



VIEWPOINT

The low-carbohydrate diet and cardiovascular risk factors: Evidence from epidemiologic studies



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KEYWORDS

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Abstract *Aims:* Obesity is an important public health issue because of its high prevalence and concomitant increase in risk of cardiovascular diseases. Low carbohydrate diets are popular for weight loss and weight management but are not recommended in leading guidelines due to the perception that increases in dietary fat intake may lead to an adverse cardiovascular risk profile. To clarify the effects of a low-carbohydrate diet for weight loss on cardiovascular disease risk factors as compared to a low fat diet for weight loss, we systematically reviewed data from randomized controlled clinical trials and large observational studies.

Data synthesis: We searched the MEDLINE database (Jan 1966–Nov 2013) to identify studies that examined a low-carbohydrate diet as compared to a low-fat diet for weight loss or the improvement of cardiovascular disease risk factors.

Conclusions: Recent randomized controlled trials document that low-carbohydrate diets not only decrease body weight but also improve cardiovascular risk factors. In light of this evidence from randomized controlled trials, dietary guidelines should be re-visited advocating a healthy low carbohydrate dietary pattern as an alternative dietary strategy for the prevention of obesity and cardiovascular disease risk factors.

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Introduction

Obesity is an important public health issue. In 2005, there were roughly 937 million overweight and 396 million obese people in the world, and the high prevalence is still projected to increase [1]. Further, obesity is a well-known risk factor for cardiovascular disease, type-2 diabetes and metabolic syndrome, and recently recognized as a disease by the American Medical Association. Therefore, the spread of obesity requires an intensive and effective intervention.

There has been increasing interest in the low-carbohydrate diet for weight loss and weight management. Nevertheless, the low-carbohydrate diet has never been recommended in leading guidelines because there is the perception that a low-carbohydrate diet will have adverse effects on cardiovascular disease risk factors, mostly due to the idea that saturated fats will be increased on a low-carbohydrate diet as compared to other weight-loss regimens [2–4]. Several professional organizations, such as the American Dietetic Association, have even cautioned against the use of a low-carbohydrate diet [5]. However, recent randomized controlled trials document that low-carbohydrate diets not only decrease body weight but also improve cardiovascular risk factors [6–9]. Since lowering the quantity of carbohydrate intake decreases total energy intake which is related to obesity [10], it remains unknown whether the cardiovascular effects of

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a low-carbohydrate diet are results of the decrease in dietary carbohydrates or total energy intake. To clarify this issue, we systematically reviewed data from randomized controlled clinical trials that examined the effects of low-carbohydrate diets as compared to an isocaloric low-fat diet for weight loss. We also reviewed data from large observational cohort studies to assess long-term associations of low carbohydrate diets with cardiovascular events, including specific food choices which may be included as a part of a low-carbohydrate dietary intervention and their potential influence on cardiovascular health.

Low-carbohydrate diets and cardiovascular risk factors: evidence from randomized controlled trials

We used the MEDLINE online database (Jan 1966–Nov 2013) to identify studies that examined the low-carbohydrate diet as compared to the low-fat diet. The following key words or medical subject headings in MEDLINE were used: (“low-carbohydrate diet”, “carbohydrate restriction”, “carbohydrate”, “fiber”, “body mass index”, “waist circumference”, “fat mass”, “obesity”, “diabetes”, “insulin resistance”, “blood glucose”, “hypertension”, “HDL”, “LDL”, “triglycerides”, “cholesterol”, “lipids”, “dyslipidemias”, “blood pressure”, “adipocytokines”, “inflammatory cytokines”, “C-reactive protein”, “heart diseases”, “cardiovascular diseases”, and “seizure”).

In this systematic literature review, we included randomized controlled trials conducted in adults, which compared a low-carbohydrate diet ($\leq 45\%$ of energy from carbohydrates) with a low-fat diet ($\leq 30\%$ of energy from fat) over an intervention duration of at least 6 months and reported cardiovascular risk factors as outcomes [11–13]. Thus we include both ketogenic and non-ketogenic low-carbohydrate diets in this review.

