



# KETOGENIC DIET FOR WEIGHT LOSS AND ITS IMPLICATION ON HEALTH

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## ABSTRACT

Progressively, obesity is rising and it has become a public health issue. In India, the rate of annual increase of adult obesity is at 5.2% and the rate of child obesity is at 9.1% so ketogenic diet is a strategy was done to overcome obesity as well health issues. The ketogenic diet defines as low carbohydrate diet, include high fat diet and offers much health benefits. Keto diet causes the body to break down fat into molecules called ketone. The reduction in carbohydrates lay down your body into a metabolic state called ketosis. This diet restricts the consumption of 50gram of carbohydrates per day. It is very effective in weight loss and give effect in 6 months. Keto diet have both beneficial effect as well as harmful effects This diet is not effective for anyone, thus people with chronic diseases should take guidance from dietitian or doctor. Studies show that it improves health and may even have benefits against diabetes, cancer, epilepsy and Alzheimer's diseases. The maintenance of very high ratio of fats to carbohydrates with a low total calorie intake for the diet to be successful.

**Index Terms:** ketogenic diet; carbohydrates; obesity; ketone; fats; proteins

## INTRODUCTION

Obesity has become world health issue which is keep on rising. keto diet is one kind of diet which predominantly used to overcome from the body weight. Obesity is the main root for increased risk for many serious diseases and health problem that include high blood pressure (hypertension). High LDL cholesterol, Low HDL cholesterol, or high level of triglycerides, coronary heart disease, stroke, diabetes mellitus. many efforts have been bringing off to overcome the obesity generality, one of them is keto diet therapy that refer to a low carbohydrate, high fat diet [1]. Aim is to force body to break down deposit fat into the energy source and largely used for weight loss in adults and the most common advantage of keto diet is for treating epilepsy, mostly in children [2]. The ketogenic diet shows linear growth within normal parameters concerning growth of children with in their first year of treatment [3]. Choosing a keto diet for management the health offers a range of valuable benefits. Study shows that keep to the nutritional ketosis leads to noteworthy improvement in weight loss and blood glucose control. The main reason for people with diabetes is the blood level. To follow a ketogenic diet is its ability to stabilise and lower the body sugar level [4]. During initially and maintenance phases of diet, the potential adverse effects can be avoided with careful attention [5]. The inclusion of low carbohydrate food in diet changes the metabolism of the body thus initiating fatty acid oxidation [6]. The keto diet has many possible benefits including potential weight loss, increased energy and treating chronic illness. Keto diet works as it changes the way of body uses food. Basically, have carbohydrate in diet provide most fuel to the body that needs as the energy. It gives the habit to body to burn fat for fuel instead. The keto diet consists of 70% to 80% fats, 5% to 10% carbohydrates and 10% to 20% proteins. This diet restricts the

consumption of 50 gram of carbohydrate per day to stay in ketosis. Usually, it will take two to four days to enter ketosis. This diet is acceptable to the public because it believes can lose weight quickly as well treat the disease arises due to overweight [7]. The result of adopting ketogenic diet is decrease in libido because the body would suffer from low carbohydrates probably causing symptoms of keto flu i.e. constipation, fatigue, nausea, headache. As the level of carbohydrates decrease during the keto diet, now the body will use ketones body for nutrition rather than glucose [8]. The Short term side effects of keto diet are Dehydration, Hypoglycaemia, Lethargy, Halitosis, Gastrointestinal side effects, Hyperuricemia [9]. Obese patients follow Ketogenic Diet to achieve significant weight loss but usually it does not last for more than few weeks. So it is required to keep regular check on the nutrition composition of diet during the follow up period. The restrictive nature of KD result in higher dropout rates during long intervals, which cause difficulties in maintaining diet, in case of extreme calories reduction diet plan [10].

