Review Article

Carbohydrates: Villain behind Cardiovascular Disease?

Karunadas Chakkalakal Prabhakaran, MD, DNB, DM, FESC

Additional Professor of Cardiology Government Medical College, Thrissur, Kerala

Abstract

Diet is known to be linked to health and diseases; over-eating and under-eating are both harmful. Over the years, our dietary pattern has changed. There are implications that excessive consumption of carbohydrates can lead to cardiovascular disease (CVD). There is a strong movement to decrease the intake of carbohydrates so as to reduce the occurrence of CVD. In the last 2 years, many studies have been published pertaining to this: some favoring the concept of intake of low dietary carbohydrates while others highlighting the ill effects of a low-carbohydrate diet. These studies give an estimate of the exact percentage of the total energy requirement that should be obtained from carbohydrates for beneficial effects. The present article discusses the recent data for and against carbohydrates, with the conclusion that neither a very high intake nor a very low intake of carbohydrate is good. Moreover, the beneficial range appears to be 50%–55% of the total calorie requirements be obtained from carbohydrates.

Keywords

- Carbohydrates
- Diet
- Cardiovascular disease
- Macronutrient

Introduction

Carbohydrates are naturally occurring compounds composed of carbon, hydrogen and oxygen and include sugars, starch, cellulose, etc. They are produced by green plants via the process of photosynthesis and stored in fruits and seeds. The chemistry of carbohydrates was described in detail by Justus von Liebig in 1803.[1]

Change in dietary patterns

Carbohydrates, fats and proteins form the three macronutrients in our diet, and their proportion may vary in an individual diet. The concept that excess fats in the diet is the leading cause for cardiovascular disorders emerged in the 1960s; therefore, alternative diets were introduced to reduce the fat content.[2] Notably, when consumption of one macronutrient is reduced, the intake of one of the other two has to be increased to maintain the energy balance. Thus, decrease in fat content was compensated by increase in carbohydrate content. However, the incidence of cardiovascular disorders continued to soar and reports started trickling implicating carbohydrates as the reason behind this rise. Subsequently, low-carbohydrate diets started gaining popularity. As mentioned previously, a reduction in carbohydrate intake was made by increasing the fat or protein content.[3,4] These diets include the low-carbohydrate, high-fat (LCHF) diet or the ketogenic diet as well as the low-carbohydrate, high-protein (LCHP) diet.

Received: 02-04-2019; Revised: 12-08-2019; Accepted: 07-08-2019
Disclosures: This article has not received any funding and has no vested commercial interest.
Acknowledgments: None.

Initially, these diets were used in the treatment of patients with diabetes and to gain control over hyperglycemia. In 1863, William Banting popularised low-carbohydrate diet for weight loss.[5] In both these contexts, low-carbohydrate diets were found beneficial over short periods of time. By 1990s, such diets were being promoted, predominantly by Robert Atkins[5] as a way of healthy living. People started adopting these diets and using them for prolonged periods of time assuming that they are healthy. Long-term follow-up studies that analysed the carbohydrate content of diets have been published in the last 2 years. This article reviews the current evidence with respect to the impact of intake of a high- or a low-carbohydrate diet on a long-term basis and its relation with cardiovascular disorders.

Recent trials

In the last 2 years, many trials regarding the impact of intake of a high- or a low-carbohydrate diet on a long-term basis and its relation with cardiovascular disorders were published. Some studied the ill effects of high carbohydrate intake while others examined the ill effects of low carbohydrate intake.

