

Ketogenic diet for weight loss

Chronic non-communicable diseases are increasing in recent years.^[1] Obesity is a rapidly growing endemic disease and poses a major health problem.^[2] A recent study has reported that globally, more than 1.9 billion adults are overweight, and 650 million people are obese.^[2] Approximately 2.8 million deaths occur as a result of being overweight or obese.^[2] Diet is the cornerstone of any lifestyle intervention programme. Optimisation of nutrition is one of the foremost strategies and a desirable target to be achieved in combating obesity. Studies have shown that a diet with carbohydrate restriction has resulted in marked weight loss.^[3] Among diets promoted for various health problems, the ketogenic diet (KD) has a long history. The term KD was coined by Wilder in 1921 who proposed its first use in epilepsy.^[4] KD, which is a low-carbohydrate diet, has been tried for weight loss in obesity and has shown greater weight loss when compared to another dietary regimen.^[5] KD limits carbohydrate intake, with high-fat levels replacing the lost calories while maintaining a normal protein intake.^[1] It comprises around 80% fat, 15% protein and 5% carbohydrates.^[1] There are various types of KD. The standard KD (SKD) is a very low carbohydrate with moderate-protein and high-fat diet, consisting of 70% fat, 20% protein and 10% carbohydrates.^[6] The cyclical KD includes periods of higher carbohydrates in between the KD cycles, for example, 5 ketogenic days followed by two high-carbohydrate days as a cycle.^[6] The targeted KD allows additional carbohydrates around the periods of the intensive physical workout, mostly used by athletes and bodybuilders.^[6] The high-protein KD comprises more protein when compared to SKD, and the ratio is 60% fat, 35% protein and 5% carbohydrates.^[6] Fat in most of the KDs is provided in the form of long-chain triglycerides (LCTs), e.g., meat, fish, dairy products and eggs.^[7] Some KDs incorporate medium-chain triglycerides (MCTs) instead of LCT. MCTs are more ketogenic and accessible to the liver than LCTs and can be used to generate more ketone bodies (KBs).^[8] Furthermore, an MCT-based KD is more palatable than LCT-based KD and just as effective as the traditional KD.^[8] The main goal of a KD is to create a state of ketosis.^[1] Ketosis is the process of KB generation and accumulation as a result of an excessive breakdown of fat due to inadequate carbohydrate availability.^[9] Thus, the body shifts from using glucose as the main source of fuel to using KBs.^[1] Glucose and fatty acids are broken down to acetyl-coenzyme A (CoA) (a product of the incomplete

breakdown of free fatty acids in the liver) to enter the citric acid cycle by combining with oxaloacetate (pyruvate being precursor).^[5] Due to low carbohydrates in KD, glycolysis fails and oxaloacetate is not available to combine with acetyl-CoA produced by fatty acid metabolism.^[5] This results in shunting of acetyl-CoA to ketogenesis and results in the production of ketones.^[10] KBs synthesised in the body are β -hydroxybutyrate, acetoacetate and acetone.^[1] They can pass through the blood–brain barrier and can be used as an alternative source of fuel for the brain and other tissues.^[1] Erythrocytes do not have mitochondria and cannot utilise KB.^[11] Liver lacks in the enzyme thiophorase and hence does not utilise KB.^[11] The possible mechanisms for greater weight loss may be decreased appetite due to higher satiety effect of proteins, due to direct appetite suppressant action of KB and also due to changes in circulating the level of various hormones, such as ghrelin and leptin which control appetite.^[12,13] Hence, KD decreases overall energy intake and results in weight loss.^[5] Other mechanisms put forwarded are reduced lipogenesis, increased lipolysis, decreased insulin secretion and the thermic effect of proteins.^[3,14] Ketosis is the most reliable marker of fat loss.^[6] The process of ketosis is a completely physiological mechanism.^[6] It was differentiated from pathological ketoacidosis seen in type 1 diabetes by Sir Hans Krebs.^[15] In physiological ketosis as seen with intake of KD, serum KB levels rarely exceed 7–8 mmol/L as the brain efficiently uses these ketones and also there is no lowering of blood pH.^[16] However, in diabetic ketoacidosis, it can exceed 20 mmol/L and results in lowering of the pH.^[16] Besides weight loss, studies have also shown that low-carbohydrate KDs also reduce serum triglycerides and blood glucose levels and thereby reducing risk factors for various chronic diseases.^[17] However, there are also various short-term and long-term adverse effects of KDs. These include headache, muscle cramps, backache, bad breath, changes in bowel habits and keto-flu.^[5,6] Other side effects observed are dyslipidaemia, hypoproteinaemia, mineral deficiencies, metabolic acidosis and increased risk of renal stones.^[5] People on a KD initially experience rapid weight loss up to 4.5 KG in 2 weeks or less due to diuretic effects.^[18] The early weight loss is due to water weight loss.^[18] Long-term compliance is poor and can be a major concern.^[18] Long-term KD causes glucose intolerance due to insufficient insulin secretion, insulin resistance and reduced beta and alpha cell mass.^[19] People with diabetes mellitus

taking insulin or oral hypoglycaemic agents can suffer severe hypoglycaemia if the diet is not properly timed.^[18] KD is contraindicated in patients with pancreatitis, liver failure, disorders of fat metabolism, primary carnitine deficiency, carnitine palmitoyltransferase deficiency, carnitine translocase deficiency, porphyria or pyruvate kinase deficiency.^[18] Diet tolerance can be improved by increasing the frequency of meal.^[20] Supplements of calcium, selenium, zinc, Vitamin D and oral alkalis may be used to overcome nutritional deficiencies and kidney stones.^[21] Gastrointestinal dysmotility and gastro-oesophageal reflux can be overcome using proton pump inhibitors.^[20] KD may be considered for effective weight loss, but the effect is usually limited in time and may also be associated with adverse effects.

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Conflicts of interest

There are no conflicts of interest.

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