sup>2</sup>.

**FOODS INVOLVED IN KETOGENIC DIET:****FOODS TO EAT:**

A keto diet contains 70% fats, 25% protein, and 5% carbohydrate. Eat foods such as fish, egg, meat, butter, cheese, nuts, oils which are rich in fats and contains low carbohydrate. Between 20-30g of net carbs is recommended for everyday dieting.<sup>3</sup>

**Table 1: Foods To Eat:**

Keto source	Calories	Fats (g)	Net carbs (g)	Protein (g)
Protein source				
Ground beef (4 oz., 80 /20)	280	23	0	20
Pork chop (4 oz.)	286	18	0	30
Chicken thigh (4 oz.)	250	20	0	17
Salmon (4 oz.)	236	15	0	23
Liver (4 oz.)	135	5	0	19
Egg (1 large)	70	5	0.5	6
Veggie source				
Cabbage (6 oz.)	43	0	6	2
Cauliflower (6 oz.)	40	0	6	5
Broccoli (6 oz.)	58	1	7	5
Spinach (6 oz.)	24	0	1	3

Green beans (6 oz.)	26	0	4	3
Dairy source				
Heavy cream (1 oz.)	100	12	0	0
Greek yogurt (1 oz.)	28	1	1	3
Mayonnaise (1 oz.)	180	20	0	0
Cottage cheese (1 oz.)	25	1	1	4
Cream cheese (1 oz.)	94	9	1	2
Nut source				
Almonds (2 oz.)	328	28	5	12
Coconut flour (2 oz.)	120	4	6	4

**Table 2: Sample menu options for ketogenic diet:**

Vegetarian menu	Nonvegetarian menu
<b>Breakfast</b>	<b>Breakfast</b>
Cheese /paneer pakora Bullet coffee /tea mixed with coconut oil, cream and butter) /coffee with cream /coconut milk Grilled mushrooms with buttered vegetables tofu Coconut milk or almond milk	Scrambled whole eggs /hard boiled eggs with mozzarella and salami slices Bacon wrapped meatloaf Chicken wings with cheesy cauliflower puree Ham and cheese omelette Coconut milk or almond milk
<b>Mid-morning</b>	<b>Mid-morning</b>
Onion frittata and Mushroom Coconut with cabbage rolls Walnut crust cream of tomato soup with Apple crumb pie with stir fried broccoli and cheesy crackers	Chicken cracklings or Pork rinds Mushroom cream sauce with Hamburger patties and bacon Parmesan cream sauce and Roast chicken (with the skin left on) Cauliflower cheese with Roast pork belly Cream cheese roll-ups and Smoked salmon
<b>Lunch</b>	<b>Lunch</b>
Spinach pancakes made with lots of cheese and flaxseed flour Cauliflower curry in coconut Oil and coconut milk Soya curry Sour cream with Chilli beans, salsa and cheese Full - fat yoghurt tofu pudding Salad stirs fried in butter topped with cheese Red channa salad with olive oil	Pie Meat Hummus lettuce wraps and herb butter chicken Baked fish with butter sauce Cauliflower sauteed in flaxseed or olive oil Bacon Tuna salad with lettuce leaves Egg mayonnaise with green salad

Evening	Evening
Vegetables spring rolls wrapped in peanut sauce with lettuce	Creamy tomato sauce
Coconut milk with Pumpkin smoothie	Cheese burger
Peanut butter with Carrot and cucumber sticks	Poached eggs with melted cheese and spinach
Cheesy muffins topped with berries	Deep fried chicken wings
Green tea (without sugar) fried peanuts	Chocolate Chip cookie
	Chicken stock
	Herbal coffee with heavy cream without sweetener
Dinner	Dinner
Almond and Chia seeds	Baked salmon
The diet is usually designed to give 80 percent to 90 percent of energy from fat, with a 4:1 ratio of fat to protein plus carbohydrate. i.e., 4 g fat, 1 g protein, and carbohydrate. (For example, a 1500-calorie diet could have 133.5 g of fat, 55 g of protein, and 20 g of total.)	

#### FOODS TO AVOID:

On the keto diet, stay away from meals that are high in carbohydrates, both sweet and starchy. Starchy meals like bread, rice, pasta, and potatoes fall under this category. These foods are very high in carbs. Avoid fruits such as apple, orange, etc. Also avoid or limit highly processed foods and low-fat diet products.

