Glycaemic index and body weight

Gary Frost
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Percentage of people with a BMI over 30kg/m²
Change in nutrient intake over time

- Decrease dietary fibre
- Increase GI

Stable but mismatched genetic background
What is glycaemic index
Known from the beginning of the century that different CHO have different effects on blood glucose and insulin.

Early 1980’s Jenkins, Wolever and Leeds termed the phrase GI. Aimed at improving glycaemic control in people living with diabetes.
Glycaemic response of carbohydrates

Delta change in glucose (mmol/l)

Time (minutes)

White Bread  Wholemeal Bead  White pasta  Kidney beans
What is Glycaemic Index

Incremental area under the blood glucose response curve for 50g of available carbohydrate from test food

\[ \frac{\text{Corresponding area after equi-carbohydrate portion of glucose}}{\text{Incremental area}} \times 100 \]
# Glycaemic index

<table>
<thead>
<tr>
<th>FOOD</th>
<th>GI bread</th>
<th>GI glucose</th>
</tr>
</thead>
<tbody>
<tr>
<td>White bread</td>
<td>100</td>
<td>71</td>
</tr>
<tr>
<td>Wholemeal bred</td>
<td>100</td>
<td>71</td>
</tr>
<tr>
<td>Brown rice</td>
<td>81</td>
<td>56</td>
</tr>
<tr>
<td>White rice</td>
<td>81</td>
<td>56</td>
</tr>
<tr>
<td>Boiled potato</td>
<td>98</td>
<td>70</td>
</tr>
<tr>
<td>Pasta</td>
<td>65</td>
<td>44</td>
</tr>
<tr>
<td>Yam</td>
<td>53</td>
<td>37</td>
</tr>
<tr>
<td>Green banana</td>
<td>54</td>
<td>38</td>
</tr>
<tr>
<td>Sucrose</td>
<td>83</td>
<td>58</td>
</tr>
<tr>
<td>Baked beans</td>
<td>69</td>
<td>48</td>
</tr>
<tr>
<td>Chickpeas</td>
<td>39</td>
<td>28</td>
</tr>
</tbody>
</table>
Glycaemic Index

- Amount and type of resistant starch
- Degree of starch gelatinisation
- Amylose to amylopectin ratio
- Sugar
- Protein-starch and fat-starch interactions

- Physical form of food
- Fibre
- Fat
- Anti-nutrients
Physical form of food

The larger the particle size, the lower the G.I. factor.
Evidence in diabetes
Systematic review
Brand-Miller 2004

Figure 1—A meta-analysis was performed using either the end point HbA1c or fasting glucose data in all 14 studies. Because these factors have different units of measurement, the difference between the two data has been expressed as percentage terms. Points to the left of the vertical line indicate that the low-GI diet reduced values by 3% or above those seen with the high-GI diet. When final values were adjusted for differences at baseline, the mean difference was −7.4% (−8.8 to −6.0) in favor of the low-GI diet, assuming independence.
Meta-analysis of observational studies

GI and diabetes risk (RR = 1.39)

**Meta-analysis of Low GI studies - Type 2 diabetes**

<table>
<thead>
<tr>
<th>Model</th>
<th>Group by Dis</th>
<th>Study name</th>
<th>Statistics for each study</th>
<th>Rate ratio and 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Rate ratio</td>
<td>Lower limit</td>
</tr>
<tr>
<td>Fixed</td>
<td>Type 2 diab</td>
<td>SalmeronF</td>
<td>1.37</td>
<td>1.09</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SalmeronM</td>
<td>1.37</td>
<td>1.02</td>
</tr>
<tr>
<td></td>
<td>Type 2 diab</td>
<td>Schulze</td>
<td>1.59</td>
<td>1.21</td>
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<tr>
<td></td>
<td>Type 2 diab</td>
<td>Hodge</td>
<td>1.36</td>
<td>0.95</td>
</tr>
<tr>
<td></td>
<td>Type 2 diab</td>
<td>Zhang</td>
<td>1.30</td>
<td>1.00</td>
</tr>
<tr>
<td>Random</td>
<td>Type 2 diab</td>
<td></td>
<td>1.39</td>
<td>1.23</td>
</tr>
</tbody>
</table>

Favours high GI  
Favours low GI

Barclay et al. 2007, AJCN, in press
The evolution of Man...

