Glycemic Index: from Research to Practice

Maria Kalergis, PhD, RD, CDE

Research Dietitian / Clinical Research Co-ordinator
Clinical Investigation Unit, Royal Victoria Hospital,
McGill University Health Sciences Centre
Outline

- Selection of Topic and CFDR
- Background of Glycemic Index
- Rationale for CFDR-Funded Study
- Presentation of CFDR-Funded Study
- Impact of Study
- Future Directions
Selection of Topic

- Personal interest in GI since undergrad
- Growing evidence base in prevention and management of *diabetes, obesity and CVD*
- Recommended by *Canadian Diabetes Association* (CDA) for use in clinical practice
Selection of CFDR

- Support practice-based research by dietitians
- Topic in line with criteria for funding emerging concept with important health implications for Canadians
- Relevant to the practice of dietitians
Glycemic Response vs. Glycemic Index

- Glycemic response to food refers to the **extent** to which blood glucose (BG) **risks** with food ingestion.
Glycemic Index (GI) was developed in 1981, by Dr. David Jenkins of the University of Toronto, as a way to standardize the glycemic response to carbohydrates (i.e., sugars and starch) and carbohydrate-containing foods (grain products, fruits, vegetables, milk products).
Glycemic Index: Definition

The GI describes the glycemic response to ingestion of 25g or 50g *available carbohydrate* in a test food compared to 25g or 50g available carbohydrate in a reference food.

Reference food = glucose or white bread

*available carbohydrate (excludes fibre)*
Glycemic Index: Definition

- Ranks the *postprandial glycemic response* to different sources of carbohydrate, reflecting the rate of conversion of carbohydrates into glucose.

- Expressed as the *incremental area* under the BG response curve, above baseline, over a period of 2 to 3 hours.
Glycemic Index: Definition

- **Quickly converted carbs (High GI)**
  - greater rise in BG and insulin secretion

- **Slowly converted carbs (Low GI)**
  - lower BG concentrations and lower insulin responses
Glycemic Index: Methodology

- Individuals, similar health status, consume 25g or 50g available carb in test food and 25g or 50g available carb in reference food in *random order*

- BG measured every 15-30 minutes over 2-3 hours

- The reference food (glucose or white bread) assigned value of 100, against which test foods are compared

- Mean GI from 8-10 individuals is used as the GI rating for a particular food
Glycemic Index: Calculation

Incremental BG area of 25g or 50g carbohydrate in test food

\[ \text{GI} = \frac{\text{Incremental BG area of 25g or 50g carbohydrate in test food}}{\text{Incremental BG area of 25g or 50g carbohydrate in reference food}} \times 100\% \]
<table>
<thead>
<tr>
<th>Category</th>
<th>GI Rating (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>$\leq 55$</td>
</tr>
<tr>
<td>Medium</td>
<td>55-69</td>
</tr>
<tr>
<td>High</td>
<td>$\geq 70$</td>
</tr>
</tbody>
</table>
Glycemic Index of Spaghetti

Change in BG (mmol/L) vs. Time (min)

- **Glucose**: GI = 100
- **Spaghetti**: GI = 41
Blood Glucose Concentrations with High vs. Low GI Foods

Adapted from: Anderson et al. Modern Nutrition in Health and Disease. 2001
Areas of Controversy

- Application in mixed meals
- Effectiveness (relevance to health)
- Use in clinical practice
Application in Mixed Meals

- Typical servings may not reflect portions used in GI testing (i.e. 25g or 50g carbohydrate)

- Impact of other nutrients, especially fat and protein
GI can predict *glycemic* and *insulin* responses when applied to mixed meals in individuals with and without diabetes

Evidence for Glycemic Index

- Prevention of type 2 Diabetes
- Management of BG and Lipids in type 1 and 2 diabetes
- Prevention of Cardiovascular Disease
- Prevention and management of Obesity
GI in Prevention of type 2 Diabetes

