Review Article

Carbohydrates – the good, the bad and the wholegrain

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Weight loss can be achieved by any means of energy restriction, but the challenge is to achieve sustainable weight loss and prevent weight 'creep' without increasing the risk of chronic disease. The modest success of low fat diets has prompted research on alternative dietary strategies including high protein diets and low glycemic index (GI) diets. Conventional high carbohydrate diets, even when based on wholegrain foods, increase postprandial glycaemia and insulinemia and may compromise weight control via mechanisms relating to appetite stimulation, fuel partitioning and metabolic rate. This paper makes the case for the benefits of low glycemic index diets over higher protein diets. Both strategies are associated with lower postprandial glycemia and both are commonly labelled as 'low glycemic load' but the long-term health effects are likely to be different. There is now a large body of evidence comprising observational prospective cohort studies, randomised controlled trials and mechanistic experiments in animal models, that provides robust support for low GI carbohydrate diets in the prevention of obesity, diabetes and cardiovascular disease. While lower carbohydrate, higher protein diets also increase the rate of weight loss, cohort studies and meta-analyses of clinical trials suggest the potential for increased mortality.

Key Words: carbohydrate, glycemic index, protein, weight loss, cardiovascular disease

INTRODUCTION

As a public health strategy, the low fat diet has had only modest success. Indeed, the increasing prevalence of obesity and diabetes suggests that alternate nutritional strategies are urgently needed. Reducing dietary fat leads to an increase in carbohydrate intake, increasingly recognized as a two-edged sword. On one hand, carbohydrate foods can optimize insulin sensitivity, reduce LDL-cholesterol and provide essential micronutrients in the form of wholegrains, legumes, fruits and vegetables. On the other hand, in the context of a typical western diet, carbohydrate foods can be a liability, providing large amounts of quickly digested starches and sugars, with the potential to increase serum triglycerides and reduce HDL-cholesterol. Technological advances in food processing and increased dependence on convenient, instant and pre-cooked foods has resulted in faster and faster rates of digestion and absorption.

Hence, modern carbohydrate staples, including potatoes, breads, breakfast cereals and other processed cereal foods have a high glycemic index (GI), even when high in fibre[1] (Figure 1). The evidence base relating postprandial glycemia, GI and dietary glycemic load (the product of GI and amount of carbohydrate) to the prevention and management of obesity and chronic disease is now very strong.[2] This paper argues the case for low GI diets as a dietary strategy that is superior to that of lowering carbohydrate intake or increasing dietary protein.

The glycemic index and chronic disease

Observational studies, clinical trials, meta-analyses and mechanistic studies in animal models have examined links between the glycemic nature of carbohydrates, obesity and chronic disease.[3] Most recently, Halton et al.[4] found that dietary glycemic load but not protein, fat or low-carbohydrate diet score, predicted cardiovascular disease in a 20-year follow-up of the Nurses Health Study, with a relative risk of 1.9 comparing highest and lowest quintiles. In large scale prospective studies, gestational and type 2 diabetes have been linked to overall diet GI independently of fibre, but not to protein or carbohydrate intake.[5,6] Body mass index has also been positively associated with the dietary GI although not with carbohydrate or protein intake.[7] In women, a high GI diet was prospectively associated with changes in body weight, body fat and waist circumference over a 6-year period.[26]

Glycemic index and weight management

Carbohydrate foods with a lower GI may assist in weight management via several mechanisms.[8]

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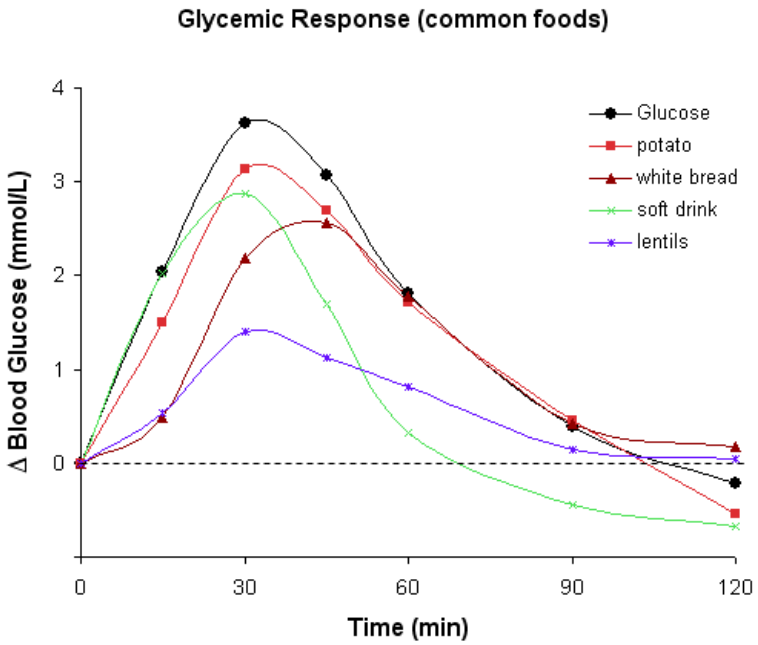

Figure 1. The glycemic response to 50 g carbohydrate portions of common foods. The GI is a relative scale based on comparing the incremental area under the curve to the test food versus the reference food (GI =100). In standard testing, 25 g or 50 g carbohydrate portions are tested in 10 subjects and the reference food is an equal amount of glucose (dextrose). Day-to-day variability in glycemic response is managed by testing the reference food on 2-3 separate occasions.