## **BENEFITS OF KETOGENIC DIET**

### **1.POLYCYSTIC OVARY SYNDROME(PCOS)**

Polycystic ovary syndrome (PCOS) is indeed a common endocrine disorder in females, affecting around 6–10% of women. Its symptoms often include hyperandrogenism, ovulatory dysfunction, obesity, insulin resistance, and subfertility. Insulin resistance and hyperinsulinemia are prevalent features of PCOS, affecting approximately 65–70% of women with the condition. It's worth noting that insulin resistance is more commonly observed in obese patients, affecting 70–80% of them, compared to 20–25% of lean individuals with PCOS. Hyperinsulinemia can indeed interfere with the central actions of androgens by disrupting the inhibitory effect of progesterone on the gonadotropin-releasing hormone pulse generator. This disruption can lead to dysregulation of reproductive hormone levels and potentially contribute to conditions like polycystic ovary syndrome (PCOS) or other endocrine disorders. Interventions aimed at reducing insulin resistance and hyperinsulinemia, such as lifestyle modifications (exercise, diet, and weight loss) as well as pharmacological treatments like thiazolidinedione or metformin, are commonly recommended for managing PCOS. These interventions not only improve insulin sensitivity and reduce metabolic syndrome-related symptoms like obesity, glucose intolerance, and dyslipidaemia but also have beneficial effects on hyperandrogenism, ovulation, and other symptoms of PCOS. The chavarro study found that protein consumption also effects fertility. It is observed that animal protein negatively impact ovulation due to release of insulin and IGF1. Whereas, plant protein increases the fertility rate in women less than 32 years, which is still unidentified [11]. Therefore, strategies targeting insulin resistance and weight reduction can lead to significant improvements in the overall management of PCOS [12].

### **2. REDUCES SEIZURES**

A non-drug treatment, Ketogenic Diet had proven its efficacy in treatment of epilepsy in children especially in management of Drug Resistant Epilepsy. KD is highly effective and reduces the incidence of seizure by 50% in half of the patients [13]. When the body is forced to use for the fuel that need due to a small amount of carbs or sugar, ketones are construct. These ketones, which the brain can use as an alternative source of energy have an anti-epileptic effect on the brain. This can lead to improved seizure control [14].

### 3.LOWER INSULIN LEVEL

Study have shown that the keto diet is beneficial for reducing blood glucose [15]. Lower insulin levels usually, high card diet leads to the formation of high sugar that increase the insulin level so, on a ketogenic diet low carbohydrates leads the formation of low blood sugar that keep insulin levels lower [16].