Trials indicating the ill effects of high carbohydrate intake

The Prospective Urban Rural Epidemiology (PURE) study is a major trial indicating the ill effects of high carbohydrate intake.[6] This prospective cohort study examined the associations of fat and carbohydrate intake with cardiovascular disease (CVD) and mortality in 18 countries from 5 continents. Overall, 1,35,335 individuals aged between 35 and 70 years were enrolled from 2003 to 2013 and followed up for a mean period of 7.2 years. Dietary intake was recorded using validated questionnaires. The primary outcomes were total mortality and major cardiovascular events (fatal CVD, nonfatal myocardial infarction, stroke and cardiac failure). Participants were categorised into quintiles of nutrient intake (carbohydrate, fats and protein) based on percentage of energy provided by nutrients. The associations of consumption of carbohydrate, total fat and the type of fat with CVD and total mortality were calculated. During follow-up, there were 5796 deaths and 4784 major CVD events. Based on the intake of carbohydrates, the participants were classified into four quintiles. Higher carbohydrate intake was associated with an increased risk of total mortality (Figure 1). Comparing the highest quintile of carbohydrate intake with the lowest quintile category, the hazard ratio (HR) for total mortality was 1.28. There was no association of carbohydrate intake with the risk of CVD or CVD mortality. Interestingly, it was found that the intake of total fat and each type of fat was associated with a lower risk of total mortality (highest quintile of intake vs. lowest quintile; HR, 0.77 for total fat; HR, 0.86 for saturated fat; HR, 0.81 for monounsaturated fat and HR, 0.80 for polyunsaturated fat). Higher saturated fat intake was associated with lower risk of stroke. Total saturated and unsaturated fat intake was not significantly associated with the risks of myocardial infarction or CVD mortality. Therefore, high carbohydrate intake was found to be associated with a higher risk of total mortality, whereas total fat and individual types of fat were found to be related to a lower risk of total mortality.[7]

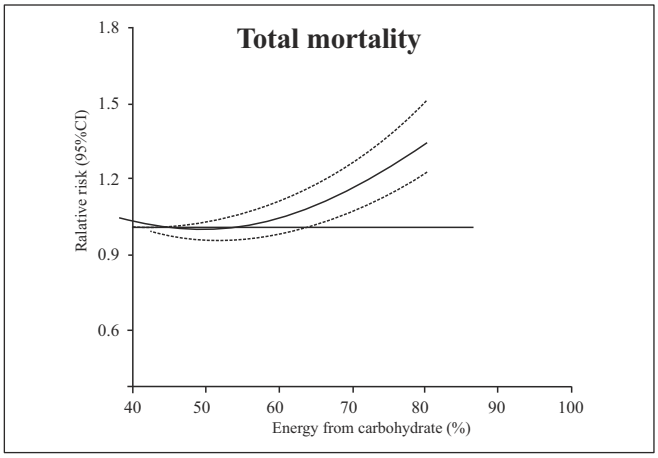

Figure 1: The Prospective Urban Rural Epidemiology (PURE) study: Mortality versus percentage of carbohydrate intake

The PURE study also investigated the association of the intake of fruits, vegetables and legumes with CVD and deaths.[8] The combined mean fruit, vegetable and legume intake was 3.91 servings per day. Higher total fruit, vegetable and legume intake was inversely associated with major CVD, myocardial infarction, cardiovascular mortality, non-cardiovascular mortality and total mortality. The HR for total mortality was the lowest for 3–4 servings per day. There was no further decrease in HR with higher consumption. When examined separately, fruit intake was associated with a lower risk of cardiovascular, non-cardiovascular and total mortality, while legume intake was inversely associated with non-cardiovascular death and total mortality. Regarding vegetable intake, raw vegetable intake was strongly associated with a lower risk of total mortality, whereas cooked vegetable intake showed a modest benefit only against mortality. Benefits appeared to be maximum for both non-cardiovascular mortality and total mortality at 3–4 servings per day (equivalent to 375–500 g/day).

In addition, another large study published in *Nutrients* in 2018 investigated the association of carbohydrate intake with CVD.[9] It was a large-scale ecological analysis of nutritional and other environmental factors between 1993 and 2011 that could be associated with CVD. A comparison was made between the indicators of CVD from 158 countries and the statistics of mean supply of 60 food items. CVD indicators considered were increased blood pressure, CVD mortality and hyperglycemia. The comparison identified high

carbohydrate consumption (particularly in the form of cereals and wheat) as the dietary factor most consistently associated with the risk of CVD.