#### KETOGENIC DIET IN EPILEPSY

Recurrent seizures, which are short periods of uncontrollable movement that can affect part or all of the body and are occasionally followed by loss of consciousness and control of bladder or bowel function, characterise epilepsy. Patients who have not responded well to two well-selected and well-dosed antiepileptic medicines should explore a ketogenic diet. As a result, neurologists frequently prescribe alternative therapy such as food, especially the ketogenic diet, to help patients achieve better antiepileptic control. With a considerable reduction in seizure frequency, a ketogenic dietary treatment enhances quality of life. A decrease in brain glucose intake and synthesis of glycolic ATP under ketogenic diet settings may trigger potassium channels sensitive to ATP opening, resulting in neuronal hyperpolarization. Membrane decreases the brain's electrical activity and raises the seizure threshold. It also modulates the seizure threshold in the brain and inhibits excessive neuron activation. Clinical research suggests that the key to achieving high efficacy is to follow a stringent and strict beginning strategy that includes carbohydrate restriction and increased fat intake. The first randomised clinical controlled trial of a ketogenic diet in drug-resistant epilepsy was undertaken by the Neal's group in 2008. They looked at 145 children with epilepsy who had not responded to two antiepileptic medications. The youngsters were randomised into two groups at random: one was given a ketogenic diet right away, while the other was given a combination of two antiepileptic medicines after three months. When compared to the control group, the ketogenic dietary group exhibited a 75 percent reduction in seizure frequency after three months. Furthermore, 38 percent of children in the ketogenic diet group saw a >50% reduction in seizures, and 7% experienced a >90% reduction in seizure frequency.<sup>5</sup>

#### KETOGENIC DIET IN ALZHEIMER'S DISEASE:

Alzheimer's disease, a devastating neurodegenerative disorder, It is characterized by cognitive impairment with a progressive decline in memory, disorientation, impaired self-care, and personality changes. Progressive deposition of amyloid Beta peptides in amyloid plaques and hyperphosphorylated tau protein in intracellular as neurofibrillary tangles, as well as neuronal death and poor glucose metabolism, are all possible causes. The keto diet may help to alleviate Alzheimer's symptoms and slow the disease's progression. The ketogenic diet is a biochemical model of fasting which promotes organs to utilize Ketone bodies as the dominant fuel source to replace glucose for the central nervous system (CNS). On aged brain cells, the presence of ketone bodies (KBs) has a neuroprotective effect. Due to the restriction of glucose metabolism in the ketogenic diet, energy must be obtained from adipose tissue FAs. Surprisingly, because of its diminished ability to use FAs as an energy source, the brain is forced to rely on KBs instead. KBs through mitochondrial beta oxidation yield acetyl Co A, these acetyl Co A molecule produce AcAc and beta OHB. Later, KBs enter the circulation, where they create energy for cells in mitochondria. Beta OHB and AcAc penetrate the BBB and provide an alternate substrate for the brain. KBs may provide up to 70% of brain energy requirements after protracted periods of fasting. When KBs are

present in adequate quantities, they can meet the energy needs of non-signalling neurons as well as up to 50% of activity-dependent oxidative neuronal requirements. Furthermore, their synthesis may improve mitochondrial function and lower inflammatory and apoptotic gene expression. As a result, it's gaining traction as a potential treatment for neurological diseases like Alzheimer's. Newport et al. (2015) studied the effects of ketone monoester (R)-3-hydroxybutyl-(R)-3-hydroxybutyrate supplementation on cognitive abilities in an adult AD patient for 20 months to induce ketosis. In fact, the patient's mood, affect, self-care, cognition, and daily activity performance all improved. In 23 adult patients with mild cognitive impairment treated for over six weeks, Krikorian et al. [2010] compared a reduced carbohydrate diet to a high carbohydrate diet. The carbohydrate-restricted group had better verbal memory performance, which was positively linked with KBs levels.<sup>6</sup>

