**New diabetes nutrition therapy guidelines:**
**the evidence and controversies**
**- focus on macronutrients**

# Carbohydrate

# high or low

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| Type of carbohydrate | Digestion and absorption in small intestine[a] | US food labeling designation |
|---|---|---|
| **Monosaccharides** | | |
| Glucose, fructose, galactose | + | Sugars |
| Sorbitol, mannitol, etc | +/− | Sugar alcohol |
| **Disaccharides** | | |
| Sucrose, maltose, lactose | + | Sugars |
| Lactitol, maltitol, etc | +/− | Sugar alcohol |
| **Oligosaccharides** | | |
| α-Galactosides (eg, raffinose, stachyose) | − | Other carbohydrate |
| Fructooligosaccharides | − | Other carbohydrate |
| Maltodextrins | + | Other carbohydrate |
| Polydextrose | − | Other carbohydrate |
| **Polysaccharides** | | |
| **Starch (α-glucans)** | | |
| Amylose | +/− | Other carbohydrate |
| Amylopectin | +/− | Other carbohydrate |
| Modified food starches | +/− | Other carbohydrate |
| **Nonstarch (non-α-glucans) polysaccharides** | | |
| Cell wall and chemically related polymers (eg, cellulose, hemicelluloses, pectins, β-glucans) | − | Dietary fiber |
| Storage (eg, inulins or fructans, guar) | − | Dietary fiber |
| Plant gums, exudates, and seed mucilages (eg, Ispaghula or psyllium) | − | Dietary fiber |
| Algal polysaccharides | − | Dietary fiber |

**Figure.** Main types of food carbohydrates. [a]Plus sign (+) represents complete/nearly 100% digestion and absorption in the small intestine, whereas plus-or-minus sign (+/−) represents partly digested and absorbed, with the range being very large (2% to 90%), and minus sign (−) represents no digestion and absorption in the small intestine. Adapted with permission from reference 4: *Am J Clin Nutr*. 1995;61(suppl):930S-937S, American Society for Nutrition, and from reference 5: *Am J Clin Nutr*. 1995;61(suppl):938S-945S, American Society for Nutrition.

Wheeler et al, J Am Diet Assoc., 2008;108:S34-S39

**Table 1. Timeline of diets for treating diabetes mellitus**

| Historical period | Author/title | Type of diet |
|---|---|---|
| 1550 BC | Ebers Papyrus | Rich in carbohydrates such as wheat, grains, grapes, honey and berries |
| AD 128–200 | Galen | Sun-dried membranes from young roosters' abdomen or drinks made of a mixture of mountain copper, dry acorn, flower of the wild pomegranate, oak gall, honey of roses and cold water |
| 980–1037 | Avicenna | Rich in lupin, fenugreek and zedoary |
| 1621–75 | Thomas Willis | Milk and barley-water boiled with bread |
| 1799 | John Rollo | 1500-calorie diet, low in carbohydrates and high in fat and protein, based on rancid meat and blood pudding |
| Beginning of the 20th century | Allen, Joslin | Very low-calorie diet, called the 'starvation diet', high in protein and fat and low in carbohydrates. Contained 70% fat, 10% carbohydrate, 20% protein |
| 1940s | American Diabetes Association | Carbohydrate content of 40% |
| 1950 | American Diabetes Association | Normal quantity of calories, comprise 43% carbohydrate, 19% protein, 37% fat |
| 1971 | American Diabetes Association | 45% or more carbohydrate |
| 1979 | American Diabetes Association | 50–60% carbohydrate, 12–20% protein, 20–30% fat |
| 1986 | American Diabetes Association | 55–60% carbohydrate, 0.8 g/kg protein, total fat <30% |
| 1994 | American Diabetes Association | 10–20% protein, <10% from saturated fat |
| 2008 | American Diabetes Association | 130 g/day carbohydrate, 14 g fibre/1000 kcal, cholesterol <200 mg/day, 20% protein |

Diabetes Metab Res Rev 2014;30(Suppl. 1): 24–33

| Standards of Medical Care in Diabetes—2015 | | |
|---|---|---|
| Eating patterns and macronutrient distribution | Evidence suggests that there is not an ideal percentage of calories from carbohydrate, protein, and fat for all people with diabetes B; therefore, macronutrient distribution should be based on individualized assessment of current eating patterns, preferences, and metabolic goals. E | B, E |
| | Carbohydrate amount and available insulin may be the most important factors influencing glycemic response after eating and should be considered when developing the eating plan. | A |
| | Monitoring carbohydrate intake, whether by carbohydrate counting or experience-based estimation, remains critical in achieving glycemic control. | B |
| | Carbohydrate intake from vegetables, fruits, whole grains, legumes, and dairy products should be advised over intake from other carbohydrate sources, especially those that contain added fats, sugars, or sodium. | B |

Q. Adequate carbohydrate distribution(amount)?

FOCUS in glucose control

RCT

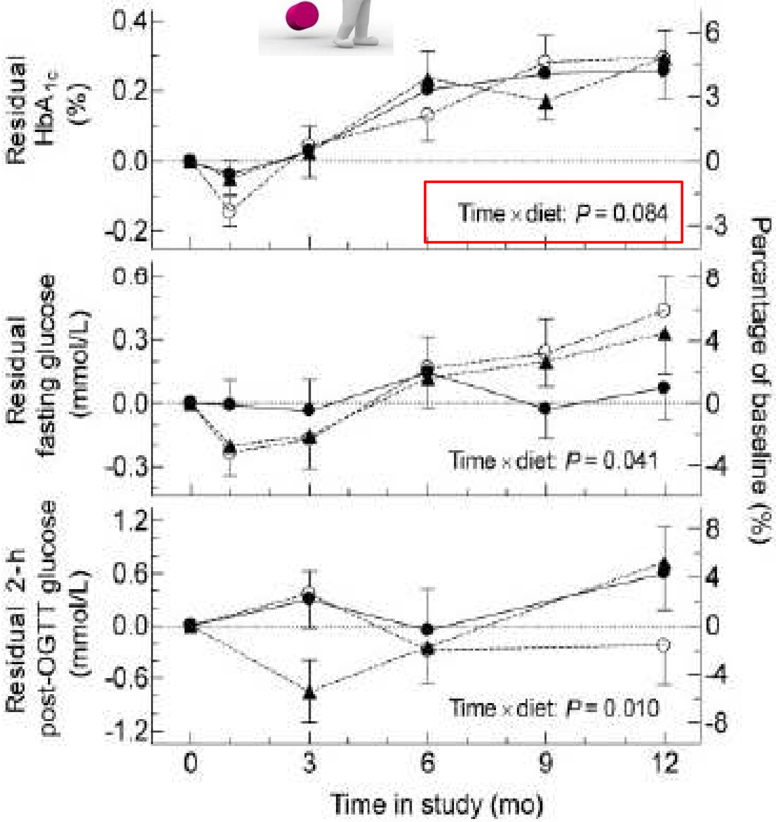



**FIGURE 2.** Mean (±SEM) glycated hemoglobin ($HbA_{1c}$), fasting glucose, and plasma glucose concentrations 2 h after a 75-g oral-glucose-tolerance test (OGTT) in subjects receiving the high-glycemic-index (●; $n$ = 48), low-glycemic-index (○; $n$ = 55), and low-carbohydrate (▲; $n$ = 53) diets. Values are the residuals of regression models including the baseline value and other significant confounding variables, which were as follows: $HbA_{1c}$, none; fasting glucose, BMI; 2-h post-OGTT glucose, fasting glucose.

Wolever et al, Am J Clin Nutr:2008;87(1):114-25.