2 large epidemiological studies:
- Nurses’ Health Study and Health Professionals’ Study of Harvard University

⇒ High GI intake positively associated with increased risk of developing type 2 diabetes

Salmeron J et al. Diabetes Care, 1997;
Glycemic Index and type 2 DM Risk

Salmeron et al. Diabetes Care, 1997
Health Professionals’ Study
GI in Management of types 1 and 2 Diabetes

Meta-analysis of randomized, controlled trials of low GI diets in management of type 1 and 2 diabetes concluded that:

⇒ Choosing low GI in place of high GI foods has a clinically significant effect on glycemic control

Other Benefits for People with Diabetes

- Reduced number of hypoglycemic episodes
  
  Giacco et al. Diabetes Care, 2000

- Improved Quality of Life
  
  Gilbertson et al. Diabetes Care, 2001
Studies since the 1980’s have shown improved serum lipids in type 1 and 2 diabetes with low vs. high GI diets


Recent studies have shown an association of GI with new CVD risk factors: PAI-1 and high-sensitivity C-reactive protein

Glycemic Load and CHD Risk

BMI (kg/m²)

Tertile 1
Tertile 2
Tertile 3

*GL

RR

< 23
23-29
>29

1.00
1.05
1.42

1.11
1.2

1.74
1.97


Nurses’ Health Study

* reflects higher GI
GI in Obesity and Weight Management

- High GI diets may play a role in etiology of obesity and metabolic syndrome
  
  Kopp W. Metabolism, 2003

- The GI has been associated with satiety and loss of fat mass


- More studies are needed in this area
GI in Development of type 2 Diabetes: Hypothetical Model

High GI Diet

↓

Hyperglycemia

↓

Glucotoxicity

↓

Beta Cell Failure

↓

Type 2 Diabetes

↑Free Fatty Acids

↓

Lipotoxicity

Adapted from: Ludwig DS. JAMA, 2003
GI in Development of CVD: Hypothetical Model

High GI Diet

↓ ↓

Hyperglycemia

↓

Oxidative Stress

↓

Hyperinsulinemia

↓

Insulin Resistance

↓

Cardiovascular Disease

Adapted from: Ludwig DS. JAMA, 2003
The American Diabetes Association (ADA) does not currently endorse use of GI in clinical practice.

Advocated for use in clinical practice by the following organizations:
- The World Health Organization (WHO), the Food and Agriculture Organization (FAO) and the diabetes associations of Europe, Australia, South Africa and Canada.

Well accepted and used in countries such as Australia and New Zealand.
Clinicians report that individuals with diabetes find the GI concept *simple, easy to use and helpful* and they are not misapplying it.

- Brand-Miller JB et al. Diabetes Care, 1997;

Two randomized, controlled trials demonstrated that nutrition education based on the GI concept was more successful than *standard nutrition education*, resulting in improvements in both *A1c and quality of life*.

- Frost et al. Diab Med, 1994;
- Gilbertson et al. Diabetes Care, 2001

*Standard nutrition education* = emphasizing carbohydrate exchanges
Rationale for Study

- Evidence for important health benefits in areas of *diabetes, obesity and CVD*

- Recommended for use in clinical practice by most health organizations around the world including *Canadian Diabetes Association*

- No other study that addressed perceptions and practices of dietitians regarding GI
Canadian Dietitians’ Use and Perceptions of Glycemic Index in Diabetes Management

1Maria Kalergis
1Bonnee Belfer, 2Alain Ishac, 1Evelyne Pytka, 1Jean-François Yale, 1Nancy Mayo, 2Irene Strychar

1McGill University and 2Université de Montréal

Funded by: Canadian Foundation for Dietetic Research
Study Objectives

- Determine whether dietitians in Canada use GI in diabetes management
- Determine how GI is being used
- Determine factors associated with use and non-use of GI
Study Design

- Postal survey with case-control design

- Sampling frame:
  - all dietitians who were active members of DC and OPDQ in 2002

