Invited Editorial

The glycaemic index of foods

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The glycaemic index of foods

The glycaemic index (GI) is a ranking of foods based on their glycaemic impact[1]. It has proven to be a logical and useful tool for comparing foods in situations such as diabetes, sport and appetite where fluctuations in blood sugar levels are considered important. In Australia, the GI concept is already being utilized in some diabetes education centres. The International Diabetes Institute in Melbourne has produced educational material describing the differences between foods in terms of their GI. In fact, Australia may be ahead of the rest of the world in its acceptance of the GI approach. New editions of most textbooks of nutrition and dietetics now devote a section to the subject[2], but most do not give their blessing, citing conflicting early studies. However, over the last few years, many studies have proven that the GI concept is not only reproducible and predictable, but clinically useful in the dietary management of insulin-dependent diabetes mellitus (IDDM), non-insulin-dependent diabetes mellitus (NIDDM) and hyperlipidaemia[3,4].

When Jenkins and co-workers introduced the GI concept in 1981[1], it confirmed what others had also found but had not tabulated in the same way, ie that equal carbohydrate portions of starchy foods varied widely in their glycaemic properties from the very high responses produced by potatoes to very low responses produced by legumes. Similarly, simple sugars produced a range of responses, with sucrose being intermediate. GI seemed a more logical approach to the dietary management of diabetes, but it went against the prevailing dietary dogma that starches were all slowly digested and absorbed, while the opposite was true of sugars. Indeed the publication of the first GI of foods suggested that the system of carbohydrate exchanges for diabetic diets had little scientific validity.

In the last 12 years nearly 300 separate foods have been subjected to GI testing, representing about 200 different kinds of foods from all around the world. The team here at the University of Sydney's Human Nutrition Unit has been responsible for about half of the data. The article by Mani et al. in this issue[5] of the journal is a further addition to the body of knowledge of GI of foods. In particular, their results provide more evidence that 'traditional', 'unprocessed' foods have a low GI. Legumes, *whole* cereal grains and millets produce exceptionally low GI values contrasting with the effects of modern foods such as bread, potatoes and many breakfast cereals which elicit high plasma glucose and insulin response[1]. Factory processing and milling markedly increase glycaemic responses to foods[6,7]. Interestingly, the staple carbohydrate foods of Nauruans, Australian Aborigines and Pima Indians were primarily low GI foods[8,9]. In the past century these population groups have adopted a Western lifestyle and modern foods, and now develop non-insulin-dependent diabetes mellitus (NIDDM) in alarming numbers. It is not unreasonable to suggest that the high GI of the diet may have some role to play. A preliminary study in rats supports the hypothesis that high GI foods worsen insulin resistance and therefore the risk of NIDDM[10].

In early 1980s the debate on the GI approach to diabetes management became increasingly polarized, with the open expression and publication of directly opposing views on its usefulness[11]. Its reproducibility, application to mixed meals and long-term effects were all open to question. There was a widespread belief that GI was useful only in the comparison of single foods but not where mixed meals were concerned[12,13]. In 1986, the NIH consensus conference on diet and exercise in NIDDM recommended *against* the use of GI in the dietary management of diabetes[14]. The main criticisms were: no differences were apparent when individual carbohydrate foods were taken as part of a mixed meal and, secondly, there were no studies showing long-term benefits.

In the intervening six years since the NIH statement, these criticisms have been shown to be without foundation. There are now at least 15 studies on mixed meals and 11 medium-to-long term studies using the GI approach in the dietary management of diabetes. Although several early studies failed to show any differences in glycaemic response when foods of different GI were incorporated into mixed meals[12,13,15], there are now three times as many studies which show that GI is very predictable in mixed meals[16-25]. Methodological differences can explain some of the conflict, but studies addressing the long-term effects help to answer both criticisms.

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Of the 11 medium-to-long-term studies (2–12 weeks) which have specifically used the glycaemic index (GI) approach to determine the clinical gains in diabetes or lipid management [26-36], all but one produced positive findings. Altogether 156 subjects (63 NIDDM, 45 IDDM, 42 hyperlipidaemic, 6 normal) have been studied, all on an outpatient basis, in a cross-over design in which patients consumed both types of diet for an equal period of time in random order.