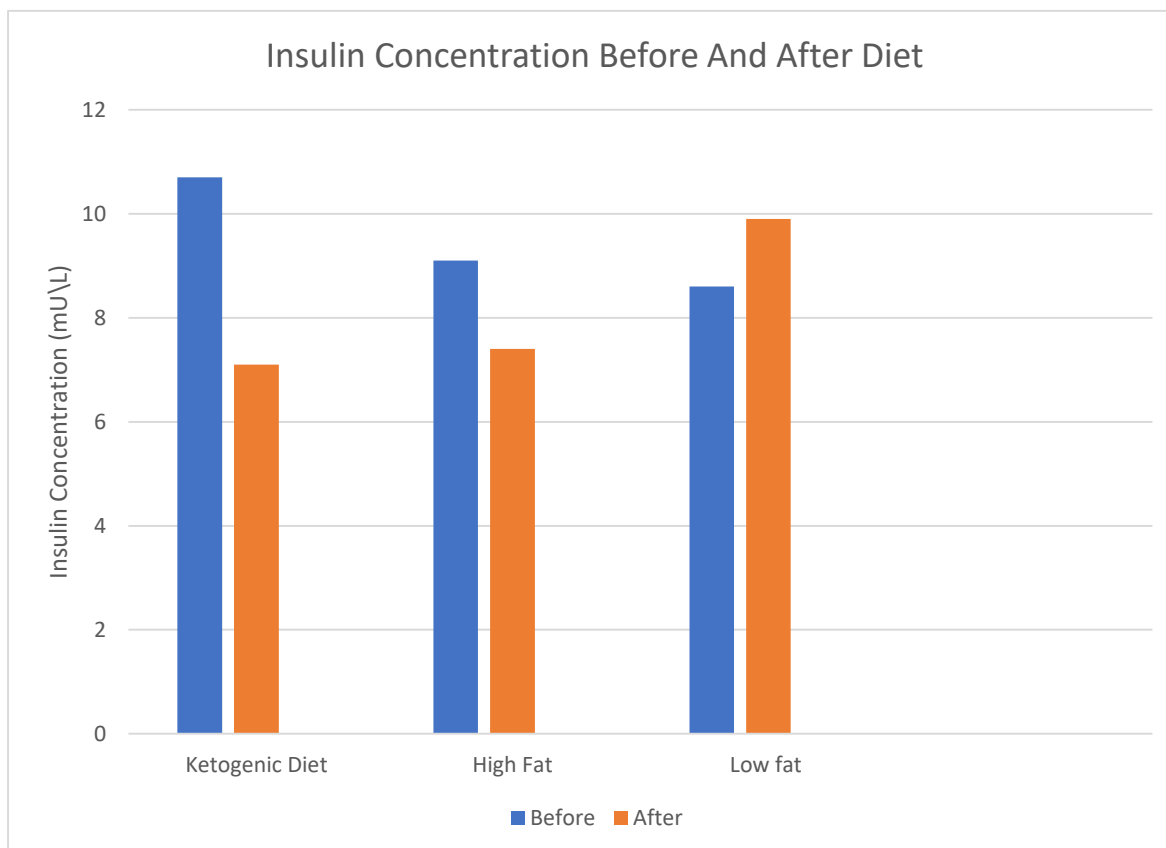


Figure 1. The Effects of the Keto Diet On Insulin.

### 4.REDUCE OBESITY AND WEIGHT MANAGEMENT

The intake of low carbohydrates of keto diet have been proposed as an appealing nutritional strategy for reducing obesity and weight management [17]. It gives the habit to body to burn fat for energy instead.

### 5.IMPROVE HEART DISEASE

Ketogenic Diet has shown effect on prevention and treatment of CVD. As, it has a beneficial effect on blood lipid profile, compared to other diet and also have strong anti-inflammatory and cardio protective potential. It eliminates simple sugar, restricts carbohydrates and supply of omega-3 fatty acids. The ketogenic diet has a beneficial effect on blood pressure and other CVD risk factors through weight loss [18]. The long term effects of Ketogenic Diet on various risk factors are not well established, its composition varies from one study to another. For instance, restricted carbohydrate diet might be either high in fat or protien and differ in their fatty acids and protein sources [19].

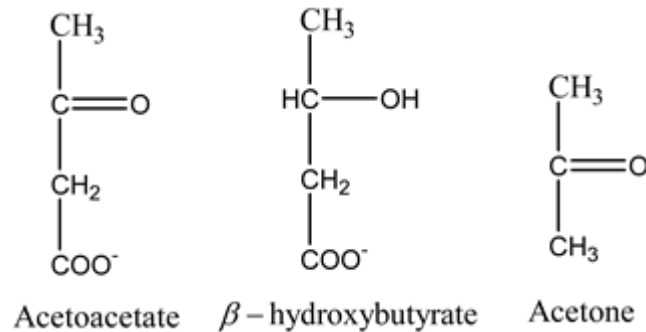
### 6.IMPROVES ACNE

Acne is indeed a chronic inflammatory condition of the pilosebaceous unit, which includes the hair follicles and oil glands (sebaceous glands). It typically results from various factors, including increased sebum (oil) production induced by androgens, abnormal keratinization (the process of skin cell shedding), inflammation, and colonization of hair follicles by Propionibacterium acnes bacteria. Acne lesions commonly appear on the face, neck, chest, and back due to the high density of pilosebaceous units in these areas. The production of ketone bodies during ketosis, a metabolic state induced by VLCKD, has been suggested to have anti-inflammatory effects. Consequently, it's hypothesized that VLCKD may reduce the exacerbation of clinical

manifestations of acne or even prevent the onset of acne by modulating inflammation. However, further research is needed to fully understand the impact of VLCKD on acne and its underlying mechanisms. [20].