- Exclusion criteria:
  - students and retired members
Sampling Strategy

Post card sent $\quad n = 6,060$ (DC and OPDQ)

$\downarrow$ 47% response rate

$n = 2,856$

Questionnaire sent $\quad n = 1,805$ (worked in diabetes)

$\downarrow$ 59% response rate

$n = 1,062$

5 excluded

$n = 1,057$ (questionnaire respondents)
Results:
Use of GI by Questionnaire Respondents

61% non users (n=642)

39% users (n=415)

n= 1,057
### Application of GI by Users

<table>
<thead>
<tr>
<th>Mode of application</th>
<th>% of users (n= 415)</th>
</tr>
</thead>
<tbody>
<tr>
<td>General concept</td>
<td>90%</td>
</tr>
<tr>
<td>Erratic blood sugars</td>
<td>56%</td>
</tr>
<tr>
<td>Daily meal planning</td>
<td>49%</td>
</tr>
<tr>
<td>Weight control</td>
<td>49%</td>
</tr>
<tr>
<td>Treatment of hypoglycemia</td>
<td>25%</td>
</tr>
</tbody>
</table>
Reasons for Non Use of GI

Reasons

- Complex for client
- Access to educational tools
- Uncertain how to use
- Complex to teach
- No time
- Unaware of concept

% of non users (n= 642)

- 57%
- 46%
- 31%
- 19%
- 15%
- 3%
Factors Associated with Use and Non Use of GI

<table>
<thead>
<tr>
<th>Factors</th>
<th>Users</th>
<th>Non users</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge of CDA recommendation of GI</td>
<td>67%</td>
<td>26%</td>
</tr>
<tr>
<td>Member of CDA Diabetes Educators</td>
<td>47%</td>
<td>12%</td>
</tr>
<tr>
<td>Counsel &gt; 10 clients/wk</td>
<td>44%</td>
<td>13%</td>
</tr>
<tr>
<td>Certified Diabetes Educator</td>
<td>31%</td>
<td>2%</td>
</tr>
</tbody>
</table>
## Differences between Users and Non Users of GI

<table>
<thead>
<tr>
<th>Factors</th>
<th>Users</th>
<th>Non users</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceived confidence</td>
<td>2.7</td>
<td>1.8</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Perceived benefits</td>
<td>2.9</td>
<td>2.5</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Perceived barriers</td>
<td>2.2</td>
<td>2.8</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Knowledge</td>
<td>4.4</td>
<td>3.8</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>
Conclusions

- Dietitians need to become aware that GI is recommended by CDA
- Continuing education is needed
- Further development of educational tools
Impact of Study

- Education of Healthcare Professionals

**Dissemination of Study Results**

*Oral presentation & travel award, CDA conference, 2004*

*Publication in Canadian Journal of Dietetic Practice and Research, 2006*

**CDA review paper**

*Role of GI in the prevention and management of diabetes, Canadian Journal of Diabetes, 2005*

**Article for OPDQ**

*Target Quebec Dietitians*

**CDA GI Patient Education Tool**
THE
GLYCEMIC INDEX

What is the Glycemic Index of food?
The Glycemic Index (GI) is a scale that ranks carbohydrate-rich foods by how much they raise blood glucose levels compared to a standard food. The standard food is glucose or white bread.

Why should I eat foods with a low Glycemic Index?
Eating foods with a low Glycemic Index may help you to:
• Control your blood glucose level
• Control your cholesterol level
• Control your appetite
• Lower your risk of getting heart disease
• Lower your risk of getting type 2 diabetes

Use these meal planning ideas to include the Glycemic Index as part of healthy eating.
• Enjoy vegetables, fruits and low-fat milk products with your meals. These are carbohydrate-rich foods that, in general, have low glycemic index.
• Plan your meals with foods in the low and medium Glycemic Index starch choices on the list that follows.
• Try foods such as barley, bulgar, couscous, or lentils, which have a low Glycemic Index.
• Consult a registered dietitian for help with choosing low GI foods, adapting recipes, and other ways to incorporate low GI foods in your meal plan.

