



## **Glycemic Index - Understanding the Glycemic Response to Carbohydrates** *June 2004*

### **What is Glycemic Index?**

The glycemic index (GI) was developed by Dr. David Jenkins and colleagues as a way to “standardize” the glycemic response to the ingestion of carbohydrates (i.e. sugars and starch) and foods predominant in carbohydrate such as grain products, fruits and vegetables and dairy products (Jenkins et al 1981; Jenkins et al 1984). The glycemic index is a ranking of the postprandial glycemic response to different sources of carbohydrate in comparison to a reference carbohydrate, usually glucose or white bread. GI is expressed as the *incremental area under the blood glucose response curve, above baseline* measured over a period of 2 to 3 hours. It should be noted that the incremental area under the blood glucose response curve does not include values which fall below baseline (Wolever 1990).

### **How is the GI established?**

To establish the glycemic index, an individual must consume, in random order, 50g of available carbohydrate from a test or reference food after an overnight fast. This is followed by consumption of the same quantity of carbohydrate from a test or reference food (depending on what was consumed first) after an overnight fast on an alternate day (Wolever et al 1991; FAO/WHO 1998; Wolever et al 2003). In each case, blood glucose is measured every 15–30 minutes over a period of 2 to 3 hours. The reference food is assigned a value of 100 against which test foods are compared. To reduce variability, ingestion of the reference food should be repeated at least three times by each subject (Wolever et al 1991; Wolever et al 2003). The mean or average GI obtained from approximately 10 individuals is used as the GI rating for a particular food (Brand-Miller et al 1999).

To simplify interpretation, the GI is often divided into categories as follows: *high (>70)*, *medium (55-70)* and *low (<55)* (Brand-Miller et al 1999). The numbers refer to percentages in comparison to the reference food. It should be noted that the GI values based on a glucose standard are lower than those based on white bread but the relative ranking remains the same. It is possible to convert from one to the other using a factor of 1.4 (100/70) since white bread has a GI of 70 when compared to glucose (Wolever et al 2003). In other words, the area under the blood glucose response curve produced by white bread is 70% of that produced by an equivalent amount of carbohydrate when consumed as glucose. Some scientists have decided to use white bread instead of glucose as the reference because it is more typical of what we eat. However, there has been criticism against using white bread as a reference because of difficulty with standardization, whereas this is not the case for glucose. A recent multi-laboratory study confirmed that although white bread can be used as the reference food, glucose is a more logical choice for international use (Wolever et al 2003).

### **What is the role of GI in health and disease?**

Interest in the glycemic index is evident from a number of recent diet and lifestyle books such as *South Beach diet*, *Good Carbs, Bad Carbs*, and *the Glucose Revolution*. This growing interest is supported by scientific evidence, including data from epidemiological and clinical studies, which have linked low GI diets with improved outcomes such as a decreased risk of development of type 2 diabetes (Salmeron et al 1997a,b) and improvements in both metabolic control (Wolever et al 1992a, Jarvi et al 1995, Collier et al 1998, Jenkins et al 1987, Fontvieille et al 1988, Brand et al 1991, Giacco et al 2000, Gilbertson et al 2001) and quality of life (Gilbertson et al 2001) in individuals with established diabetes. As well, there is evidence for the GI concept in the control

of cardiovascular disease risk factors such as blood lipids (Jenkins et al 1987; Jenkins et al 1988; Fontvielle et al 1988; Wolever et al 1992a; Wolever et al 1992b; Brand al 1991; Fontvielle et al 1992; Jarvi et al 1999; Liu et al 2000; Buyken et al 2001). There is also evidence that GI may play a role in prevention and management of obesity (Liljeberg et al 1999; Bouché et al 2002; Ball et al 2003). However, long-term studies are needed to clarify the role of the GI concept in weight regulation. Until there is more conclusive evidence, debate continues regarding the merits of low GI diets in the management of obesity (Pawlak et al 2002; Raban 2002).

Although not endorsed by the American Diabetes Association (Franz et al 1994; Franz et al 2002), the GI is being advocated by most diabetes and health organizations world wide including the World Health Organization (FAO/WHO 1998) and diabetes associations in Europe, Australia, South Africa and Canada (Nantel 2003). The use of the GI in practice, and in particular the use of low GI diets, is being advocated by a joint Food and Agriculture Organization (FAO) and World Health Organization (WHO) Expert Consultation on the role of Carbohydrates in Human Nutrition (FAO/WHO 1998). The consultation report highlights how the GI can be applied to mixed meals or to entire diets and favors its use in the management of individuals at high risk of developing diabetes (i.e. individuals with impaired glucose tolerance), as well as those with established diabetes (FAO/WHO 1998; Nantel 2003).