## KETONE BODY METABOLISM

Ketone bodies are the product which are produced during breakdown of fatty acids. There are relatively main 3 ketones bodies, namely acetoacetate, acetone and  $\beta$ -hydroxybutyrate.



But mainly acetoacetate and acetone are true ketone bodies because  $\beta$ -hydroxybutyrate doesn't pass a keto group (C=O). They are water soluble. Oxidation of fatty acid occurs it produces large amount in acetyl CoA. In general, fatty acids is specifically oxidized in Krebs cycle.

Reaction carried out during metabolism of ketone bodies.

### STEP 1

Formation of Acetoacetate from  $\beta$ -Hydroxybutyrate

Firstly,  $\beta$ -Hydroxybutyrate is turning to Acetoacetate and get metabolise. By  $\beta$ -Hydroxybutyrate dehydrogenase enzyme (it is reversible of synthesis).

### STEP 2

Conversion of Acetoacetate to Acetoacetyl-CoA. In this step - Acetoacetate is turning to Acetoacetyl-CoA by the transfer of CoA molecule from succinyl CoA and this catalysation reaction occur through Succinyl CoA: Acetoacetate CoA transferase.

### STEP 3

Splitting into two molecules of Acetyl-coA by catalytic reaction occur by Thiolase enzyme.

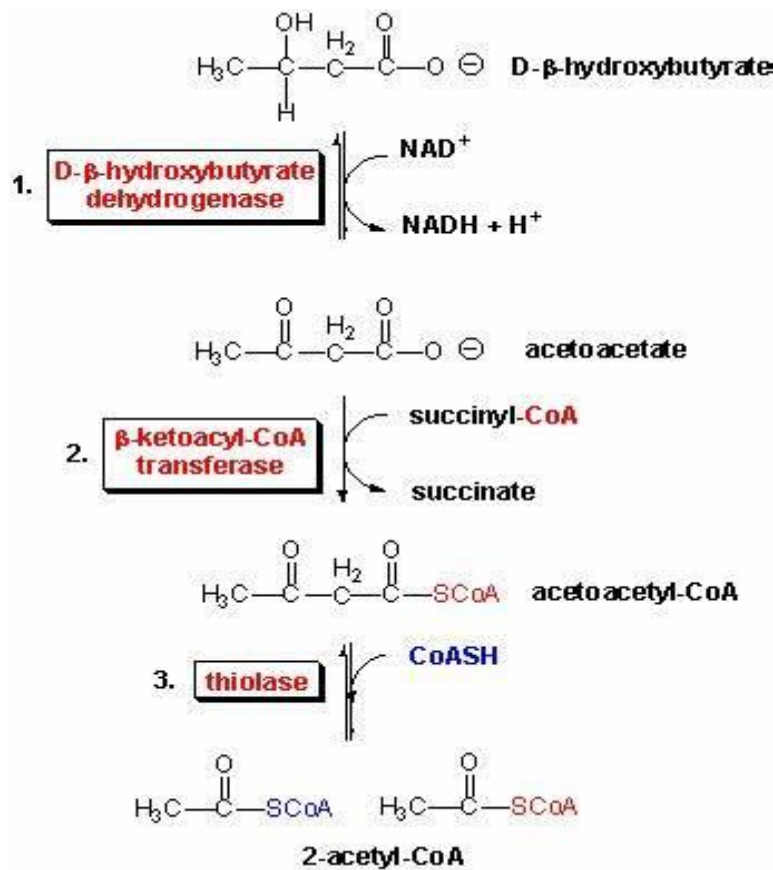


Figure-2: Metabolism of ketone bodies to acetyl CoA

## KETOGENESIS

Process of production of ketone bodies is relatively called. Organ which is capable of ketogenesis is liver and it occurs in mitochondria of liver cells (enzyme for synthesis of ketone bodies presents in mitochondria). Oxidation of fatty acids occurs in mitochondria which produce large amount of acetyl-CoA.