Human evolution says otherwise

In the light of these studies, it appears that high carbohydrate intake is harmful. However, it does not mean that we should reduce carbohydrate intake to very low levels. If we go back to human evolution, we would find that there has been an increase in the size of our brains compared to our ancestors. There has been a tremendous increase in the skull size (Figure 2) and a decrease in the jaw size.[10] Carbohydrates are considered as the fuel for our brains. Some historians are of the opinion that it was the use of carbohydrates, obtained in large amounts once humans started cultivation, that led to the rapid increase in our brain sizes. So, logically, carbohydrates are essential for us and too low an intake may be harmful.

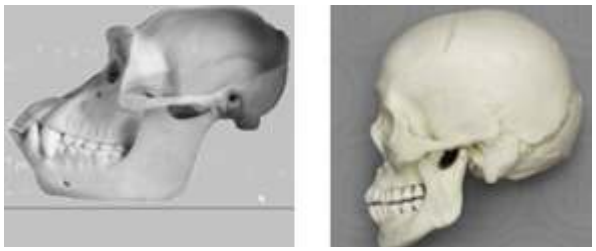

Figure 2: Change in skull and jaw size: chimpanzee versus human

Trials indicating the ill effects of low carbohydrate intake

At the *European Society of Cardiology* 2018 meeting, Mazidi et al. presented their findings on the effects of a low-carbohydrate diet taken over a long period of time.[11] They analysed data from the National Health and Nutrition Examination Survey (NHANES) from 1999 to 2010. There were 24,825 participants, of which 48.6% were men. The mean age was 47.6 years. Participants in the top quartile of low-carbohydrate diet had the highest risk of total, cardiovascular, cerebrovascular and cancer mortality. The association between low-carbohydrate diet and total mortality was stronger in the non-obese than in the obese participants.

A meta-analysis of seven prospective cohorts by the same authors with 447,506 participants and 39,326 mortality cases indicated a positive association between low-carbohydrate diet and total, CVD and cancer mortality. Thus, they recommended not taking such diets on a long-term basis.

Another article that examined the dietary carbohydrate intake and mortality was published in the *Lancet Public Health* in September 2018.[12] The study included 15,428 adults aged 45–64 years from four US communities. These adults had completed a dietary questionnaire at enrolment in the Atherosclerosis Risk in Communities (ARIC) study (between 1987 and 1989). The primary outcome was all-cause mortality. The association between the percentage of energy from carbohydrate intake and all-cause mortality was investigated. Based on the intake of carbohydrates, the participants were classified into four quintiles. This association was further examined by combining ARIC data with data for carbohydrate intake reported from seven other multinational prospective studies in a meta-analysis. In addition, the substitution of animal or plant sources of fat and protein for carbohydrate and its relation to mortality were studied.

The median follow-up was of 25 years, and 6283 deaths were reported in the ARIC cohort. There were 40,181 deaths across all cohort studies. In the ARIC cohort, after multivariable adjustment, the U-shaped association was found between the percentage of energy consumed from carbohydrate (mean, 48.9%; standard deviation, 9.4) and mortality. Overall, 50%–55% energy from carbohydrate was associated with the lowest risk of mortality (Figure 3). In the meta-analysis of all cohorts (4,32,179 participants), both low carbohydrate consumption (<40%) and high carbohydrate consumption (>70%) conferred greater mortality risk than did moderate intake, which was consistent with a U-shaped association (HR, 1.20 for low carbohydrate consumption; HR, 1.23 for high carbohydrate consumption). Mortality increased when carbohydrates were substituted with animal-derived fat or protein (HR, 1.18) and mortality decreased when the substitutions were with plant-based fat or protein (HR, 0.82).