### **Areas of Controversy**

Since its conception in the 1980's, the GI has been the subject of much debate and its usefulness as a concept open to question. The controversy focuses on four issues – its application to mixed meals, effectiveness, complexity for client education and potential limitation in food choice.

#### *Application to Mixed Meals*

Much of the controversy surrounding the clinical utility of the GI relates to its application to mixed meals. Typical servings of carbohydrate-containing foods do not always reflect the portions used for GI testing. In addition, the presence of fat and protein in a meal may negate any differences in GI observed when individual foods are consumed alone (Hollenbeck et al 1986; Hollenbeck and Coulston 1991). Some investigators have found that the GI of individual foods could predict the glycemic and insulin response in individuals with and without diabetes, when applied to mixed meals (Wolever et al 1985; Collier et al 1986; Chew et al 1988; Wolever et al 1990; Wolever and Bolognesi 1996). However, others have not made this observation (Nuttall et al 1983; Coulston et al 1984; Laine et al 1987; Hollenbeck et al 1988). The reason(s) for this discrepancy may be related to differences in the populations studied, length of the studies and lack of consistency in the methods used for calculating the glycemic response. For example, some investigators (Nuttall et al 1983; Coulston et al 1984; Laine et al 1987; Hollenbeck et al 1988) have chosen different methods for calculating the glycemic response than that originally proposed and recommended (Wolever 1990; FAO/WHO 1998; Wolever et al 2003). Those studies which have consistently used the methods recommended by Wolever (Wolever, 2003 et al; Wolever et al 1985; Collier et al 1986; Chew et al 1988; Wolever et al 1990; Wolever and Bolognesi 1996) have been able to demonstrate that the GI can be applied to mixed meals.

#### *Effectiveness of the Concept of GI*

The American Diabetes Association (ADA) appears to be the only organization which does not endorse use of GI in the nutritional management of diabetes (Franz et al 1994; Franz et al 2002; Nantel 2003). The ADA contends that although low GI foods may reduce postprandial glucose levels, there is a lack of sufficient evidence of long-term benefit (i.e. improvements in A<sub>1c</sub> and lipid levels) to recommend the use of low GI diets as a primary strategy for meal planning for individuals with type 1 and type 2 diabetes (Franz et al 1994; Franz 1999; Franz 2001; Franz et al 2002). Furthermore, it is believed that individuals with diabetes will not be able to implement the concept into their daily lives and it would likely complicate meal planning (Franz 2001). On the other hand, most studies, including a recent meta-analysis, do show benefits of low GI diets beyond reduction of postprandial glucose including improvements in A<sub>1c</sub> levels, lipid levels and

quality of life (Jenkins et al 1987a,b; Collier et al 1988; Fontvieille et al 1988; Giacco et al 2000; Buyken et al 2001; Gilbertson et al 2001; Brand-Miller et al 2003).

#### *Complexity of the Concept for Client Education*

Some educators believe that the GI is too complicated to teach (Rendell 2000; Beebe 1999; Franz 1999). However, work conducted by Brand-Miller and colleagues has demonstrated that this belief is unfounded, as they have easily integrated the concept into practice (Brand-Miller 1994; Brand-Miller et al 1997) and have demonstrated benefits in both metabolic control and quality of life in individuals with diabetes (Frost et al 1994; Gilbertson et al 2001). As we would not expect our clients to calculate the GI of their meal or diet, application of the GI concept will have to involve use of exchange lists and/or food lists and simple advice as has already been demonstrated (Frost et al 1994; Brand-Miller et al 1999; Gilbertson et al 2001). The development of educational tools, as well as continuing education for health care professionals, will assist practitioners to successfully implement this concept into clinical practice.

#### *Limitation on Food Choice*

Some critics of the GI concept fear that focusing on low GI foods may limit food choice (Franz 1994) and possibly have a negative impact on the nutritional adequacy of the diet. In addition, not all foods have an assigned GI value and this can be an obstacle for the day-to-day use of the GI concept (Trout and Behall 1999). However, recent interest in the GI has led to an increase in the number of foods that have been tested and assigned GI values; currently this list consists of over 1000 foods, including Canadian foods (Foster-Powell et al 2002). As is the case with nutrients, the GI is subject to regional differences in food composition. Therefore, use of GI values that are country-specific is critical for both research and application of the GI concept. Although the new international table of GI values is quite extensive, it is clear that more testing is urgently needed, especially of Canadian foods (Foster-Powell et al 2002).