[Method]

1. 162 Type 2 diabetes, Canada, 12months
2. High GI(●) : 46.5% carbohydrates, 30.8% fat, 20.4% protein
   Low GI(○) : 51.9% carbohydrates, 26.5% fat, 20.6% protein
   Low CHO(▲) : 39.3% carbohydrates, 40.1% fat, 19.1% protein

[Result]

: no significant difference in HbA1c with the different diets

RCT

Haimoto et al, Diabetes Res Clin Pract. 2008;79(2):350-356

**Table 4 – Changes in HbA1c level, BMI, serum cholesterols, uric acid and creatinine in the conventional diet and CARD groups in the 2-year study period**

| | CD | | | CARD | | |
|---|---|---|---|---|---|---|
| | Baseline (n = 57) | After 1 year (n = 57) | After 2 years (n = 57) | Baseline (n = 76) | After 1 year (n = 70) | After 2 years (n = 45) |
| HbA1c (%) | 7.1 ± 1.0 (5.9–10.6) | 7.0 ± 1.0[a] (6.0–10.2) | 7.5 ± 1.3[a] (6.0–13.7) | 7.4 ± 1.1 (6.2–12.6) | 6.7 ± 0.7[a] (5.3–8.8) | 6.7 ± 0.6[a] (5.4–8.3) |
| BMI | 24.2 ± 2.9 (19.3–30.4) | 24.0 ± 2.9[a] (19.1–29.7) | 23.8 ± 3.0[a] (18.7–30.8) | 25.1 ± 3.4 (17.9–34.5) | 24.3 ± 3.3[a] (17.7–33.1) | 23.8 ± 3.5[a] (17.1–32.7) |
| Total cholesterol[b] (mg/dl) | 201 ± 34 | | 210 ± 38[c] | 205 ± 33 | | 200 ± 29[c] |
| LDL cholesterol[b] (mg/dl) | 122 ± 30 | | 134 ± 39[d] | 122 ± 29 | | 117 ± 25[d] |
| Uric acid (mg/dl) | 5.0 ± 1.2 | | 5.3 ± 1.4[e] | 4.9 ± 1.4 | | 5.8 ± 1.4[e] |
| Creatinine (mg/dl) | 0.86 ± 0.17 | | 0.70 ± 0.16[f] | 0.86 ± 0.20 | | 0.73 ± 0.22[f] |

Values are means ± S.D. The time trends were statistically tested by ANOVA. The numbers in parenthesis express ranges.
[a] $P < 0.001$.
[b] Fourteen patients (CD: 5, CARD: 9) were excluded because they received lipids-lowering agents.
[c] $P = 0.037$.
[d] $P = 0.011$.
[e] $P = 0.192$.
[f] $P = 0.653$.

[Method]
1. 133 Type 2 diabetes, Japan, 24months
2. CARD, carbohydrate-reduced diet : 45% carbohydrates, 33% fat, 18% protein
   CD, conventional diet : 57% carbohydrates, 26% fat, 16% protein

[Result]
: 2-year follow-up period, HbA1c levels were significantly improved in the CARD group (P < 0.001)

RCT

Davis et al, Diabetes Care; 2009;32(7):1147-52

Table 2—*Change in anthropometric and metabolic outcomes at 3, 6, and 12 months after diet initiation*

| | 3 months | 6 months | 12 months | P |
|---|---|---|---|---|
| A1C | | | | |
| Low-carbohydrate diet | −0.64 ± 1.4 | −0.29 ± 0.92 | −0.02 ± 0.89 | 0.71 |
| Low-fat diet | −0.26 ± 1.1 | −0.15 ± 1.1 | 0.24 ± 1.4 | |
| Weight (kg)* | | | | |
| Low-carbohydrate diet | −5.2 ± 2.8 | −4.8 ± 3.5 | −3.1 ± 4.8 | 0.005 |
| Low-fat diet | −3.2 ± 3.7 | −4.4 ± 5.3 | −3.1 ± 5.8 | |
| Systolic blood pressure (mmHg) | | | | |
| Low-carbohydrate diet | −5.8 ± 19.2 | −0.78 ± 17.7 | 2.0 ± 15.6 | 0.15 |
| Low-fat diet | −0.98 ± 21.0 | −37 ± 19.8 | −1.8 ± 22.6 | |
| Diastolic blood pressure (mmHg) | | | | |
| Low-carbohydrate diet | −2.2 ± 12.5 | −0.93 ± 12.4 | −2.9 ± 9.4 | 0.62 |
| Low-fat diet | −0.40 ± 12.6 | 0.95 ± 9.8 | −2.2 ± 11.6 | |
| Total cholesterol (mmol/l)† | | | | |
| Low-carbohydrate diet | | 0.05 ± 0.79 | 0.10 ± 0.76 | 0.37 |
| Low-fat diet | | −0.27 ± 0.74 | −0.13 ± 0.70 | |
| LDL (mmol/l) | | | | |
| Low-carbohydrate diet | | −0.10 ± 0.52 | −0.04 ± 0.63 | 0.23 |
| Low-fat diet | | −0.25 ± 0.56 | −0.18 ± 0.66 | |
| HDL (mmol/l) | | | | |
| Low-carbohydrate diet | | 0.16 ± 0.28 | 0.16 ± 0.27 | 0.002 |
| Low-fat diet | | −0.01 ± 0.22 | 0.06 ± 0.21 | |
| Triglycerides (mmol/l) | | | | |
| Low-carbohydrate diet | | −0.02 ± 0.85 | −0.15 ± 0.88 | 0.53 |
| Low-fat diet | | 0.04 ± 0.56 | −0.01 ± 0.86 | |

Data are means ± SD. *P values for diet difference over all time points. †Lipid values were not collected at 3 months.

[Method]

1. 105 Type 2 diabetes with overweight, USA, 12months
2. Low-carbohydrate diet : 33.4% carbohydrates, 43.9% fat, 22.7% protein
   Low fat diet : 50.1% carbohydrates, 30.8% fat, 18.9% protein

[Result]

: There was no significant change in A1C in either group at 1 year

Cross-sectional

…panese patients with type 2 diabetes divided by quartiles of glycated hemoglobin A1c