## SYNTHESIS OF KETONE BODIES

### STEP-1

Condensation of 2 moles of acetyl co-enzyme leads to formation of Acetocetyl COA. Which is carried out with the help of enzyme that is thiolase (enzyme involve in final step of β- oxidation).

### STEP-2

In this step acetocetyl COA again bind with one molecules of acetyl COA which leads to formation of HMG-COA.

### STEP-3

The HMG-COA is cleaved into acetoacetate and formed acetoacetate and acetyl COA. This step catalysed by HMG-COA lyase. In this step first ketone body is to be synthesized.

### STEP-4

Then other bodies are synthesized from acetoacetate then further acetoacetate undergoes decarboxylation reaction to give acetone then acetone is further produced by the decarboxylation of acetoacetate then other side formation of β-hydroxybutyrate is formed by enzymatic reduction that is β-hydroxybutyrate dehydrogenase.

During oxidation of fatty acids NAD/NAD<sup>+</sup> ratio becomes high. Therefore, most of the acetoacetate is reduced to β-hydroxybutyrate.

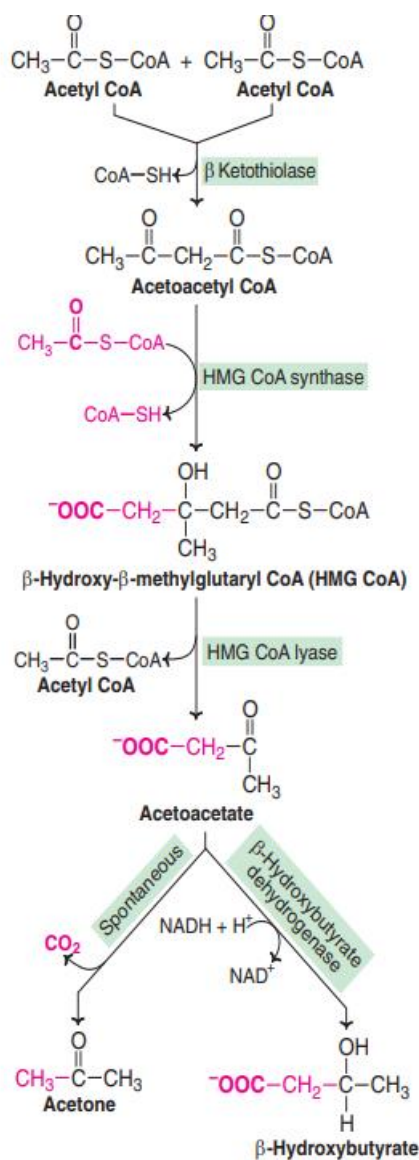


Fig.3: Synthesis of ketone bodies.

## UTILIZATION

- Ketone bodies are water soluble so they easily cross the cells of liver and then easily transportation occurs from liver to other tissues.
- Mostly the two ketone bodies pre dominant for the source of energy are acetoacetate or  $\beta$ -hydroxybutyrate for the peripheral tissues such as skeletal muscles, cardiac muscles, renal cortex etc.
- Ketone bodies are synthesized in liver but their utilization cannot take place in liver because in liver there is no presence of enzyme which is required for the utilization
- Therefore, utilization of ketone bodies take place other than liver.
- Utilization not occur in the tissue which is lack of mitochondria (example- ERYTHROCYTES)
- During starvation and diabetes mellitus there is a supply of glucose take place to the tissues so the utilization and production become more significant.
- When there is low availability of carbohydrate then, ketone bodies are released into the blood by liver then they are used as fuel by extrahepatic tissues.
- During long time starvation the main fuel source for the brain are ketone bodies [21] [22].