An overview analysis of these 11 studies[4] showed that, on average, low GI diets reduced glycosylated haemoglobin by 9%, fructosamine by 8%, urinary C-peptide by 20% and day-long blood glucose by 16%. Cholesterol was reduced by an average of 6% and triglycerides by 9%. Improvements were found in well-controlled, poorly controlled and overweight NIDDM subjects and applied to both adults and children with IDDM. One can criticize these results as 'modest' improvements but, so too, were the changes to the diet. They were not exceptionally high in fibre or low in fat and the subjects did not have to lose weight. In most studies, only half the carbohydrate was exchanged from high to low GI which meant that foods such as bread and potatoes could still be eaten on the low GI diet. Furthermore, the findings applied to free-living subjects, not to institutionalized or metabolic ward patients whose food intake can be strictly controlled but is not necessarily realistic. In our study[28], compliance was high on the low GI diets and patients remarked that they 'felt better' on them.

A recent study from the Hammersmith Hospital in London, UK, is also cause for confidence because it was a large study in a typical clinical setting. Sixty newly diagnosed NIDDM subjects were randomly assigned to either standard dietary advice or standard plus low GI advice for 12 weeks[37]. The low GI group not only had a significantly lower GI, but also achieved a lower fat intake and high carbohydrate and fibre intake. There was a significantly greater fall in fructosamine and cholesterol in the low GI group.

GI and sports performance

Diabetes is not the only area where GI of foods may be important. The sport physiologists have suddenly discovered the GI concept and have recommended high and low GI foods for different situations[38]. Thomas et al.[40] found that consumption of low GI foods before prolonged strenuous exercise may increase endurance time by as much as 20 minutes. The findings are relevant to all forms of prolonged strenuous activity, in both humans and animals, including sport and even national defence.

GI and satiety

There is another area in which GI is relevant, that of satiety and weight maintenance. Flatt[39] has hypothesized that meals producing a high respiratory quotient (RQ) result in carbohydrate being burned at the expense of fat and less deposition of glucose as glycogen. The lower glycogen stores are thought to result in hunger developing sooner rather than later and therefore greater food intake. Both situations predispose to weight gain. Our research has shown that high GI foods produce higher RQs than low GI foods, both before and during exercise, and therefore have the potential to promote greater weight gain[40]. We and others have also found that higher glucose and insulin responses are consistently associated with lower satiety and vice versa[41-43]. These findings provide support for Flatt's hypothesis and may help to explain why modern diets (with their high GI foods) are particularly associated with overweight and obesity.

What criticisms of GI still remain?

The GI approach has been criticized because some foods have been rated as 'good' or 'bad' simply on the basis of their GI. It was never intended that the GI be used in isolation. The fat, fibre and salt content of a food are particularly relevant to diabetes. Some people have argued that GI makes high-fat foods appear in a falsely favourable light because fat slows gastric emptying and blunts the glycaemic response to the carbohydrate. High-fat foods do tend to have a low GI, including ice cream and Mars Bars™, but fat may not be the main reason. Carbohydrates such as lactose and sucrose produce moderate glycaemic responses by themselves. Jenkins and colleagues have argued that the GI approach should be applied only to low-fat, starchy foods[44]. There is some dissention about recommending high-carbohydrate diets for all individuals with diabetes because of their tendency to lower HDL cholesterol[45-47]. However, this criticism of high carbohydrate diets is overcome by use of *low-GI*, high-carbohydrate diets.

The insulin response to a food is also important and does not always correlate with the glycaemic response[48]. Some rice varieties, for example, may produce a high GI but a substantially lower 'insulin index', compared to white bread[49]. The clinical significance of this is not clear, but it may mean that we should be producing an insulin index of foods as well as GI. The insulin index may be more relevant to individuals with impaired glucose tolerance, hyperinsulinaemia and high blood pressure ('Syndrome X'). Another criticism of the GI is that the usual serving size is often not a 50g carbohydrate portion. Some foods may contain so little carbohydrate that even a high GI is of little practical significance, such as the case with carrots (GI=92), but there are few other foods in this category. Theoretically, it is possible to show that the expected glycaemic response to the usual serving size correlates well with the GI of a 50g carbohydrate portion. Another factor which has been hindering the practical application of the GI has been the lack of a comprehensive list of GIs, including common supermarket brand names and ethnic foods. We have been addressing this issue and plan to publish an extensive list comprising nearly 300 separate food items representing about 200 different types of food in the near future.

Australians are renowned for giving things a 'fair go' and the GI appears to be no exception. The ground work has been well prepared and the only remaining problem is how best to explain it all to the patients. Various teaching strategies are being explored at present. The GI concept is arguably one of the most logical ways to teach individuals how to manage their blood glucose levels. I think it is time that we acknowledge that the GI of foods is a clinically proven method of determining which carbohydrate foods are best.

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Editor's note: Of related interest is the Concise review in this issue entitled *Clinical nutrition of diabetes* (Mark L. Wahlqvist and Richard O'Brien, pp. 149–50).