| | Q1 (-7.90) (n = 89) | Q2 (7.90-8.30) (n = 128) | Q3 (8.30-8.80) (n = 93) | Q4 (8.80-) (n = 107) | Total (n = 417) | P for trend | Women Q1 (-7.90) (n = 117) | Q2 (7.90-8.30) (n = 141) | Q3 (8.30-8.80) (n = 110) | Q4 (8.80-) (n = 127) | Total (n = 495) | P for trend |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age (years) | 71.7 ± 4.8 | 70.9 ± 4.3 | 72.0 ± 4.5 | 71.5 ± 4.8 | 71.4 ± 4.6 | 0.782 | 73.0 ± 4.5 | 72.0 ± 4.9 | 71.3 ± 4.5 | 72.7 ± 5.1 | 72.3 ± 4.8 | 0.483 |
| Body height (cm) | 162.4 ± 5.6 | 162.2 ± 6.6 | 162.9 ± 6.4 | 163.1 ± 6.8 | 162.6 ± 6.4 | 0.336 | 150.1 ± 5.2 | 149.8 ± 5.0 | 150.1 ± 5.6 | 149.4 ± 5.5 | 149.9 ± 5.3 | 0.358 |
| Body weight (kg) | 62.3 ± 8.3 | 61.8 ± 9.2 | 61.9 ± 8.2 | 62.9 ± 9.8 | 62.2 ± 8.9 | 0.582 | 54.8 ± 9.5 | 53.1 ± 8.5 | 54.8 ± 9.7 | 53.1 ± 8.3 | 53.9 ± 9.0 | 0.347 |
| BMI (kg/m2) | 23.6 ± 3.0 | 23.5 ± 2.9 | 23.3 ± 3.0 | 23.6 ± 3.4 | 23.5 ± 3.1 | 0.986 | 24.3 ± 4.0 | 23.6 ± 3.5 | 24.3 ± 4.0 | 23.7 ± 3.2 | 24.0 ± 3.7 | 0.523 |
| Waist circumference (cm) | 86.7 ± 8.1 | 85.9 ± 9.2 | 85.6 ± 8.9 | 87.2 ± 8.7 | 86.3 ± 8.8 | 0.657 | 84.0 ± 11.2 | 81.0 ± 11.0 | 81.8 ± 10.9 | 80.3 ± 9.6 | 81.7 ± 10.7 | 0.025* |
| Hip circumference (cm) | 95.5 ± 7.0 | 94.3 ± 7.2 | 93.6 ± 7.0 | 94.9 ± 6.9 | 94.6 ± 7.0 | 0.517 | 94.5 ± 8.1 | 92.2 ± 8.8 | 94.0 ± 8.9 | 92.4 ± 8.3 | 93.2 ± 8.6 | 0.244 |
| Waist/hip ratio | 0.91 ± 0.06 | 0.91 ± 0.06 | 0.91 ± 0.06 | 0.92 ± 0.06 | 0.91 ± 0.06 | 0.165 | 0.89 ± 0.08 | 0.88 ± 0.08 | 0.87 ± 0.07 | 0.87 ± 0.07 | 0.88 ± 0.08 | 0.042* |
| Therapy for diabetes (n) | 17/59/13 | 21/72/35 | 9/58/26 | 5/65/37 | 52/254/111 | 0.004†** | 12/75/30 | 10/85/46 | 8/65/37 | 8/79/40 | 38/304/153 | 0.789† |
| (Diet/oral diabetes drug/insulin) (%) | 19.1/66.3/14.6 | 16.4/56.3/27.3 | 9.7/62.4/28.0 | 4.7/60.7/34.6 | 12.5/60.9/26.6 | 0.004†** | 10.3/64.1/25.6 | 7.1/60.3/32.6 | 7.3/59.1/33.6 | 6.3/62.2/31.5 | 8/61/31 | 0.789† |
| HbA1c (%) | 7.59 ± 0.13 | 8.04 ± 0.10 | 8.47 ± 0.14 | 9.56 ± 0.91 | 8.43 ± 0.86 | 0.000** | 7.62 ± 0.14 | 8.03 ± 0.11 | 8.48 ± 0.14 | 9.67 ± 0.99 | 8.45 ± 0.93 | 0.000** |
| Fasting plasma glucose (mg/dL) | 155.1 ± 36.0 | 167.1 ± 48.3 | 171.6 ± 50.6 | 180.7 ± 58.3 | 169.0 ± 50.0 | 0.001** | 154.5 ± 40.3 | 158.9 ± 45.4 | 169.2 ± 48.1 | 181.5 ± 60.9 | 166.2 ± 50.5 | 0.000** |
| Total cholesterol (mg/dL) | 193.6 ± 31.0 | 187.1 ± 29.8 | 192.0 ± 36.9 | 199.5 ± 31.9 | 192.7 ± 32.5 | 0.072 | 211.5 ± 33.5 | 208.0 ± 32.1 | 213.1 ± 39.5 | 213.0 ± 36.8 | 211.3 ± 35.3 | 0.484 |
| Triglycerides (mg/dL) | 146.1 ± 90.8 | 123.3 ± 65.0 | 131.2 ± 86.1 | 141.7 ± 169.6 | 134.6 ± 109.9 | 0.949 | 135.4 ± 71.4 | 136.5 ± 69.2 | 131.9 ± 67.7 | 129.1 ± 69.9 | 133.3 ± 69.4 | 0.388 |
| LDL cholesterol (mg/dL) | 112.5 ± 28.2 | 113.3 ± 30.1 | 115.1 ± 31.1 | 120.1 ± 25.6 | 115.3 ± 28.9 | 0.051 | 122.4 ± 32.1 | 122.1 ± 30.0 | 125.8 ± 34.5 | 128.5 ± 32.5 | 124.6 ± 32.2 | 0.085 |
| HDL cholesterol (mg/dL) | 53.1 ± 20.9 | 49.0 ± 13.6 | 51.7 ± 16.8 | 52.8 ± 14.3 | 51.5 ± 16.3 | 0.669 | 62.1 ± 20.8 | 60.3 ± 19.7 | 60.9 ± 17.9 | 58.6 ± 16.3 | 60.4 ± 18.7 | 0.196 |
| Albumin (g/dL) | 4.16 ± 0.36 | 4.20 ± 0.30 | 4.20 ± 0.38 | 4.22 ± 0.33 | 4.19 ± 0.34 | 0.294 | 4.22 ± 0.31 | 4.26 ± 0.40 | 4.20 ± 0.44 | 4.21 ± 0.32 | 4.22 ± 0.37 | 0.418 |
| Systolic blood pressure (mmHg) | 139.8 ± 14.8 | 135.7 ± 15.6 | 134.2 ± 16.4 | 133.2 ± 15.0 | 135.6 ± 15.6 | 0.003** | 140.6 ± 17.3 | 134.9 ± 14.7 | 135.7 ± 16.2 | 138.0 ± 15.9 | 137.2 ± 16.1 | 0.338 |
| Diastolic blood pressure (mmHg) | 76.4 ± 9.5 | 75.0 ± 9.9 | 75.6 ± 9.9 | 74.9 ± 9.7 | 75.4 ± 9.7 | 0.404 | 74.1 ± 11.1 | 74.1 ± 9.9 | 74.3 ± 8.6 | 75.1 ± 8.5 | 74.4 ± 9.6 | 0.406 |
| Energy (kcal/day) | 1756 ± 329 | 1750 ± 372 | 1899 ± 382 | 1820 ± 468 | 1802 ± 396 | 0.054 | 1645 ± 330 | 1659 ± 331 | 1721 ± 357 | 1625 ± 329 | 1661 ± 337 | 0.932 |
| Energy/standard bodyweight (kcal/day/kg) | 30.4 ± 6.1 | 30.3 ± 6.5 | 32.6 ± 6.7 | 31.1 ± 7.5 | 31.0 ± 6.8 | 0.153 | 33.2 ± 6.8 | 33.6 ± 6.8 | 34.8 ± 7.3 | 33.1 ± 6.7 | 33.7 ± 6.9 | 0.836 |
| Energy/present bodyweight (kcal/day/kg) | 28.6 ± 6.2 | 28.8 ± 6.9 | 31.2 ± 7.3 | 29.4 ± 7.9 | 29.4 ± 7.2 | 0.152 | 30.8 ± 7.5 | 32.1 ± 8.4 | 32.1 ± 8.0 | 31.3 ± 7.8 | 31.6 ± 7.9 | 0.646 |
| Protein (%E) | 15.2 ± 2.4 | 15.0 ± 1.9 | 15.4 ± 2.3 | 15.2 ± 2.2 | 15.2 ± 2.2 | 0.671 | 15.6 ± 2.1 | 15.8 ± 2.2 | 15.5 ± 1.8 | 15.7 ± 2.3 | 15.7 ± 2.1 | 0.910 |
| Fat (%E) | 24.7 ± 4.4 | 25.1 ± 5.1 | 26.0 ± 5.0 | 25.7 ± 5.1 | 25.4 ± 5.0 | 0.095 | 25.3 ± 4.2 | 25.9 ± 4.5 | 26.1 ± 4.4 | 25.6 ± 4.7 | 25.8 ± 4.5 | 0.594 |
| Carbohydrate (%E) | 60.1 ± 5.8 | 59.9 ± 6.0 | 58.6 ± 6.2 | 59.2 ± 6.6 | 59.5 ± 6.2 | 0.134 | 59.0 ± 5.7 | 58.3 ± 5.6 | 58.4 ± 5.3 | 58.7 ± 6.3 | 58.6 ± 5.7 | 0.708 |
| Protein (g/day) | 66.9 ± 16.8 | 65.6 ± 17.2 | 73.4 ± 19.0 | 69.5 ± 23.6 | 68.6 ± 19.5 | 0.066 | 65.1 ± 19.0 | 65.7 ± 16.8 | 67.0 ± 17.5 | 64.6 ± 19.0 | 65.6 ± 18.0 | 0.929 |
| Fat (g/day) | 48.7 ± 15.0 | 49.7 ± 17.4 | 55.9 ± 19.4 | 53.0 ± 21.7 | 51.7 ± 18.7 | 0.026* | 47.2 ± 15.1 | 48.8 ± 16.1 | 50.7 ± 16.4 | 47.3 ± 16.2 | 48.4 ± 16.0 | 0.794 |
| Carbohydrate (g/day) | 245.6 ± 41.5 | 245.9 ± 46.6 | 260.6 ± 49.8 | 248.3 ± 58.5 | 249.7 ± 49.8 | 0.337 | 236.2 ± 39.7 | 235.6 ± 41.3 | 244.9 ± 45.7 | 231.6 ± 38.0 | 236.8 ± 41.3 | 0.731 |