2.5 million years

50 years
Acute studies
Glycaemic response to foods: Impact on satiety and long-term weight regulation

- 19 studies covering 248 volunteers
- 12 supported an increase in satiety with low GI using VAS
- 4 out of the 7 studies using an objective method for satiety assessment
Effect of the glycemic index of carbohydrates on day-long (10 h) profiles of plasma glucose, insulin, cholecystokinin and ghrelin

R C Reynolds etal 2008
Influence of Glycemic Index/Load on Glycemic Response, Appetite, and Food Intake in Healthy Humans

Rita C.G. Alfenas, etal

Mean (±SE) breakfast and lunch self-reported hunger (A), fullness (B), and desire-to-eat (C) ratings obtained on a general labeled magnitude scale by 39 participants on days 1 and 8.

Alfenas R C, and Mattes R D Dia Care 2005;28:2123-2129
Effects of dietary glycemic index on brain regions related to reward and craving in men

Mean ± SE changes in plasma glucose (A), serum insulin (B), and hunger (C) after test meals.

Why is this different: GI difference 47 points different
Regions with significantly different cerebral blood flow 4 h after test meals (P ≤ 0.002).

- Cerebral blood flow was greater 4 h after the high-than low-GI meal in the right nucleus accumbens
- right striatum down regulate dopamine and lead to overeating
Total glucagon-like peptide-1 (GLP-1), total peptide YY (PYY), dipeptidylpeptidase-4 (DPP-4) activity, blood glucose, and insulin in rats fed control diet (□) or resistant starch (RS) diet (♦) ad libitum for 10 days in study 1.


2008 by American Physiological Society
Long term
Low glycaemic index or low glycaemic load diets for overweight and obesity (Review)

Thomas D, Elliott EJ, Baur L

Potentially relevant articles from electronic databases: 892 publications

Articles retrieved for more detailed evaluation: 68 publications (19 potentially relevant RCTs)

Titles or abstracts excluded because they did not fulfill inclusion criteria: 824

Full text articles excluded: 62 publications (13 RCTs)

Studies that met inclusion criteria: 6 publications (6 RCTs)

Body mass

Pooled data from the four studies reporting change in body mass (Bouche 2002; McMillan-Price 2006; Slabber 1994; Sloth 2004) showed that weight loss was significantly greater in participants receiving the low glycaemic diet compared with those receiving the comparison diet (WMD -1.1 kg, 95% CI -2.0 to -0.2, P < 0.05) (n =163). The fifth study (Ebbeling 2005) reported % change in body mass (WMD -0.60 kg, 95% CI -4.56 to 3.36).
### Analysis 1.1. Comparison 1 Low glycaemic diet versus high glycaemic or other diet, Outcome 1 change in body mass (kg).

**Review**: Low glycaemic index or low glycaemic load diets for overweight and obesity

**Comparison**: 1 Low glycaemic diet versus high glycaemic or other diet

**Outcome**: 1 change in body mass (kg)

<table>
<thead>
<tr>
<th>Study or subgroup</th>
<th>Intervention</th>
<th>Control</th>
<th>Mean Difference</th>
<th>Weight</th>
<th>Mean Difference</th>
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<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mean(SD)</td>
<td>N</td>
<td>Mean(SD)</td>
<td>IVFixed, 95% CI</td>
</tr>
<tr>
<td>I change in body mass (kg)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bouche 2002</td>
<td>11</td>
<td>-0.3 (9.6)</td>
<td>11</td>
<td>0.5 (8.9)</td>
<td></td>
</tr>
<tr>
<td>McMillan-Price 2006</td>
<td>32</td>
<td>-5.6 (4)</td>
<td>32</td>
<td>-4.3 (4)</td>
<td></td>
</tr>
<tr>
<td>Slabber 1994</td>
<td>16</td>
<td>-7.42 (2.49)</td>
<td>16</td>
<td>-4.48 (4.23)</td>
<td></td>
</tr>
<tr>
<td>Sloth 2004</td>
<td>23</td>
<td>-1.9 (2.4)</td>
<td>22</td>
<td>-1.3 (1.4)</td>
<td></td>
</tr>
<tr>
<td><strong>Total (95% CI)</strong></td>
<td><strong>82</strong></td>
<td><strong>81</strong></td>
<td></td>
<td></td>
<td><strong>100.0 %</strong></td>
</tr>
</tbody>
</table>