#### KETO DIET IN PARKINSONISM:

Parkinson's disease (PD) is a central nervous system illness that causes tremors and affects movement. It is the second most common neurodegenerative disease that affects almost 1% of individuals over 60 years of age. Despite the fact that many novel treatments for Parkinson's disease (PD) have been developed in recent decades, levodopa remains the most effective medication for motor symptoms. According to preliminary findings dietary adjustment may alter both motor and nonmotor symptoms in Parkinson's disease. In this ketogenic diet may also be used. In ketogenic diet Ketones themselves plays an important role in neuroprotection activity. Ketone bodies act on the nerve cells to protect them from degenerating, ketones provide an efficient energy source for neurons. In Parkinson's disease, the ketogenic diet improved motor function and increased nerve cell survival in the substantia nigra. Ketones may also have antioxidant activity and protect the body from oxidative damage. Oxidative damage to the substantia nigra is a crucial element in Parkinson's disease. This oxidative damage contributes to the degeneration of the nerves, which then leads to Parkinson's symptoms. Because ketones are antioxidants, they can help protect the brain and nerves from further oxidative damage. Since the ketogenic diet shows greater improvements in non-motor symptoms. Maintaining a low-fat or ketogenic diet for 8 weeks is feasible and safe for PD patients. Matthewc.l.philipset.al (2018) conducted a Pilot RCT, randomized 47 patients, of which 44 commenced the diets and 38 completed the study. One group taken low fat diet and another as keto diet. Part 1 (nonmotor daily living experiences) improved in both diet groups, but the ketogenic group improved even more; every single patient in the ketogenic group improved in Part 1, resulting in a significant 41 percent drop in baseline Part 1 scores over the 8-week diet intervention.<sup>7</sup>

#### KETOGENIC DIET IN OBESITY:

Obesity is a condition characterised by an excess of body fat that raises the risk of health complications.<sup>8</sup> Obesity is commonly caused by consuming more calories than are burnt via exercise and routine everyday activities. Obesity rates have tripled globally since the 1970s, and obesity is now a major underlying risk factor for chronic diseases such as type 2 diabetes mellitus (T2DM), cardiovascular disorders, metabolic syndromes, chronic renal disorders, and malignancies, resulting in increased morbidity and mortality. Dietary restriction, specifically caloric restriction, is recommended as the first nutritional change for weight loss in obesity treatment guidelines. Because fats contain the most calories among macronutrients, many patients begin with a low-fat diet that contains a relatively high amount of carbs. A ketogenic diet, on the other hand, is a high-fat, low-carbohydrate diet that restricts carbohydrate intake to 5% to 10% of total daily dietary requirements and replaces the rest with dietary fat and enough protein (1 gramme per kilogramme of body weight). Several elements appear to be involved in the weight-loss impact of the Very Low Carbohydrate Ketogenic Diet (VLCKD), including 1. Appetite suppression due to greater protein satiety, impact on appetite control hormones, and a putative direct appetite-suppressant effect of KBs. 2. Increased lipolysis and decreased lipogenesis. 3. An increase in metabolic efficiency while consuming lipids due to a decrease in the resting respiratory quotient. 4. Increased gluconeogenesis metabolic costs and thermic impact of proteins. Thus, in patients with overweight or obesity, the ketogenic diet was more helpful in improving weight control and metabolic parameters related to glycaemic and lipid regulation. A ketogenic diet can also help you lose weight by lowering your BMI and waist circumference.<sup>4</sup>

**KETOGENIC DIET IN DIABETES:**

Diabetes is a condition in which the blood glucose level, often known as blood sugar, is too high. In patients with type 2 diabetes, a ketogenic diet improved glycaemic indices and other metabolic markers. The ketogenic diet lowers insulin levels, which encourages lipid metabolism to shift away from synthesis and storage and toward breakdown and oxidation, resulting in nutritional ketosis, which mimics metabolic famine in the body and allows it to use ketone bodies as an alternative energy source. With the increased plasma ketones, there is decreased plasma glucose, decreased cerebral metabolic rate of glucose (CMRglc), and increased cerebral metabolic rate of

acetoacetate (CMRa). In obese patients with type 2 DM, high-ketogenic VLED (Very low energy diet) treatment lowers fasting, OGTT glycemia (Oral Glucose Tolerance Test) and improves glycaemic control. High-protein, low-carbohydrate KD reduces hunger, and lowers food intake. In overweight and obese individuals with type 2 diabetes, KD are significantly beneficial in improving glycaemic control (glycated haemoglobin), eliminating/reducing diabetic medications, increasing high-density lipoprotein-cholesterol (HDL-C), and causing weight loss over a 24-week period when compared to a low glycaemic index diet. Moreover, limiting both protein and carbohydrates in KD reverses diabetic nephropathy.<sup>4</sup>