Body weight, body composition, and waist circumference

Randomized controlled trials have consistently shown that low-carbohydrate diets reduce body weight, with mean reductions ranging from 2.1 to 14.3 kg over at least 6 months of intervention [6,8,9,14–21]. The body weight reduction may not differ by level of carbohydrate restriction. A study comparing ketogenic diets with non-ketogenic low-carbohydrate diets demonstrated that their efficacy at reducing body weight was equivalent over a 4-week intervention period [22], but long-term comparison has not been conducted. Moreover, both fat mass and lean mass were decreased but fat mass comprises the majority of weight lost on low-carbohydrate diets [14,15,17,18,20].

Compared to a low-fat diet, an isocaloric low-carbohydrate diet is at least as effective at reducing body weight. A 2006 meta-analysis including 5 randomized controlled trials showed that low-carbohydrate diets resulted in significantly more reduction in body weight than isocaloric low-fat diets at 6 months (net changes -3.3 kg, 95%CI: -5.3 to -1.4), but non-significantly more reduction at 12 months (net changes: -1.0 kg, 95%CI: -3.5

to 1.5) [23]. Those on low-carbohydrate diets experienced a similar reduction in fat mass and non-fat mass as those on low-fat diets, so that the changes in body composition were not significantly different between the two diets [9,14,15,17,18,20].

Low-carbohydrate diets may have the added benefit of decreasing the risk of central obesity. Brinkworth and colleagues reported that a low-carbohydrate diet decreased abdominal fat mass by approximately 30% as assessed using dual-energy X-ray absorptiometry scanning over a one-year intervention period compared to an isocaloric low fat diet [15]. While dual-energy X-ray absorptiometry scanning provides highly specific information on the anatomic location of fat, waist circumference is a much more commonly used measure of central obesity. Decreases in waist circumference on low-carbohydrate diets have ranged from 2.2 to 9.5 cm across studies and are comparable or greater than those seen on low fat diets [8,16,18].

Glucose, insulin, and HOMA

Most published randomized controlled trials also show that low-carbohydrate diets decrease fasting levels of blood glucose [9,14–16,18,21], HbA1c [18,19,24,25], serum insulin and/or HOMA [9,14–16,21] to a similar extent as seen on isocaloric low-fat diets. Moreover, reductions in insulin resistance do not appear to be different between ketogenic and non-ketogenic low-carbohydrate diets [22].

Lipids

Despite widely held beliefs, with the exception of a few studies, most randomized controlled trials have shown that low-carbohydrate diets increase HDL cholesterol and decrease total and LDL cholesterol [6,8,9,14–21]. Results from a 2006 meta-analysis did, however, show a greater increase in HDL (net change 3.1 mg/dL, 95%CI: -0.8 to 7.0) and a lesser reduction in total cholesterol (net change 10.1 mg/dL, 95%CI: 3.5 to 10.2) and LDL cholesterol (net changes 7.7 mg/dL, 95%CI: 1.9 to 13.9) on low-carbohydrate diets as compared to low-fat diets [23]. In addition, the ratio of total to HDL cholesterol decreased among those on low-carbohydrate diets, and this decrease was not significantly different from those seen on isocaloric low-fat diets in most trials [16,17,20,21] except for one study showing a greater decrease on the low-carbohydrate diet [8]. Moreover, studies consistently reported that the low-carbohydrate diet reduced triglycerides, and to a greater extent than the isocaloric low-fat diet (net change -31.0 mg/dL, 95%CI: -59.3 to -2.7) [6,8,9,14–21].

Despite fears of more atherogenic lipid profiles on low carbohydrate diets as compared to low-fat diets for weight loss, in general, the low-carbohydrate diet itself improved lipids profiles including total cholesterol, LDL cholesterol, HDL cholesterol, total/HDL ratio, and triglycerides. In fact, both low carbohydrate and low fat diets appeared to improve the lipids profiles, without strong evidence that either one was better.

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