If I eat foods with a low Glycemic Index can I eat as much as I want?
No. Using the Glycemic Index to choose foods is only one part of healthy eating.

Healthy eating also means:
✓ Eating at regular times
✓ Choosing a variety of foods from all food groups
✓ Limiting sugars and sweets
✓ Reducing the amount of fat you eat
✓ Including foods high in fibre
✓ Limiting salt, alcohol and caffeine

Remember that checking your blood glucose before and 1 or 2 hours after a meal is the best way to know how your body handles the meal.

Know who to turn to

Check out the Canadian Diabetes Association website, www.diabetes.ca, for more information.
A lot of starchy foods have a high Glycemic Index (GI). Choose medium and low GI foods more often.

<table>
<thead>
<tr>
<th>Low GI (55 or less) *†</th>
<th>Medium GI (56-69) *†</th>
<th>High GI (70 or more) *†</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BREADS:</strong></td>
<td><strong>BREADS:</strong></td>
<td><strong>BREADS:</strong></td>
</tr>
<tr>
<td>100% stone ground whole wheat</td>
<td>Whole wheat</td>
<td>White bread</td>
</tr>
<tr>
<td>Heavy mixed grain</td>
<td>Rye</td>
<td>Kaiser roll</td>
</tr>
<tr>
<td>Pumpernickel</td>
<td>Pita</td>
<td>Bagel, white</td>
</tr>
<tr>
<td><strong>CEREAL:</strong></td>
<td><strong>CEREAL:</strong></td>
<td><strong>CEREAL:</strong></td>
</tr>
<tr>
<td>All Bran™</td>
<td>Grapenuts™</td>
<td>Bran flakes</td>
</tr>
<tr>
<td>Bran Buds with Psyllium™</td>
<td>Shredded Wheat™</td>
<td>Corn flakes</td>
</tr>
<tr>
<td>Oatmeal</td>
<td>Quick oats</td>
<td>Rice Krispies™</td>
</tr>
<tr>
<td>Oat Bran™</td>
<td></td>
<td>Cheerios™</td>
</tr>
<tr>
<td><strong>GRAINS:</strong></td>
<td><strong>GRAINS:</strong></td>
<td><strong>GRAINS:</strong></td>
</tr>
<tr>
<td>Parboiled or converted rice</td>
<td>Basmati rice</td>
<td>Short-grain rice</td>
</tr>
<tr>
<td>Barley</td>
<td>Brown rice</td>
<td></td>
</tr>
<tr>
<td>Bulgur</td>
<td>Couscous</td>
<td></td>
</tr>
<tr>
<td>Pasta/noodles</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>OTHER:</strong></td>
<td><strong>OTHER:</strong></td>
<td><strong>OTHER:</strong></td>
</tr>
<tr>
<td>Sweet potato</td>
<td>Potato, new/white</td>
<td>Potato, baking (Russet)</td>
</tr>
<tr>
<td>Yam</td>
<td>Sweet corn</td>
<td>French fries</td>
</tr>
<tr>
<td>Legumes</td>
<td>Popcorn</td>
<td>Pretzels</td>
</tr>
<tr>
<td>Lentils</td>
<td>Stoned Wheat Thins™</td>
<td>Rice cakes</td>
</tr>
<tr>
<td>Chickpeas</td>
<td>Ryvita™ (rye crisps)</td>
<td>Soda crackers</td>
</tr>
<tr>
<td>Kidney beans</td>
<td>Black bean soup</td>
<td></td>
</tr>
<tr>
<td>Split peas</td>
<td>Green pea soup</td>
<td></td>
</tr>
<tr>
<td>Soy beans</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baked beans</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*expressed as a percentage of the value for glucose  †Canadian values where available

Adapted with permission from: Foster-Powell K, Holt SHA, Brand-Miller JC. International table of glycemic index and glycemic load values Am J Clin Nutr 2002;765-76