## KETOGENIC DIET FOR WEIGHT LOSS

The most commonly accepted dietary strategy for managing weight loss typically focuses on a balanced approach rather than high carbohydrates and low fat content. It often involves:

Balanced Macronutrients: Emphasizing a balanced intake of carbohydrates, proteins, and healthy fats to help stabilize blood sugar levels and support overall health.

**Complex Carbohydrates:** Prioritizing complex carbohydrates with a low glycaemic index (GI), such as whole grains, legumes, fruits, and vegetables, to minimize blood sugar spikes and insulin resistance.

**Healthy Fats:** Including sources of healthy fats, such as avocados, nuts, seeds, and olive oil, which can help with satiety and hormone regulation.

**Lean Proteins:** Incorporating lean protein sources, such as poultry, fish, tofu, and legumes, to support muscle mass and regulate appetite.

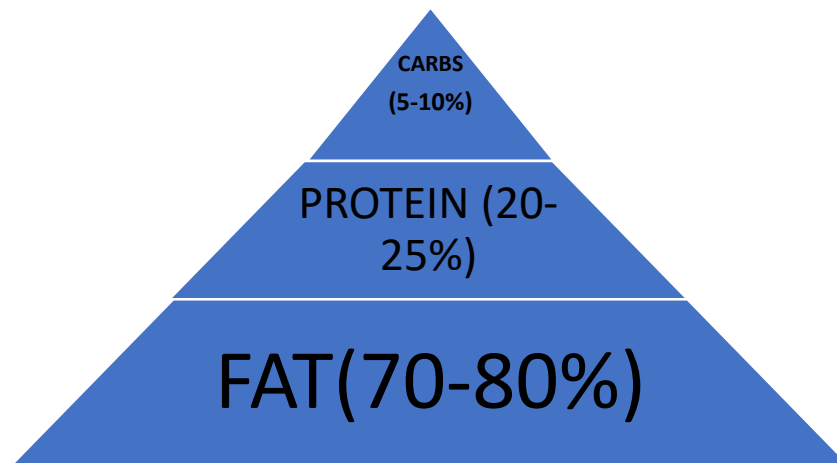
**Moderation:** Moderating intake of processed foods, sugary snacks, and refined carbohydrates, which can exacerbate insulin resistance and contribute to weight gain.

This balanced approach aims to support overall health, manage insulin resistance, and promote weight management [23].

Important thing is during ketosis avoid food that contains high carbohydrates such as potatoes, sugar, white rice, beer, bread etc.

## A KETO DIET

(What can eat)



### STAGE 1

It is very necessary to prepare a beneficial keto diet plan before proceeding. Aim is to start burning body fat faster than ever.

### STAGE 2

It will take a few days to body where it will compel the body into the ketosis process. change will appear as the body adapts the keto diet.

### STAGE 3

And at this stage, the body needs to take a more balanced meal that contains macronutrients. The body is already in the ketosis process and will reduce the weight.

### STAGE 4

As you will keep to the balanced diet with needed macronutrients, will get a point where you will spot significant results in body and body get used to the diet and feel more motivated. An advantageous metabolic change happens in the body in a short stretch of time [24].

Assemble a balanced and healthy diet plan.