**Table 3**

Year and site of the study	Sample description	Intervention and duration	Results
Westman et al. 2008 USA	84 obese and type 2 diabetic community volunteers 18-65 years with BMI: 27-50 kg/m <sup>2</sup>	Randomly assigned LCKD and LGID Nutritional supplements and exercise recommended 24 weeks 49 (58.3%) completed study	HbA1c, fasting glucose, fasting insulin, weight loss improved in both groups Significantly greater improvement among LCKD group in HbA1c (P=0.03), Body weight (P=0.008), HDL cholesterol (P<0.001) Reduced anti-diabetic drugs to 95.2% in LCKD group versus 62% in LGID group (P<0.01)
Dashti et al. 2007	64 healthy obese diabetic subjects	Study parameters determined before and at 8, 16, 24, 48 and 58 weeks after KD being administered	Significant reduction in body weight, BMI, blood glucose level, total cholesterol, LDL-cholesterol, triglycerides and urea from week 1-56 (P<0.0001), HDL-cholesterol increased significantly (P<0.0001), More significant results in subjects with hyperglycemia
Boden et al. 2005 University hospital	10 obese patients with type 2 DM	Inpatient comparison of 2 diets Usual diets for 7 days followed by KD for 14 days	KD resulted in significant Spontaneous reduction in energy intake Weight loss Improved 24-h blood glucose profiles, insulin sensitivity, and HbA1c Decreased plasma triglyceride and cholesterol levels
Yancy et al. 2005 Durham VAMC clinic, USA	21 type 2 diabetic overweight participants 3 white, 8 African-American Mean±SD age 56.0±7.9 years BMI 42.2±5.8 kg/m <sup>2</sup>	LCKD counseling Medication adjustment 16 weeks.	HbA1c decreased by 16%, Mean body weight decreased by 6.6%, Fasting serum triglyceride decreased 42%, Reduction in antihyperglycemic medications, Positive effect on waist measurement.
Gumbiner et al. 1996	13 obese patients with type 2 diabetes	7 patients treated with high-ketogenic VLED for 3 weeks, 6 patients treated with low-ketogenic VLED for 3 weeks, Patients crossed over and treated with alternate diet for another 3 weeks.	Fasting and OGTT glycemia were lower during treatment with high-ketogenic VLED (P<0.05) Strong correlation between basal HGO and fasting plasma ketone bodies (P<0.05), No significant difference in weight loss, fasting and OGTT plasma insulin and C-peptide concentrations.
VLED=Very low-energy diets, HGO=Hepatic glucose output, LCKD=Low carbohydrate ketogenic diet, KD=Ketogenic diet, LGID=Low-glycaemic, reduced calorie diet, HDL=High-density lipoprotein, OGTT=Oral glucose tolerance test, VAMC=Veterans Affairs Medical Centre, BMI=Body mass index, SD=Standard deviation, DM=Diabetes mellitus, LDL=Low-density lipoprotein, HbA1c=Glycosylated haemoglobin.			

**KETOGENIC DIET IN METABOLIC SYNDROME:**

Hyperglycemia, hyperinsulinemia, aberrant fatty acid metabolism, and atherogenic dyslipidaemia in MetS, as well as cardiovascular disorders, are all symptoms of insulin resistance in peripheral tissues. Lipolysis, lipoprotein assembly, and processing are all influenced by dietary carbohydrate. When compared to a low-fat diet, KD promotes decreased body weight, triglycerides, and diastolic blood pressure while increasing HDL-C and low-density lipoprotein-C over time (12 months or more). Lower levels of the mevalonate precursors acetoacetyl-CoA and 3-hydroxy-3-methylglutaryl-CoA in the liver correlate with decreased plasma cholesterol, mevalonate (a liver cholesterol synthesis biomarker), and lower levels of the mevalonate precursors acetoacetyl-CoA and 3-hydroxy-3-methylglutaryl-CoA. Increased BetaOHB supports a nonatherogenic lipid profile, improves cardiovascular risk markers, decreases blood pressure, and reduces insulin resistance while having no.