The values are mean ± SD. P-value for trend: $^*P < 0.05$, $^{**}P < 0.01$. $^{\dagger}\chi^2$-test was used for statistical analysis. BMI, body mass index; %E, percentage of total energy intake; HbA1c, glycated haemoglobin A1c, HDL, high-density lipoprotein; LDL, low-density lipoprotein.

Kamada et al, Geriar Gerontol Int. 2012; 41-49

[Method]

1. 1,173 Type 2 diabetes, Japan

[Objective]

: clarify the correlation between the PFC energy ratio and glycated hemoglobin A1c (HbA1c)

[Result]

: the four quartiles divided by HbA1c levels, there were <u>no significant differences</u> in carbohydrate ratio.

# Meta

Kirk et al, J Am Diet Assoc,2008;108(1):91-100

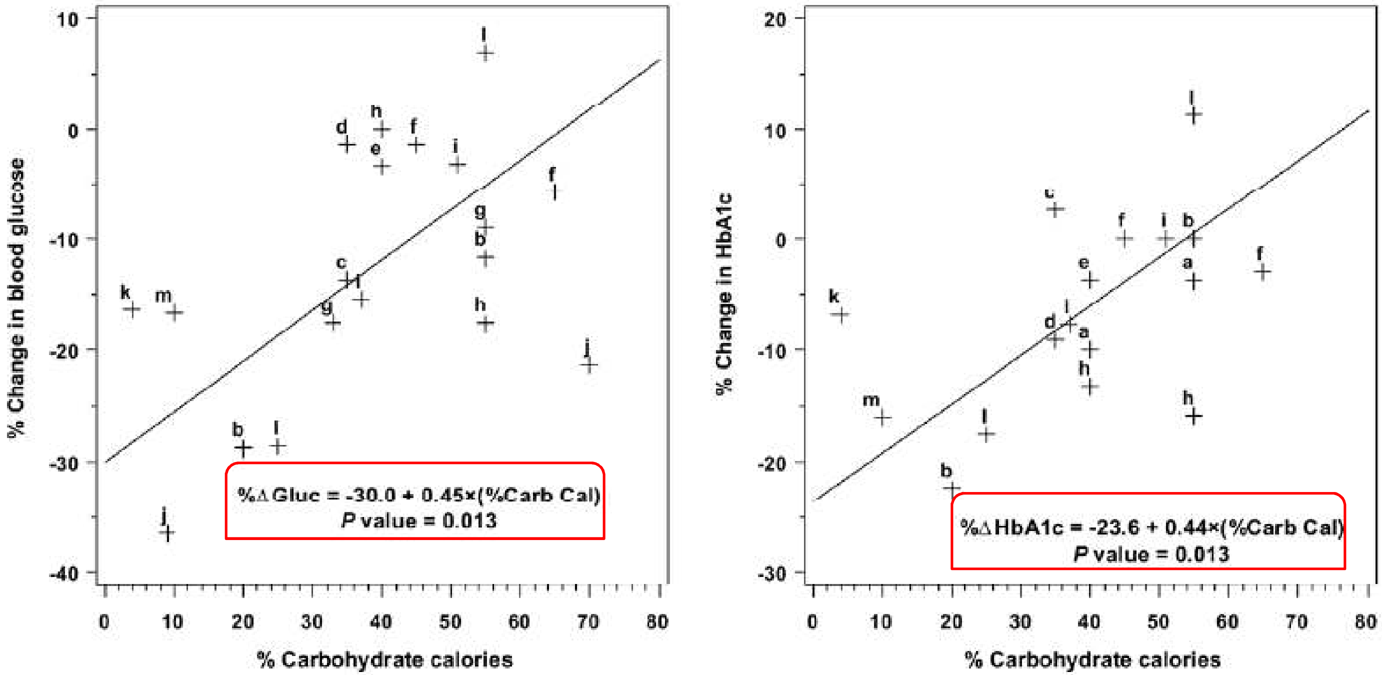



**Figure 2.** Scatter plots of percent change in blood glucose and hemoglobin A1c (HbA1c) vs percent daily caloric intake from carbohydrates. The lowercase letters correspond to the following studies (first author, year [reference number]): a=Gannon, 2003 (20); b=Gannon, 2004 (21); c=Garg, 1988 (22); d=Garg, 1992 (23); e=Garg, 1994 (24); f=Gerhard, 2004 (25); g=McCargar, 1998 (26); h=Sargrad, 2005 (27); i=Samaha, 2003 (28); j=Gumbiner, 1998 (29); k=Boden, 2005 (30); l=Gutierrez, 1998 (31); m=Yancy, 2005 (32). (Information from this figure is available online at www.adajournal.org as part of a PowerPoint presentation.)

[Method]
1. 13 RCT+two-arm&single-arm trials, 2. Type 2 diabetes

[Objective]
: to evaluate the effects of carbohydrate in diabetes pt. to control blood glucose

[Result]
: show that hemoglobin A1c, fasting glucose improved with lower carbohydrate-content diets

Meta

**Table 2**—*Overall percent changes resulting from LFHC versus HFLC diet on metabolic profiles and data on publication bias and their likely effect on the estimates*

| | A1C | FPG | 2-h glucose | Fasting insulin | 2-h fasting insulin | Total cholesterol | Triglycerides | HDL cholesterol | LDL cholesterol |
|---|---|---|---|---|---|---|---|---|---|
| Trials (*n*) | 10 | 22 | 10 | 22 | 9 | 20 | 22 | 20 | 16 |
| Overall percent change | −1.5 | 0.3 | 10.3 | 8.4 | 12.8 | 1.6 | 13.4 | −5.6 | 0.1 |
| 95% CI | −5.3 to 2.3 | −2.8 to 3.4 | 6.7–13.9 | 1.3–15.6 | 5.2–20.4 | −1.3 to 4.5 | 7.1–19.8 | −8.4 to −2.9 | −3.8 to 4.1 |
| P | 0.70 | 0.87 | <0.001 | 0.02 | <0.001 | 0.27 | <0.001 | <0.001 | 0.94 |
| Publication bias | | | | | | | | | |
| Begg's | 0.80 | 0.82 | 0.25 | 0.30 | 0.40 | 0.85 | 0.48 | 0.75 | 0.86 |
| Egger's | 0.47 | 0.30 | 0.12 | 0.13 | 0.16 | 0.26 | 0.75 | 0.08 | 0.92 |
| Trim and fill | | | | | | | | | |
| Fill* | | | | | | | | 7 | |
| Adjusted† | | | | | | | | −7.6 | |
| 95% CI | | | | | | | | −10.2 to −5.0 | |

*Studies (*n*) added by the trim-and-fill method. †Percent change after adjustment for publication bias by the trim-and-fill method. Begg's, Begg's adjusted rank correlation test; Egger's, Egger's regression asymmetry test.