Heterogeneity: Chi² = 3.03, df = 3 (P = 0.39); I² = 1%
Test for overall effect: Z = 2.35 (P = 0.019)
Test for subgroup differences: Not applicable
The study was based on a mean (±SD) difference in BMI of 1.2 ± 2.5, assuming 90% power and a 5% significance level. The needed total sample size was 148 (8). Allowing for non-compliance in both groups, the estimated sample size was 172; after further adjustment for an estimated 20% loss during follow-up, the total sample size was estimated to be 206.
No effect of a diet with a reduced glycaemic index on satiety, energy intake and body weight in overweight and obese women

LM Aston, CS Stokes and SA Jebb

MRC Human Nutrition Research, Elsie Widdowson Laboratory, Cambridge, UK

Table 3  Effect of dietary intervention on body weight and composition (n = 19)

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>High GI diet</th>
<th>Low GI diet</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>s.d.</td>
<td>Mean</td>
<td>s.d.</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>87.5</td>
<td>15.0</td>
<td>89.2</td>
<td>16.1</td>
</tr>
<tr>
<td>Waist* (cm)</td>
<td>103</td>
<td>0.12</td>
<td>106</td>
<td>0.13</td>
</tr>
<tr>
<td>Fat mass (kg)</td>
<td>42.3</td>
<td>8.4</td>
<td>42.9</td>
<td>8.9</td>
</tr>
<tr>
<td>Lean mass (kg)</td>
<td>43.8</td>
<td>5.2</td>
<td>44.6</td>
<td>5.7</td>
</tr>
<tr>
<td>Body fat (%)</td>
<td>47.8</td>
<td>3.5</td>
<td>47.6</td>
<td>3.6</td>
</tr>
</tbody>
</table>

Abbreviation: GI, glycaemic index. *Log10 transformed for statistical analysis; geometric mean and s.d. of logged data, ratio of geometric means and confidence interval around ratio of geometric means presented.
Weight maintenance
Diogenes.

The Effect of Dietary Glycemic Index on Weight Maintenance in Overweight Subjects: A Pilot Study

[Graph showing weight change over time for all subjects, HGI group, and LGI group.]
What is going on?
Inulin and Appetite

![Graph of Hunger Score vs. Inulin dose (g/day)]

![Graph of 24-hour energy intake (Kcal) vs. Inulin dose (g/24hr)]

![Graph of PYY (pmol/l) vs. Time (minutes)]
Dietary NDCs have positive biological effects – mediated by SCFA

Increased SCFA concentration
- Increased dietary NDCs
- Increased fermentation
- Reduced appetite and food intake
  - Reduced free fatty acid output
  - Increased lipogenesis
  - Increased leptin secretion
  - Reduced inflammation

Increased anorexigenic signalling
- FFAR2/3
- SCFA

Improved insulin sensitivity
- Reduced cholesterol synthesis
- Reduced glucose output
- Reduced inflammation

Change in gut flora
- FFAR2/3

Reduced inflammation
- FFAR2/3

Increased concentration of SCFA
- FFAR2/3

Reduced appetite and food intake
- Reduced inflammation

Increased dietary NDCs
- Increased fermentation

Increased leptin secretion
- FFAR2/3

Reduced cholesterol synthesis
- FFAR2/3

Reduced glucose output
- FFAR2/3

Reduced inflammation
- FFAR2/3

Increased lipogenesis
- FFAR2/3

Increased leptin secretion
- FFAR2/3
Conclusion

The effect of glycaemic index on appetite and body weight is a bit mixed.

But

Big differences show clear effects
High intakes of fermentable carbohydrate show effect

Need a fresh look with this insight.