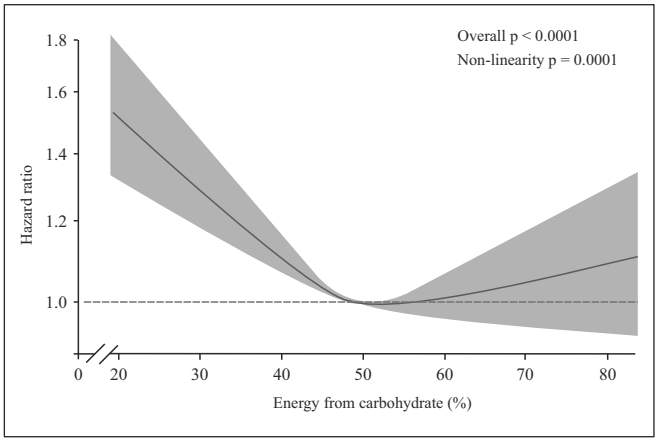

Figure 3: The Atherosclerosis Risk in Communities (ARIC) study: Hazard ratio for cardiovascular disease versus percentage of carbohydrate intake

According to the results of this study, both high and low percentages of carbohydrate in diet were associated with increased mortality. Minimal risk was observed at 50%–55% carbohydrate intake. When carbohydrates were substituted with animal-derived protein and fat sources (lamb, beef, pork and chicken), there was a higher mortality; on the other hand, when they were substituted with plant-derived protein and fat intake (vegetables,

nuts, peanut butter and whole-grain breads), there was a lower mortality. This indicated that the source of

14. Malhotra A, Sahdev N, Sharma S. Diet and Nutrition after the PURE study. Eur Heart J. 2018;39(17):1503–4.

15. Ebbeling CB, Feldman HA, Klein GL, Wong JM, Bielak L, Steltz SK, et al. Effects of a low carbohydrate diet on energy expenditure during weight loss maintenance: randomized trial. BMJ. 2018;363:k4583.

Address for correspondence:
Karunadas Chakkalakal Prabhakaran
Email ID: karunadascp@gmail.com

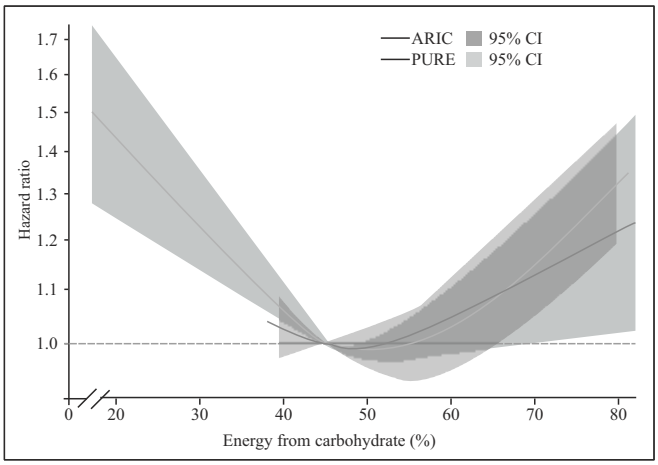

Figure 4: Combined data from the Atherosclerosis Risk in Communities (ARIC) study and the Prospective Urban Rural Epidemiology (PURE) study
CI: Confidence interval

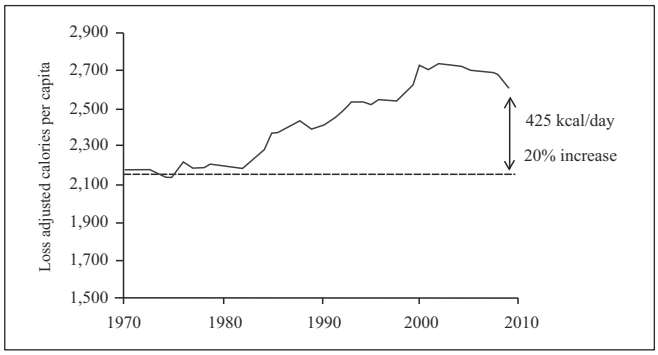

Figure 5: Increasing energy consumption over the years