Kodama et al, Diabetes Care,2009;32(5):959-65

[Method]
1. 15 randomized trials, 2. Type 2 diabetes, 4. LFHC(58/24/20), HFLC(40/40/20)
[Objective]
: to elucidate the effect of replacing dietary fat with carbohydrate
[Result]
1. <u>A1C, FPG not differ </u>significantly
2. the LFHC diet significantly increased fasting insulin compared with the HFLC diet

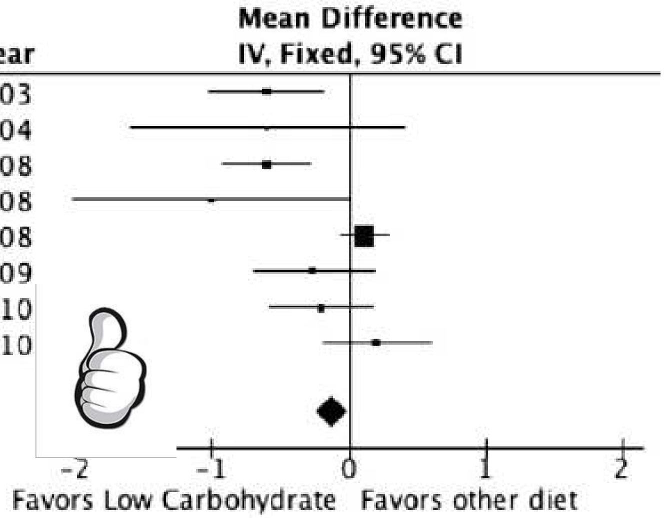
Meta

Ajala et al, Am J Clin Nutr, 2013;97:505–16

**A** Difference in Hb $A_{1c}$ low-carbohydrate versus other diets

| Study or Subgroup | Mean Difference | SE | Weight | Mean Difference IV, Fixed, 95% CI | Year |
|---|---|---|---|---|---|
| Samaha 2003 [32] | -0.6 | 0.2133 | 8.1% | -0.60 [-1.02, -0.18] | 2003 |
| Stern 2004 [33] | -0.6 | 0.5102 | 1.4% | -0.60 [-1.60, 0.40] | 2004 |
| Haimoto 2008 [8] | -0.6 | 0.1611 | 14.1% | -0.60 [-0.92, -0.28] | 2008 |
| Westman 2008 [42] | -1 | 0.5173 | 1.4% | -1.00 [-2.01, 0.01] | 2008 |
| Wolever-1 2008 [38] | 0.11 | 0.0868 | 48.6% | 0.11 [-0.06, 0.28] | 2008 |
| Davis 2009 [7] | -0.26 | 0.2254 | 7.2% | -0.26 [-0.70, 0.18] | 2009 |
| Elhayany-1 2010 [37] | -0.2 | 0.191 | 10.0% | -0.20 [-0.57, 0.17] | 2010 |
| Iqbal 2010 [43] | 0.2 | 0.2 | 9.2% | 0.20 [-0.19, 0.59] | 2010 |
| **Total (95% CI)** | | | **100.0%** | **-0.12 [-0.24, -0.00]** | |

Heterogeneity: $Chi^2 = 27.86$, df = 7 (P = 0.0002); $I^2 = 75\%$
Test for overall effect: Z = 2.02 (P = 0.04)



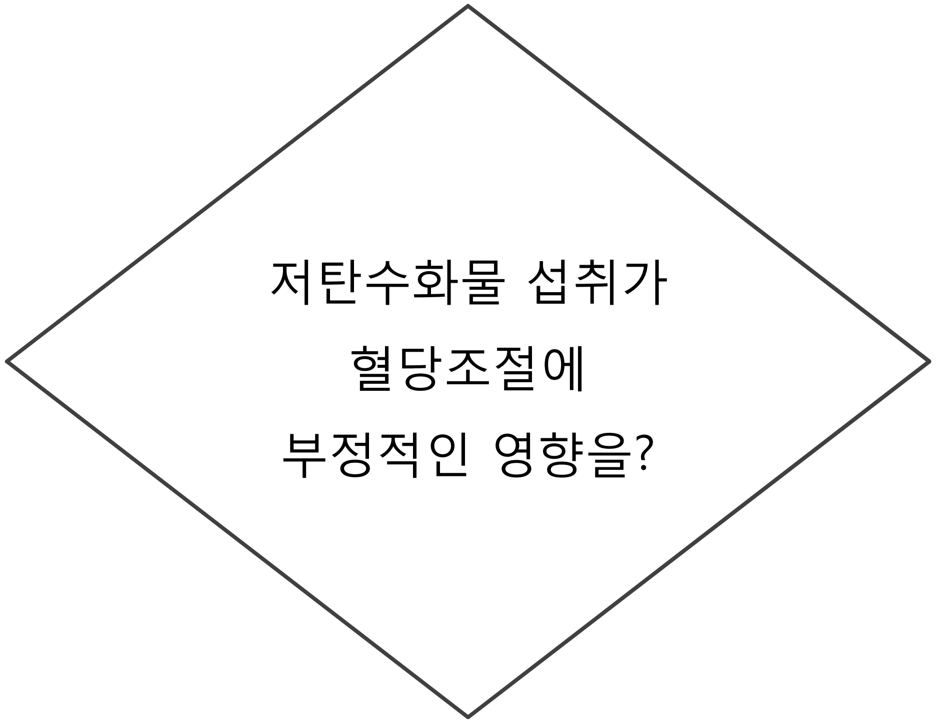

Difference in low carbohydrate vs. 'other' diets. 'Other' diets compared were low fat (Samaha [32], Haimoto [8], Davis [7] and Iqbal [43), Low GI (Westman [42] and Wolever-1[38]), Mediterranean (Elhayany-1[37]) and conventional high CHO (Stern [33])
Wolever-1 [38] is the comparison between the low-CHO and low-GI arms of the study.
Elhayany-1 [37] is the comparison between the traditional Mediterranean and low-CHO arms of the study.

[Method]
1. 9 RCTs with interventions lasted 6≥ mo, 2. Type 2 diabetes
[Objective]
: assessed the effect of low-carbohydrate diet on glycemic control
[Result]
: Meta-regression analyses show that <u>hemoglobin A1c improved with lower carbohydrate-content diets</u> [-0.12%(P=0.04)]

Q. Adequate carbohydrate distribution(amount) ?

Difficulty, 1) confounding factors : wt.loss, medication change
2) altering the level of one macronutrient affects the proportion of other macronutrients
3) the lack of standardized definition for "low carbohydrate diet"

Conclusion, 1) the ideal carbohydrate distribution(amount) is confusing
2) so, carbohydrate intake should be individualized but, free carbohydrate intake is not a right solution


저탄수화물 섭취가
혈당조절에
부정적인 영향을?