One change I will make now is
Impact of Study

Education of Healthcare Professionals

**Abbott Laboratories Inc.**

*Developed power-point slide presentation targeted at diabetes educators and physicians*

**Article in Canadian Diabetes**

*Target family physicians*

**DC Backgrounder on GI**

**PEN (Practice-Based Evidence in Nutrition)**

*Developed content related to GI for PEN*
Health Promotion / Prevention

Q: Do healthy individuals who consume a high glycemic index (GI) diet have an increased risk of developing type 2 diabetes as compared to healthy individuals who consume a low GI diet? View Key Practice Points

Planning

Q: Do individuals with diabetes need to adjust the timing and/or dose of their medication based on the glycemic index (GI) rating, even if the carbohydrate content is the same? View Key Practice Points

Q: Do individuals with type 1 diabetes have better blood lipid control when they consume a low glycemic index (GI) diet compared to a high GI diet? View Key Practice Points

Q: Do individuals with type 2 diabetes have better blood lipid control when they consume a low glycemic index (GI) diet compared to a high GI diet? View Key Practice Points
Planning

Q: Do individuals with type 1 diabetes have better glycemic control when they consume a low glycemic index (GI) diet compared to a high GI diet?

Last Updated: Thursday, January 04, 2007

Key Practice Points

1. Adults with type 1 diabetes have improved long-term glycemic control when they consume a low GI diet compared to a high GI diet.
   (A)
   Evidence | References

2. Adults with type 1 diabetes have less hypoglycemic episodes when they consume a low GI diet compared to a high GI diet.
   (B)
   Evidence | References

3. Children with type 1 diabetes have less episodes of hyperglycemia (>15 mmol/L) when they receive flexible nutrition education emphasizing low GI carbohydrate choices.
   (B)
   Evidence | References

4. Children with type 1 diabetes have better long-term glycemic control when they receive flexible nutrition education emphasizing low GI carbohydrate choices.
   (B)
   Evidence | References

5. Children with type 1 diabetes have no increased risk of hypoglycemia when they receive flexible nutrition education emphasizing low GI carbohydrate choices.
   (B)
   Evidence | References
Planning

Key Practice Point:
Adults with type 1 diabetes have improved long-term glycemic control when they consume a low GI diet compared to a high GI diet.

Evidence:
a. A meta-analysis of 14 randomized trials concluded that choosing low GI foods in place of high GI foods has a small but clinically significant effect (reduction of ~0.4) on long-term glycemic control as measured by glycosylated hemoglobin (A1C) in adults with type 1 diabetes (1).

References

Impact of Study

- Education of Potential Patients/Consumers

  Canadian Health Network

  CDA GI Patient Education Tool

  Expert Committee to Health Canada
Future Directions: Implications for Research

- Applied Research
- Prevention and management of *Diabetes, Obesity and CVD*
- Other conditions (eg. Cancer, Polycystic Ovarian Syndrome)
- Continued support of CFDR for GI-related research
Future Directions: Implications for Practice

- Development of more resources for professionals to help integrate GI into practice
  - *eg. teaching manual, online course*
- Workshops
- Client education tools and resources
  - *some available via PEN*
Future Directions: Implications for Industry

- GI testing of more Canadian foods and food products
  *GI Testing Inc. (Dr. Thomas Wolever)*

- Development of low GI foods and food products

- Nutrition labeling (GI rating)

