



Special Article



Effects of Low-Carbohydrate, High-Fat Diets on Weight Loss, Cardiovascular Health and Mortality

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Conflict of Interest

The author has no financial conflicts of
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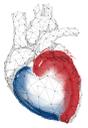
ABSTRACT

Obesity is a worldwide health challenge. The clinical consequences of obesity include nonalcoholic fatty liver disease, type 2 diabetes, and coronary heart disease. Numerous diets have been developed to reduce the incidence of cardiovascular diseases and induce weight loss. Low-carbohydrate, high-fat diets (LCHFDS) have become increasingly popular for weight loss. LCHFDS have led to weight loss in some clinical studies. However, the safety of LCHFDS and their long-term effects on the human body are still controversial. In this review, I will discuss the effects of LCHFDS on weight loss, cardiovascular health, and mortality.

Keywords: Carbohydrate-restricted diet; High-fat diet; Weight loss; Cardiovascular diseases; Mortality

INTRODUCTION

In Korea, the prevalence of obesity and abdominal obesity steadily increased from 2009 to 2015.¹ In 2015, the prevalence of obesity and abdominal obesity was 32.4% and 20.8%, respectively.¹ The clinical consequences of obesity include nonalcoholic fatty liver disease,² type 2 diabetes,³⁻⁵ and coronary heart disease.⁶ Obesity is associated with increased all-cause mortality.⁷⁻⁹ Numerous diets have been developed to reduce the incidence of cardiovascular diseases and induce weight loss.¹⁰ Low-carbohydrate, high-fat diets (LCHFDS) have become increasingly popular for weight loss. LCHFDS have led to weight loss in some clinical studies.¹¹ However, the safety of LCHFDS and their long-term effects on the human body are still controversial. There is concern about the potentially negative effect of these diets on blood lipid levels and the risk of cardiovascular diseases.¹² Recent studies that evaluated the effects of LCHFDS on cardiovascular disease risk factors have yielded mixed results, with some studies reporting that LCHFDS have favorable effects on cardiovascular risk factors,^{13,14} while others reported that LCHFDS have adverse effects in both animals¹⁵ and humans.^{15,16} In this review, we will discuss the effects of LCHFDS on weight loss, cardiovascular health, and mortality.

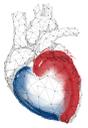


EFFECTS ON WEIGHT LOSS

Despite the controversy surrounding LCHFDS, they are still popular today. One popular LCHFD is Dr. Atkins' Diet Revolution, which was published in 1972.¹⁷⁾ Users of LCHFDS experience weight loss during the initial short-term. In a randomized trial, LCHFDS caused a greater weight loss than conventional diets during the first six months; however, the differences were not significant after one year.¹¹⁾ Several randomized trials have shown that low-carbohydrate diets cause a greater short-term (6 months) weight loss than low-fat, calorie-restricted diets.¹¹⁾¹⁴⁾¹⁸⁻²⁰⁾ The results vary over the long-term (1–2 years) trials. Some studies reported greater weight loss when low-carbohydrate diets were used than when low-fat diets were used,¹⁴⁾²¹⁾ while others found no difference between the two diets.¹¹⁾²²⁾²³⁾ Common limitations of dietary trials include poor adherence and high attrition rates (15–50%).²⁴⁾²⁵⁾ The restriction of carbohydrate intake reduces total caloric intake. However, in animal studies, the effect of diets on weight change can be investigated in the absence of confounding factors including unequal energy intake. In obese rats, very low-carbohydrate diets decreased body fat loss and insulin sensitivity compared to isocaloric, high-carbohydrate diets.²⁶⁾²⁷⁾ In one animal study, the high fat group (45%) lost less body weight and adipose depot weight than the low fat group (12%).²⁸⁾ The reason for the weight loss during the initial short-term after using LCHFDS is that the total food intake is reduced due to early satiety.²⁹⁻³¹⁾ LCHFDS contain a high proportion of protein. High protein diets induce satiety. Mechanisms that may contribute to high protein diet-induced satiety include an increase in the concentration of 'satiety' hormones (Cholecystokinin, PYY, Glucagon-like peptide-1), concentration of amino acids, energy expenditure, and process of gluconeogenesis.³¹⁾ Insulin activates key enzymes in pathways that derive energy from carbohydrates, and when dietary carbohydrate is low, the resulting decrease in insulin concentration leads to a reduction in lipogenesis and an increase in lipolysis.³²⁾ When the intake of LCHFDS is prolonged, the central nervous system is forced to use alternative energy sources.³³⁾ This condition leads to the production of ketone bodies (acetoacetate, β -hydroxybutyric acid, and acetone) by the liver.³³⁾ LCHFDS are effective for short-term, but not long-term, weight loss. This occurs due to several mechanisms.