# D. High CHO diet is a good marker of compliant pt.

## - Korean vs Western?

Cross-sectional

**TABLE 3**
Adjusted odds ratios (ORs) (and 95% CIs) of poor or good glycemic control between higher sex-specific quintiles and the lowest quintile (Q) of macronutrient intake[1]

| | Q1 (Ref) | Q2 | Q3 | Q4 | Q5 | *P* for trend |
|---|---|---|---|---|---|---|
| Carbohydrate (% of energy) | | | | | | |
| Men | ≤36.2 | 36.3–42.5 | 42.6–49.7 | 49.8–56.7 | >56.7 | |
| Women | ≤38.7 | 38.8–46.7 | 46.8–52.7 | 52.8–59.9 | >59.9 | |
| OR[2] | 1 | 0.60 (0.38, 0.95) | 0.57 (0.36, 0.90) | 0.60 (0.38, 0.95) | 0.44 (0.28, 0.69) | 0.0008 |
| OR[3] | 1 | 0.55 (0.33, 0.90) | 0.52 (0.31, 0.85) | 0.54 (0.33, 0.89) | 0.43 (0.26, 0.71) | 0.003 |

Xu et al. Am J Clin Nutr 2013;86:480-487

[Method]
1. 1,284 diabetic American Indians

[Objective]
: to examine the cross sectional association between macronutrient intake and HbA1c

[Result]
: lower carbohydrate intake were associated with poor glycemic control

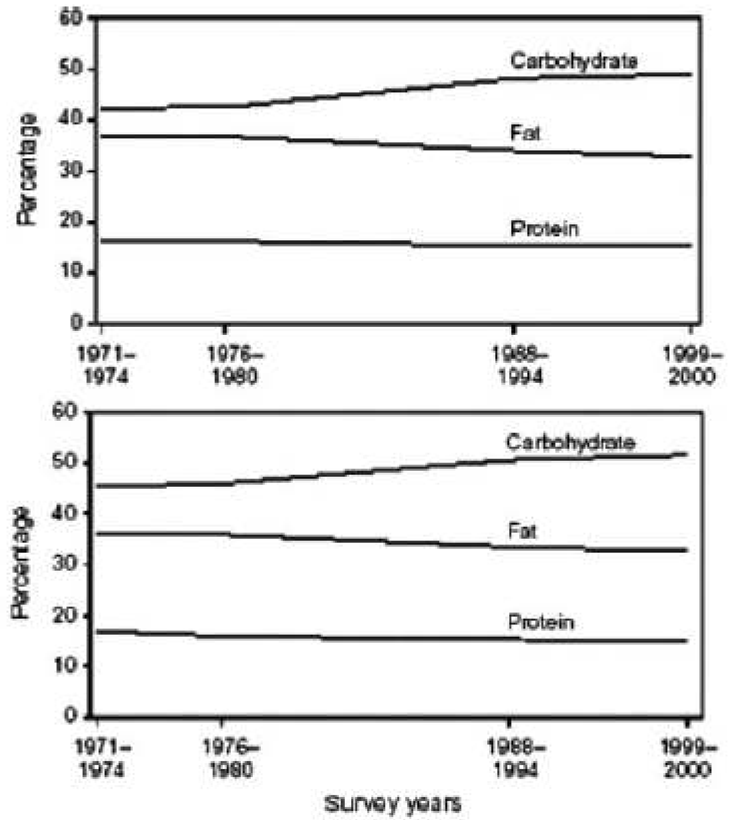



Figure 2. Percentage of kilocalories from macronutrient intake among men (top) and women (bottom) aged 20-74 (age-adjusted), by survey years. Data from National Health and Nutrition Examination (NHANES), United States, 1971-2000.[9]

Hite et al, Nutr Clin Pract, 2011;26:300-308

In USA

For men, the percentage of kcals from carbohydrate between 1971~1974 and 1999~2000, from 42.4% to 49.0%. And for women, from 45.4% to 51.6%

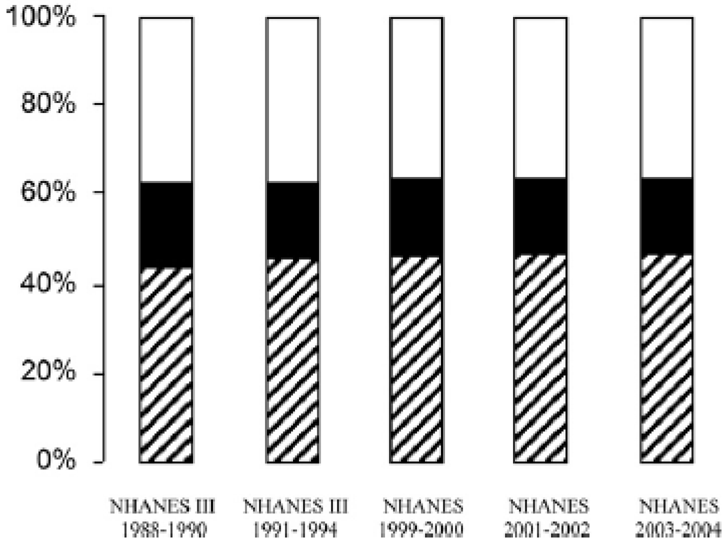



**Figure 1.** Macronutrient intake as a percentage of total energy among all respondents with self-reported diabetes in a 24-hour recall from the National Health and Nutrition Examination Survey (NHANES) III (Phase I: 1988-1990 and Phase II: 1991-1994) to NHANES 2003-2004. The percentages were calculated from the predicted marginals from weighted regression models that included respondents with complete covariate information (n=1,404). Predicted marginals were derived from regression models with each variable as a continuous outcome; independent variables were sex and age (in all models), total energy, and survey (NHANES III Phase I, NHANES III Phase II, NHANES 1999-2000, NHANES 2001-2002, or NHANES 2003-2004) as trend. NOTE: This figure is available online at www.adajournal.org as part of a PowerPoint presentation.

Oza-frank R et al, J Am Diet Assoc, 2009;109: 1173-1178

In USA, DM Pt.