- Continued support of GI research
Acknowledgements

- Canadian Foundation for Dietetic Research
- Dietitians of Canada (esp. PEN team)
- Canadian Diabetes Association
- Beth Armour
<table>
<thead>
<tr>
<th>Factor</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degree of starch gelatinization</td>
<td>Spaghetti, oatmeal</td>
</tr>
<tr>
<td>(less gelatinized, lower GI)</td>
<td></td>
</tr>
<tr>
<td>Physical form of food</td>
<td>Pumpernickle, whole grain bread</td>
</tr>
<tr>
<td>(more intact, lower GI)</td>
<td></td>
</tr>
<tr>
<td>Amylose to Amylopectin</td>
<td>Basmati rice, cornstarch</td>
</tr>
<tr>
<td>(higher amylose, lower GI)</td>
<td></td>
</tr>
<tr>
<td>Fibre (viscous)</td>
<td>Rolled oats, lentils, beans</td>
</tr>
<tr>
<td>Sugars (sucrose, fructose, galactose)</td>
<td>Some cookies &amp; breakfast cereals, fruits, milk products</td>
</tr>
<tr>
<td>Acidity</td>
<td>Oranges, sourdough bread</td>
</tr>
</tbody>
</table>
GI= standardized ranking system for carbohydrates and carbohydrate-containing foods only
  - No GI rating for fat and protein foods

Applied to mixed meals as either meal GI or Glycemic Load

Evidence in prevention of type 2 diabetes, management of type 1 and 2 diabetes, prevention of CVD and obesity

Can easily be applied into clinical practice
Glycemic Index vs. Glycemic Load

- Glycemic load (GL) takes into account both the amount of available carbohydrate (grams), in a typical serving of a food, and the GI rating of that food.

- Whereas GI is a fixed number, GL can vary depending on the available carbohydrate content in a typical serving.

\[
\text{Glycemic Load} = \frac{\text{g carbohydrate per serving} \times \text{GI}}{100}
\]
Glycemic load is best to use, instead of GI, when a typical serving of a food has a high GI but a low carbohydrate content such as the following:

- Carrots, Pumpkin, Watermelon

When a typical serving of a food has a lot less available carbohydrate than the 25g or 50g used for GI testing, it is best to use glycemic load.

eg. ½ cup boiled carrots = 6 g available carbohydrate

(GI= 92 vs. GL= 6)
### Glycemic Load: Categories

<table>
<thead>
<tr>
<th>Category</th>
<th>GL Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>( \leq 10 )</td>
</tr>
<tr>
<td>Medium</td>
<td>11-19</td>
</tr>
<tr>
<td>High</td>
<td>( \geq 20 )</td>
</tr>
</tbody>
</table>

\[ GL = \text{carbohydrate quantity (g)} \times \text{GI} \]
Implementing GI: Practical Suggestions

- Replace half the high GI foods with low GI food choices
- Base at least 2 meals per day on low GI food choices
- Replace high GI breads and breakfast cereals with low GI choices
Implementing GI: Practical Suggestions

- Most *fruits, vegetables and milk products* have a low GI rating.

- The majority of *high GI* foods are found in the *grain products and starchy food group*, therefore, this food group should be the main focus of nutrition education regarding GI.
<table>
<thead>
<tr>
<th>Glycemic Index of Selected Grain and Starchy Foods</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Low GI</strong></td>
</tr>
<tr>
<td>Multigrain bread</td>
</tr>
<tr>
<td>Oatmeal</td>
</tr>
<tr>
<td>Converted rice</td>
</tr>
<tr>
<td>Sweet Potato</td>
</tr>
</tbody>
</table>

*Adapted from: Glycemic Index Tool of Canadian Diabetes Association*
Implementing GI: Tools and Resources

- **Glycemic Index Tool** (1 page, double-sided patient education handout, based on 2003 Clinical Practice Guidelines of Canadian Diabetes Association)
  
  *available at CDA Website (www.diabetes.ca)*

- **Book:** *The New Glucose Revolution*
  Jennie Brand-Miller, Thomas MS Wolever, Kaye Foster-Powell, Stephen Colaguiri
  
  *Marlow and Company, NY, 2002*

- Recently revised international table of **Glycemic Index** and **Glycemic Load** values
  
  *Foster-Powell et al. Am J Clin Nutr, 2002*
Implementing GI: Important Reminders

- Important to use “country-specific” *Glycemic Index* and *Glycemic Load* values

- Remember to consider the *entire* nutrient composition of a food, not just GI