EFFECTS ON CARDIOVASCULAR HEALTH

The use of LCHFDS is one of the most popular alternative weight loss approaches. LCHFDS have received considerable attention in recent years particularly due to their beneficial effects on cardiovascular risk factors in obese individuals.³⁴⁾ LCHFDS cause a large proportion of energy to be derived from protein and fat, and there is concern about the potentially detrimental effect of these diets on the risk of cardiovascular diseases. Data on the long-term effects of LCHFDS are sparse. In a prospective cohort study, low-carbohydrate diets high in animal sources of fat and protein were associated with higher all-cause and cardiovascular mortality post-myocardial infarction.¹⁶⁾ LCHFDS can be high in red meat, low in vegetables, and high in whole grains, which have been shown to increase the risk of chronic diseases.³⁵⁾³⁶⁾ On the other hand, a low-calorie, low-carbohydrate diet with high amounts of plant protein has been shown to improve low-density lipoprotein (LDL) levels compared to a high-carbohydrate diet.³⁷⁾ Depending on whether the protein and fat are derived from animals or vegetables, the effect on the cardiovascular risk factors may be different. In a meta-analysis of randomized controlled trials, even though low-carbohydrate diets were associated with unfavorable changes in total cholesterol and LDL-cholesterol



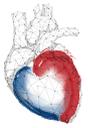
levels, they were associated with favorable changes in triglyceride and probably high-density lipoprotein (HDL)-cholesterol levels.²⁴ In several studies, LCHFDS reduced glycemic load and risk of type 2 diabetes.³⁸⁻⁴⁰ However, a recent study suggested that LCHFDS could even have negative effects on glucose metabolism in healthy men.⁴¹ In an animal study, rats fed LCHFDS exhibited insulin resistance and impaired glucose tolerance.⁴² Garbow et al.⁴³ reported the development of glucose intolerance with no effect on insulin sensitivity in mice fed LCHFDS for 12 weeks. Thus, it remains unclear whether LCHFDS are beneficial for glucose and insulin metabolism in humans and animals. In terms of reducing blood pressure, LCHFDS is not superior to the low-fat diet.¹¹⁾⁴⁴⁻⁴⁶ In animal studies, LCHFDS affect myocardial energy substrate levels and insulin signaling, and increase myocardial injury following ischemia-reperfusion in the isolated heart. Moreover, the impaired recovery of function after ischemia-reperfusion in LCHFDS is due to intrinsic effects of diet on myocardial properties.⁴⁷⁾⁴⁸ In obese rats, LCHFDS cause the derangement of mitochondrial biogenesis and suppress cardiac expression of endogenous antioxidants after myocardial ischemia and reperfusion.⁴⁹ A recent study suggested that LCHFDS are associated with poor small artery vascular reactivity in patients with increased cardiovascular risk.⁵⁰ Several animal studies showed favorable effects of LCHFDS on cardiovascular risk. In an animal study, LCHFDS reduced blood pressure and improved arterial function in spontaneously hypertensive rats.⁵¹ The effects of LCHFDS on cardiovascular health are inconsistent in several studies. Therefore, currently, LCHFDS are not recommended for the prevention of cardiovascular diseases.

EFFECTS ON MORTALITY

Data on the long-term association between LCHFDS and mortality are sparse. Randomized trials to investigate the effects of LCHFDS on mortality are not feasible because of the difficulty in maintaining compliance and follow-up for several years. In a systematic review and meta-analysis of observational studies, low-carbohydrate diets were associated with a significantly higher risk of all-cause mortality; however, they were not significantly associated with a risk of cardiovascular mortality.⁵² Low-carbohydrate diets may be linked to an array of chronic health problems. Two studies involving European cohorts reported that a low-carbohydrate, high-protein diet was associated with, a weak but statistically significant, high mortality.⁵³⁾⁵⁴ Recently, the association between low-carbohydrate diets and mortality was reported in a study. In the aforementioned prospective cohort study, a low-carbohydrate diet based on animal products was associated with a higher all-cause mortality in both men and women, whereas a vegetable-based low-carbohydrate diet was associated with lower all-cause and cardiovascular disease mortality rates.⁵⁵ Low-carbohydrate diets may contain variable amounts of plant or animal fat. This may explain why low-carbohydrate diet's effect on lipid profile has a variety of results.²⁴ The association between the intake of red and processed meats and risk of colorectal cancer is well established.⁵⁶ Additionally, red meat has been associated with higher risk of lung cancer in a prospective study.⁵⁷

CONCLUSION

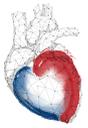
Even though LCHFDS are more likely to induce a loss of body weight in the short-term than traditional low-fat diets, they have little effect on long-term weight loss or weight maintenance. While there is a clear effect of LCHFDS on triglyceride and HDL cholesterol levels during lipid metabolism, they have no or a negative effect on the total cholesterol and LDL cholesterol levels



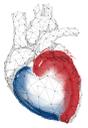
compared to low-fat diets. The hypoglycemic effect of LCHFDS may be beneficial; however, this has not been confirmed. LCHFD does not affect blood pressure control. LCHFDS have been reported to increase mortality. Therefore, LCHFDS should not be recommended.

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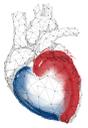
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