During and after equivalent weight loss, resting energy expenditure is higher on a low glycemic load diet compared with a conventional low fat diet.[9]

By reducing insulinemia, low GI foods may provide greater access to fatty acids as a source of fuel, promoting greater fat oxidation. During moderate exercise (but not at rest), a low GI meal, compared with a matched high GI meal, results in larger amounts of fat being oxidised at the expense of carbohydrate.[10] Small differences in substrate oxidation have been found to predict long-term weight gain. By virtue of their slower rate of digestion and absorption, low GI carbohydrate foods can increase satiety, reduce hunger and/or lower subsequent voluntary food intake. Conversely, high GI meals have been associated with appetite stimulation and higher energy intake.[11]

Meta-analyses of clinical trials support the use of low GI diets in weight loss,[12] diabetes [13] and the management of hyperlipidemia.[14] Mostly recently, Ebbeling et al. showed that a low glycemic load diet based on low GI carbohydrates and greater fat intake was more effective than a prudent low fat diet in individuals with a high 30-min insulin response after a 50 g glucose challenge (ie indicative of insulin resistance).[15] In this group, the low glycemic load diet increased the rate of body fat loss over 6 months and completely prevented weight regain over the following 12 months. Interestingly, there were no benefits for individuals with a low 30-min insulin response, a diet-phenotype interaction that could help to explain mixed findings in other studies.[16]

We compared 4 diets of varying glycemic load in 129 overweight young adults on weight loss and cardiovascular risk factors over 12 weeks.[17] The high carbohydrate-low GI diet (with intermediate glycemic load) was found to be almost twice as effective as a prudent low fat diet (with the highest glycemic load) at achieving a weight loss of 5% or more. While the high protein diet (25% of energy) with a similar glycemic load was just as effective, it was associated with adverse increases in total and LDL-cholesterol. The diet with the lowest glycemic load (more protein as well as low GI carbohydrates) increased the rate of weight loss only in those with baseline hypertriglyceridemia, again suggesting a diet-phenotype interaction.

Table 1. A low GI diet is achieved by substituting low GI sources of carbohydrate for high GI sources within the context of a prudent diet.

High GI Food	Low GI Alternative
Bread – white or wholemeal	Bread containing lots of whole grains; sourdough and pumpernickel breads
Processed breakfast cereals	Unrefined cereals such as rolled oats or natural muesli or a low GI processed cereal such as those containing psyllium husks
Plain biscuits or crackers	Biscuits made with dried fruit, oats and wholegrains
Cakes and Muffins	Make them with fruit, oats, oatbran, rice bran and psyllium husks

Carefully conducted animal studies provide mechanistic support for the use of low GI diet for weight control. Rats and mice have significantly more body fat and less lean mass when fed high GI starch-based diets than macronutrient-matched low GI starch diets over 18 weeks.[18] At the final time point, high GI-fed animals also showed impairments in glucose tolerance,

hypertriglyeridemia and macroscopic evidence of β-cell disruption.

GI, insulin resistance and the metabolic syndrome

In observational studies, increasing dietary GI has been independently linked to higher prevalence of insulin resistance, the metabolic syndrome, fatty liver and metabolic risk factors including triglycerides and HDL-cholesterol. [19,20] Using the euglycemic-hyperinsulinic clamp, Rizkalla et al. showed that low GI diets improved whole-body insulin sensitivity in individuals with type 2 diabetes.[21] More recently, Aston et al. showed that a weight-maintaining low GI diet consumed over 12 weeks was associated with higher insulin sensitivity than a macronutrient and fibre-matched high GI diet in overweight young adults.[22] Importantly, they demonstrated that indirect measures of insulin resistance such as fasting insulin and HOMA were not sensitive to the diet-induced differences. In contrast to low GI diets, the effect of higher protein intake on glucose regulation is less clear. Some studies suggest that high protein consumers have reduced glucose disposal, higher endogenous glucose output and higher glucose-stimulated insulin secretion.[23]

CONCLUSIONS

Like other dietary factors, the GI should not be the sole focus upon which food choices are made. Rather, the GI should be applied judiciously to select foods within the context of a prudent diet (Table 1). However, it is not correct to assume that wheatmeal, wholegrains and high fibre foods are low GI. Indeed, the vast majority of 'wholegrain' breads, breakfast cereals and processed cereal products have a GI over 70. Moreover, the GI cannot be guessed by examination of the nutritional composition or physical attributes of a food. The need for GI testing of local foods is critical to the practical application of low GI diets.

Unlike high protein, low carbohydrate (Atkins-style) or very high carbohydrate diets with their potential for adverse effects, there are no safety concerns surrounding low GI diets. In children and adults with diabetes, low GI diets improve glycosylated hemoglobin levels without increasing LDL-cholesterol or the risk of hypoglycaemia. [24] In healthy pregnant women, low GI diets reduce the risk of large-gestational age without increasing the number of small-gestational age infants.[25] Finally, low GI diets may be more behaviourally sustainable because they do not restrict either fat or carbohydrate, or specific food groups. While further research into the role of GI in the prevention and management of obesity and chronic disease is needed, a large body of evidence from animal models, clinical trials and epidemiological studies supports the current popularity of low GI diets.

AUTHOR DISCLOSURES

Jennie Brand-Miller, Joanna McMillan-Price, Katherine Steinbeck and Ian Caterson, no conflicts of interest.

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