### EATING PLATE

HEALTHY OILS	WHOLE GRAINS
VEGETABLES	WATER
HEALTHY PROTEIN	STAY ACTIVE

### Build A Healthy and Balanced Diet

- The plate should have half of the vegetables and remember to keep away from the potatoes because they don't count in vegetables and have a negative result in blood sugar.
- 1/4 of your plate should be whole grains that could be oats, Brown rice, Barley and their derivatives [25].
- 1/4 of the plate should be protein, for vegetarian protein sources can be chickpeas are a versatile plant-based protein containing about 7.3 grams of protein in one half of a cup and low- calorie, Peas contain 7.9 grams of protein in one cup, Beans contain 28 grams of protein in two cups, Lentils each cup contain 18 grams of protein [26], Tofu contain 8.1-gram protein in 100gram portion of tofu [27].
- For vegetarian such as Egg whites contain 11 grams of protein, cold fillet contains 17 grams of protein and avoid meat such as bacon and sausage.
- Choose a healthy and fresh plant oil like sunflower oil, olive oil, soya oil and avoid hydrogenated oil that can be unhealthy for health.
- Drinking water while staying hydrated is the best as it improves the physical performance, constipation and more. Avoid sugar containing drinks.
- Stay active as it improves physical as well as brain health, manages the weight and reduces the risk of disease [28].
- Dietary Habit is one of the main adjustable lifestyle factors for the prevention of age-related diseases [29].

### One-Week Keto Diet Plan

<b>MONDAY</b>	<ul style="list-style-type: none"> <li>• BREAKFAST: Two eggs with sauteed greens and smashed avocado</li> <li>• LUNCH: A bun less grass-fed burger topped with cheese and mushrooms</li> <li>• DINNER: Pork chops with green beans sauteed in coconut oil.</li> </ul>
<b>TUESDAY</b>	<ul style="list-style-type: none"> <li>• BREAKFAST: Mushroom omelette.</li> <li>• LUNCH: Tuna salad and tomato atop a bed of greens.</li> <li>• DINNER: Roast chicken with cream sauce and sauteed broccoli.</li> </ul>
<b>WEDNESDAY</b>	<ul style="list-style-type: none"> <li>• BREAKFAST: sweet pepper stuffed with cheese and eggs.</li> <li>• LUNCH: Arugula salad with turkey, avocado, broccoli and blue cheese.</li> <li>• DINNER: mushroom, grilled salmon with spinach sauteed in coconut oil.</li> </ul>
<b>THURSDAY</b>	<ul style="list-style-type: none"> <li>• BREAKFAST: Strawberry smoothie</li> <li>• LUNCH: Steak bowl with cauliflower rice, cheese, herbs, avocado and blue cheese.</li> <li>• DINNER: Bison steak with cheesy broccoli.</li> </ul>



<b>FRIDAY</b>	<ul style="list-style-type: none"> <li>• BREAKFAST: Baked avocado egg boats.</li> <li>• LUNCH: chicken and creamy mushroom sauce</li> <li>• DINNER: Pork chops with vegetables.</li> </ul>
<b>SATURDAY</b>	<ul style="list-style-type: none"> <li>• BREAKFAST: Cauliflower toast topped with cheese and avocado.</li> <li>• LUNCH: Bun less salmon burgers</li> <li>• DINNER: Meatballs with zucchini noodles and parmesan cheese.</li> </ul>
<b>SUNDAY</b>	<ul style="list-style-type: none"> <li>• BREAKFAST: Coconut milk chia pudding</li> <li>• LUNCH: Cobb salad made with greens, eggs.</li> <li>• DINNER: Coconut chicken curry[30].</li> </ul>

## CONCLUSION

Although, keto diet is mostly liked and patient show great interest because the data showing impressively short-term weight loss, help in type 2 diabetes where it reduces the glucose level and also helps in improving heart disease, lower blood pressure and tachycardia that cause obesity. Ketogenic diet is considered as a safe treatment of intractable seizures. It is also considered as an effective therapeutic diet but implementing the diet incorrectly can cause serious health consequences so it must be important to concerned a proper keto diet plan. Get into a balanced keto plan can lose more weight quickly and overall health benefits. Patient with hyper triglycerides, acute pancreas, and hypercholesterolemia concerned with doctor before taking ketogenic diet. This diet is more effective and being used in adolescents and adults but tough to manage in older age groups. Therefore, this diet needs to be understood and get knowledge about it before being applied.

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