**KETOGENIC DIET IN POLYCYSTIC OVARY SYNDROME:**

Obesity, hyperinsulinemia, insulin resistance, and reproductive and metabolic consequences are all connected with polycystic ovarian syndrome (PCOS). Improvements in body weight, free testosterone percentage, luteinizing hormone/follicle-stimulating hormone ratio, and fasting insulin levels are all evidence of the metabolic and endocrine effects of low carbohydrate KD. It reduces androgen secretion while increasing sex-hormone binding globulin, increases insulin sensitivity, and restores endocrine function. In the treatment of PCOS patients with obesity and type 2 diabetes, such dietary intervention and lifestyle management has been shown to be effective. It has also been demonstrated to help these individuals with depressive symptoms, psychosocial issues, and health-related quality of life.<sup>11</sup>

**KETOGENIC DIET IN CANCER**

Cancer is most pressing medical challenges. The ketogenic diet, which consists of a high-fat, low-carbohydrate, and adequate-protein diet, was adopted. It inhibits phosphatidylinositol 3-kinase (PI3K) signalling in the brain by reducing fasting insulin levels. PI3K is involved in cancer growth as well as numerous genetic changes. A decrease in blood glucose levels is accompanied by a decrease in insulin and/or IGF levels. Tumours are caused by the stimulation of insulin and/or IGF receptor signalling pathways. The Warburg effect is well-known in cancer cells, which primarily use glucose. KD lowers blood glucose levels, which appears to be a contributing factor in cancer growth resistance. The ketogenic diet is a promising dietary intervention for improving metabolic abnormalities in cancer cells. The ketogenic diet significantly improves quality of life in some forms of advanced malignancies. With reduced nausea, exhaustion, and constipation, the current ketogenic diet regimen was more tolerable. It demonstrated steady adherence and generated functional ketosis with good repeatability in advanced cancer patients after chemotherapy, and it was carefully controlled. Dablela D. Weber et al. (2019) studied two juvenile patients with advanced-stage malignant astrocytoma in a single study. For 8 weeks, the diet was given either after or in addition to normal therapy. Both children had a 21.8 percent decrease in glucose uptake at the tumour site after eight weeks of KD, according to positron-emission tomography. One of the youngsters improved significantly in mood and skill learning and remained disease-free for twelve months after starting the KD. Both patients had good quality of life and were in remission for five and four years after diagnosis, respectively.<sup>11</sup>

**KETOGENIC DIET IN CNS MALIGNANCY:**

CNS tumours are life-threatening diagnoses, and existing treatments are inadequate. The CNS, unlike other tissues, is generally exclusively reliant on glucose for energy; however, when glucose is scarce,

ketones are metabolised as an alternative energy source, as well as serving as substrates for biosynthetic activities and serving as cell signalling molecules. The Warburg effect occurs more frequently in brain malignancies. A ketogenic diet may put cancer cells under metabolic stress, inhibiting or delaying cancer growth, because cancer cells are glucose-dependent. Patients with CNS tumours were able to follow a ketogenic diet. Cristina M. Panhans et al. (2020) performed a retrospective case series study and present the experience of 12 patients with CNS malignancies who used the ketogenic diet as part of their treatment. The ketogenic diet was generally well received, with eight patients opting to continue on their own with the diet or a low-carb, modified version of it after the 120-day research period was up. A qualitative examination of the patients' symptoms revealed significant variations in energy, mood, neurocognitive function, and general well-being. This could be owing to a direct effect of the ketogenic diet on physiology in some cases, or it could be attributable to the diet's enhanced tolerability of chemotherapy and radiation therapy in others.<sup>12</sup>

## CONCLUSION

A low-carb diet is referred to as a ketogenic diet. Epilepsy, Parkinson's disease, Alzheimer's disease, Obesity, Diabetes, metabolic syndrome, Poly cystic ovarian syndrome (PCOS), and cancer are among the diseases for which it may be highly beneficial.

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