#### **Can the GI concept be applied in clinical practice?**

It is clear that there is accumulating evidence on effectiveness and ease of use of the GI concept reported by clients and clinicians. Furthermore, nutrition education involving the GI concept has been shown to be more successful than standard nutrition education in adults with newly diagnosed type 2 diabetes (Frost et al 1994) and with children with type 1 diabetes (Gilbertson et al 2002). Frost and colleagues (1994) assessed the impact of nutrition education using the GI concept against standard nutrition advice in a randomized, controlled trial of 51 newly diagnosed adults with type 2 diabetes. Their results showed that when people received nutrition education focusing on low GI foods, in addition to achieving a lower mean dietary GI intake, they also had a lower fat intake and a higher carbohydrate intake (Frost et al 1994). A more recent randomized, controlled clinical trial (Gilbertson et al 2001), also demonstrated that simple advice based on low GI foods significantly improved glycemic control ( $A_{1c}$ ) and quality of life in free-living children with type 1 diabetes, compared to traditional advice based on carbohydrate exchanges.

#### **Tips for implementing the GI concept into clinical practice**

There are many effective methods for teaching the GI concept to promote changes to client eating habits.

- ✓ It is not necessary for clients to choose only low GI foods (Brand-Miller and Foster-Powell 1999); they may exchange half of the high GI carbohydrate for a low GI choice. This will lower the whole diet GI by about 15 units, which is more than sufficient to result in clinically significant improvements in glycemic control in people with diabetes (Brand-Miller and Foster-Powell 1999). This increases the flexibility of the diet and allows staple foods such as potatoes and white bread that have a high GI, but are still nutritious, to be included in the diet.
- ✓ At least one low GI carbohydrate choice per meal should be included or one may base at least two meals daily on low GI foods (Brand-Miller and Foster-Powell 1999).

- ✓ Substituting low GI in place of high GI types of bread and breakfast cereal consumed may have the most practical impact in the western diet (Brand-Miller and Foster-Powell 1999).
  - *Examples of low GI breads and cereals include: pumpernickel, 100% stone ground whole wheat and heavy mixed grain bread; All Bran® cereal, oatmeal. High GI choices include: white bread; bran flakes, cheerios, rice krispies and cornflakes.*
  - For more information regarding low, medium and high GI choices see the GI tool developed by the Canadian Diabetes Association at [http://www.diabetes.ca/Section\\_Professionals/ng\\_glycemic.asp](http://www.diabetes.ca/Section_Professionals/ng_glycemic.asp)
- ✓ Present all high carbohydrate, low fat food as healthy, pointing out that some are “good” choices and some are “better choices”, making this distinction on the basis of both nutrient composition and GI (Brand-Miller and Foster-Powell 1999).
- ✓ Legumes have been found to be useful in lowering the GI of the diet (Trout et al 1993). Therefore suggesting ways to include legumes in recipes can be a way to help clients lower the total GI of their diets.
- ✓ Since the term “glycemic index” or “GI” may be too technical for most clients, it is suggested that terms such as “small rise” and “large rise” in blood glucose be used (Katanas 1999).
- ✓ As most fruits and vegetables and milk products generally have a low GI rating and provide many essential nutrients, a variety of foods from these food groups should be encouraged as part of a healthy diet, with an emphasis on low fat choices.
- ✓ As the majority of high GI foods are found in the grain products or in the starchy food group, this food group should be the main focus of education regarding the GI concept (Brand-Miller and Foster-Powell 1999).
- ✓ Portion management is fundamental to nutrition therapy for diabetes (Franz 1999). Overindulging in a meal consisting of low GI foods will elevate blood glucose levels. Clients should recognize that serving sizes must still be monitored, even when making low GI choices. As well, food choices must still be based on current nutrition recommendations and nutrition guidelines for healthy eating. Teaching with respect to the GI concept should be in keeping with these recommendations and guidelines.
- ✓ People with both type 1 and type 2 diabetes on medication, especially those who are using newer agents and regimens, should be encouraged to measure their blood glucose levels more frequently and be alert for the possible need to modify their treatment regimen when replacing high for low GI foods in their diet.

Whatever strategies are used, it must be remembered that education should meet the needs of the individual and so flexibility in teaching methods is recommended. Furthermore, the GI concept is not meant to replace, but to supplement existing nutritional strategies, although it can be used on its own in accordance with the needs of the client.

### **Conclusions and Future Directions**

When the GI concept is applied in research and clinical settings, positive health benefits have been identified for people both with and without diabetes. These include the prevention of diabetes and improvements in metabolic factors associated with long-term complications of diabetes such as reduction of postprandial glycemia and insulinemia, improved glycemic control ( $A_{1c}$ ), improved lipid profile including improvements in emerging cardiovascular disease risk factors. Research also appears to indicate a role for the GI concept in the prevention and management of obesity, although long-term studies are urgently needed to provide more definitive answers. Further studies are needed before a recommendation in relation to the GI of carbohydrates can be confidently made for the general healthy population.

Therefore it is important to integrate this concept into practice as clearly as possible through education of health professionals. As well, the Canadian food industry will have a vital role to play by increasing testing of a wider variety of carbohydrate-containing foods.

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