the percentage of kcals from carbohydrate

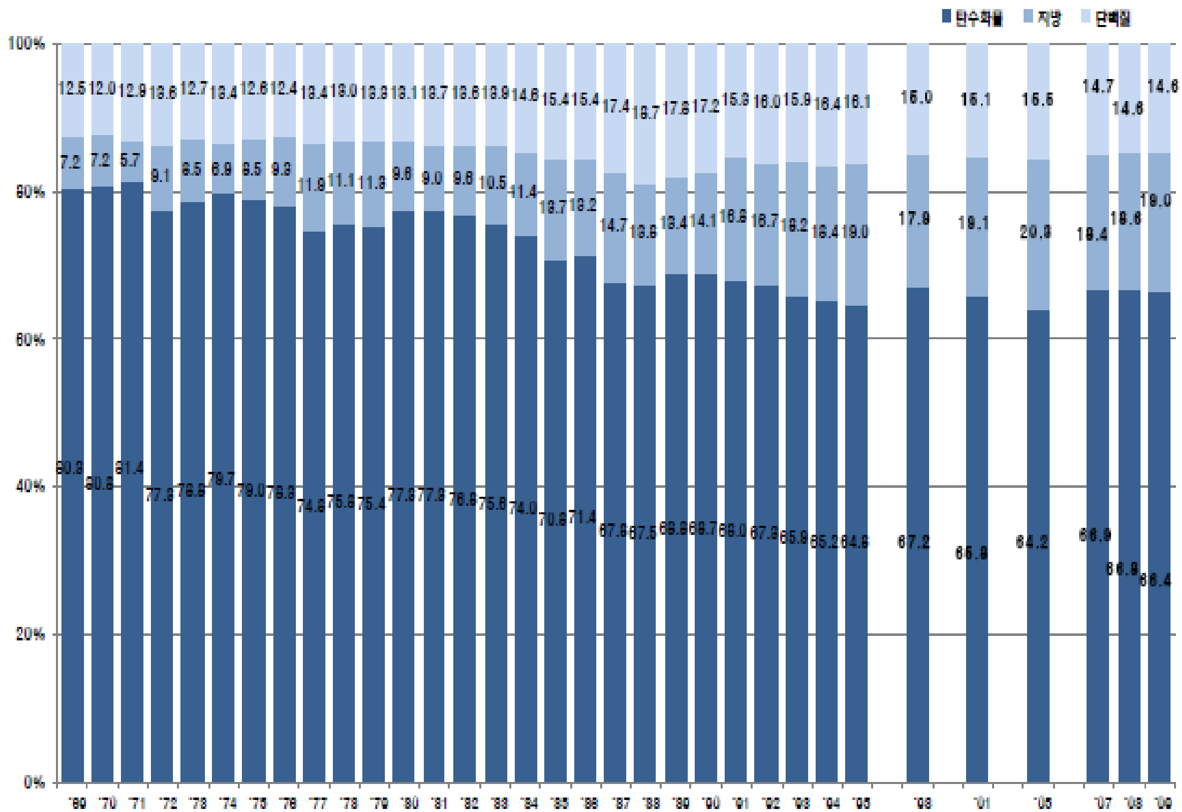
between 1988~1990 and 2003~2004,

from 43.1% to 45.7%

**Table 1. Timeline of diets for treating diabetes mellitus**

| Historical period | Author/title | Type of diet |
|---|---|---|
| 1550 BC | Ebers Papyrus | Rich in carbohydrates such as wheat, grains, grapes, honey and berries |
| AD 128–200 | Galen | Sun-dried membranes from young roosters' abdomen or drinks made of a mixture of mountain copper, dry acorn, flower of the wild pomegranate, oak gall, honey of roses and cold water |
| 980–1037 | Avicenna | Rich in lupin, fenugreek and zedoary |
| 1621–75 | Thomas Willis | Milk and barley-water boiled with bread |
| 1799 | John Rollo | 1500-calorie diet, low in carbohydrates and high in fat and protein, based on rancid meat and blood pudding |
| Beginning of the 20th century | Allen, Joslin | Very low-calorie diet, called the 'starvation diet', high in protein and fat and low in carbohydrates. Contained 70% fat, 10% carbohydrate, 20% protein |
| 1940s | American Diabetes Association | Carbohydrate content of 40% |
| 1950 | American Diabetes Association | Normal quantity of calories, comprise 43% carbohydrate, 19% protein, 37% fat |
| 1971 | American Diabetes Association | 45% or more carbohydrate |
| 1979 | American Diabetes Association | 50–60% carbohydrate, 12–20% protein, 20–30% fat |
| 1986 | American Diabetes Association | 55–60% carbohydrate, 0.8 g/kg protein, total fat <30% |
| 1994 | American Diabetes Association | 10–20% protein, <10% from saturated fat |
| 2008 | American Diabetes Association | 130 g/day carbohydrate, 14 g fibre/1000 kcal, cholesterol <200 mg/day, 20% protein |

Diabetes Metab Res Rev 2014;30(Suppl. 1): 24–33




In Korea

1970, 80.8%

1980, 77.7%

1990, 68.7%

2001, 65.8%

2009, 66.4%

from carbohydrate

**Table 1.** Dietary nutrient intake and overall percentage of KNDP participants meeting recommendation

| Nutrients | Intake | P* | Recommended dietary intake† | % Less than recommendation | % Meeting recommendation | % Above recommendation | P‡ |
|---|---|---|---|---|---|---|---|
| Energy (kcal/day) | 1,757.5 ± 423.2 | | | | | | |
| Men | 1,870.7 ± 403.5 | | | | | | |
| Women | 1,615.4 ± 404.3 | < 0.001 | | | | | |
| Protein (% energy) | 17.3 ± 3.4 | | 15-20 | 24.2 | 58.5 | 17.3 | |
| Men | 17.6 ± 3.2 | | | 19.9 | 61.9 | 18.2 | |
| Women | 16.9 ± 3.5 | < 0.001 | | 29.5 | 54.3 | 16.1 | < 0.001 |
| Fat (% energy) | 21.9 ± 7.3 | | ≤ 25 | | 68.8 | 31.2 | |
| Men | 22.8 ± 7.2 | | | | 65.0 | 35.0 | |
| Women | 20.7 ± 7.3 | < 0.001 | | | 73.7 | 26.3 | < 0.001 |
| Carbohydrate (% energy) | 60.9 ± 8.9 | | 50-60 | 10.6 | 35.3 | 54.1 | |
| Men | 59.6 ± 8.6 | | | 12.5 | 38.7 | 48.8 | |
| Women | 62.4 ± 9.2 | < 0.001 | | 8.2 | 31.0 | 60.8 | < 0.001 |
| Dietary fiber (g/1,000 kcal) | 15.5 ± 4.8 | | ≥ 12 | 24.7 | 75.3 | | |
| Men | 14.7 ± 4.6 | | | 30.1 | 69.9 | | |
| Women | 16.4 ± 4.9 | < 0.001 | | 17.8 | 82.2 | | < 0.001 |
| Saturated FA (% energy) | 3.5 ± 2.7 | | ≤ 7 | | 91.5 | 8.5 | |
| Men | 3.7 ± 2.8 | | | | 90.6 | 9.4 | |
| Women | 3.3 ± 2.4 | < 0.001 | | | 92.6 | 7.4 | 0.08 |
| Cholesterol (mg) | 258.3 ± 187.9 | | ≤ 200 | | 46.4 | 53.6 | |
| Men | 288.2 ± 198.5 | | | | 39.7 | 60.3 | |
| Women | 221.0 ± 166.4 | < 0.001 | | | 54.9 | 45.1 | < 0.001 |

Data are mean ± SD and percent unless otherwise indicated. FA, fatty acids. **P* value obtained by the Student t test or Mann-Whitney U test as appropriate for comparison of nutrient intake between men and women; †Recommended dietary intake adapted from the 2011 Treatment Guideline for Diabetes of the Korean Diabetes Association (14); ‡*P* value obtained by chi-squared test to compare the rate of achievement of recommendation for each nutrient between men and women.

In Korea, DM Pt.

Kim et al, J Korean Med Sci. 2012;27:1188-1195

[Method]
1. cross-sectional study of 2,832 type 2 diabetic patients from the Korean National Diabetes Program cohort
2. 24 hr dietary recall questionnaire

Table 1. Timeline of diets for treating diabetes mellitus

| Historical period | Author/title | Type of diet |
|---|---|---|
| 1550 BC | Ebers Papyrus | Rich in carbohydrates such as wheat, grains, grapes, honey and berries |
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Diabetes Metab Res Rev 2014;30(Suppl. 1): 24–33

RCT

# D. Carbohydrate quality?

## - Glycemic index, Dietary fiber ..etc

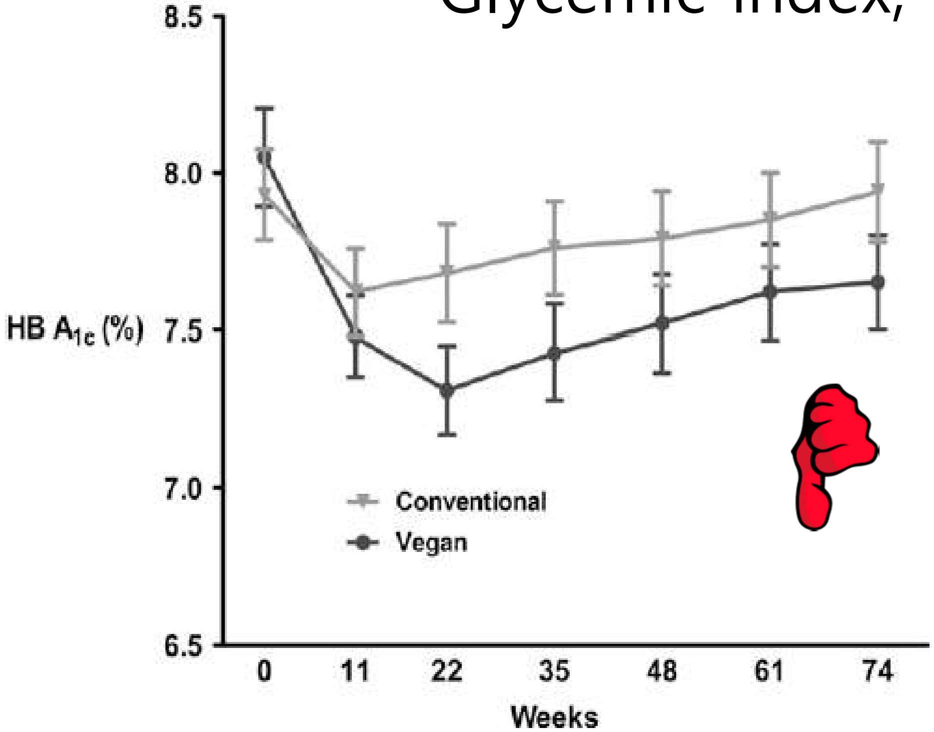



**FIGURE 1.** Glycated hemoglobin (HB $A_{1c}$) values for all participants ($n$ = 49 vegan diet; $n$ = 50 conventional diet). The mean (±SD) data shown are last values before any change to diabetes medications carried forward. $t$ Test for between-group comparison of changes from baseline to final values, $P = 0.03$.

Barnard et al, Am J Clin Nutr.
2009 May;89(5):1588S-1596S

[Method]

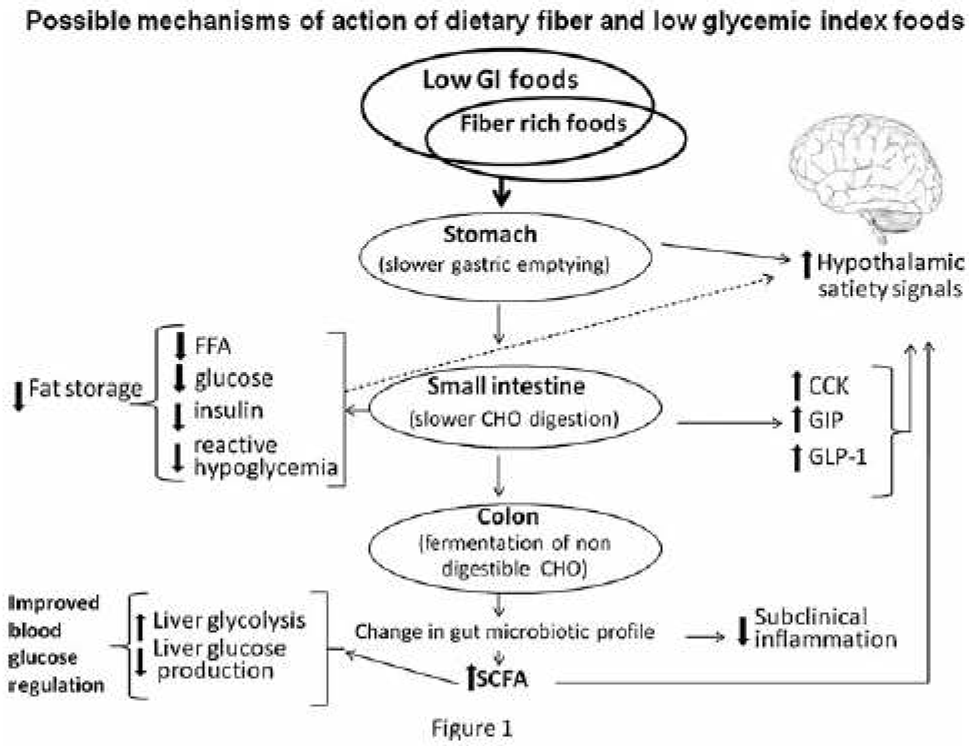
1. 83 Type 2 diabetes, USA, 74wks
2. Vegan: <u>66.3%</u> carbohydrates, 22.3% fat, 14.8% protein
   Conventional: <u>46.5%</u> carbohydrates, 33.7% fat, 21.1% protein

[Result]

: HbA1c changes from baseline to 74 wk before any medication adjustment were <u>-0.40 and 0.01 in vegan and conventional diet groups, respectively (P < 0.03)</u>

| Standards of Medical Care in Diabetes—2015 | | |
|---|---|---|
| Eating patterns and macronutrient distribution | Substituting low glycemic load foods for higher glycemic load foods may modestly improve glycemic control. | C |
| | Individuals at high risk for type 2 diabetes should be encouraged to achieve the U.S. Department of Agriculture recommendation for dietary fiber (14 g fiber/1,000 kcal) and to consume foods containing whole grains (one-half of grain intake). | B |

Fig. 1 Possible mechanism of action of dietary fiber and low glycemic index (*GI*) foods. *CCK* cholecystokinin, *CHO* carbohydrate, *FFA* free fatty acids, *GIP* gastric inhibitory polypeptide, *GLP-1* glucagon-like peptide 1, *SCFA* short-chain fatty acids




Rivellese et al.
Curr Atheroscler Rep.
, 2012;14:563–569

Glycemic index : 50 g의 탄수화물을 포함하고 있는 식품을 섭취한 후 2시간 동안의 혈당 반응 곡선의 면적을 50 g의 탄수화물을 포함하고 있는 포도당이나 흰빵을 섭취했을 때와 비교하여 백분율로 표시한 값

Glycemic load : Glycemic index에 양적 개념을 더한 것으로 식품의 1회 섭취 분량에 함유되어 있는 탄수화물양을 고려하여 혈당반응을 계산한 지표

RCT

**Table 3. Mean Study Measurements and Significance of Treatment Differences for Modified Intention-to-Treat Analysis in 121 Participants[a]**

| | Mean (95% CI) | | | | |
|---|---|---|---|---|---|
| | High Wheat Fiber Diet | | Low-GI legume Diet | | |
| Characteristic | Baseline (n = 61) | End of Study (n = 61)[b] | Baseline (n = 60) | End of Study (n = 60)[b] | *P* Value[c] |
| Body weight, kg | 82.5 (78.0-87.0) | 80.5 (76.2-84.8)[a] | 85.6 (80.4-90.9) | 83.0 (77.9-88.0)[d] | .002 |
| Waist, cm | 103.7 (100.2-107.3) | 102.4 (98.9-105.9)[a] | 106.7 (102.7-110.7) | 104.3 (100.2-108.3)[d] | .007 |
| $HbA_{1c}$ value, % of total hemoglobin | 7.2 (7.1-7.4) | 6.9 (6.8-7.0)[a] | 7.4 (7.2-7.5) | 6.9 (6.7-7.0)[d] | <.001 |
| Fasting glucose level, mg/dL | 134 (127-141) | 127 (121-133)[a] | 141 (135-147) | 132 (126-138)[d] | .001 |
| TC level, mg/dL | 163 (151-174) | 161 (150-172) | 158 (147-168) | 149 (139-160)[d] | .005 |
| LDL-C level, mg/dL | 91 (81-101) | 90 (81-99) | 84 (77-92) | 81 (74-89) | .16 |
| HDL-C level, mg/dL | 47 (44-50) | 48 (45-52)[a] | 43 (40-46) | 43 (40-45) | <.001 |
| Triglyceride level, mg/dL | 124 (104-145) | 115 (96-133)[a] | 149 (125-173) | 128 (107-148)[d] | .03 |
| TC/HDL-C | 3.57 (3.35-3.79) | 3.45 (3.22-3.67)[a] | 3.75 (3.50-4.00) | 3.61 (3.35-3.86)[d] | .46 |
| LDL-C/HDL-C | 1.98 (1.80-2.16) | 1.91 (1.73-2.09) | 1.99 (1.82-2.15) | 1.96 (1.78-2.14) | .86 |
| Systolic BP, mm Hg | 118 (115-122) | 118 (115-121) | 122 (119-124) | 118 (115-120)[d] | <.001 |
| Diastolic BP, mm Hg | 70 (67-72) | 70 (67-72) | 72 (70-74) | 69 (67-71)[d] | <.001 |
| Heart rate, bpm | 72.4 (69.7-75.1) | 71.8 (69.1-74.6) | 74.1 (70.8-77.4) | 70.7 (67.4-73.9)[d] | <.001 |
| Absolute CHD risk, 10 y[e] | 10.4 (9.3-11.4) | 9.9 (8.8-10.9)[a] | 10.7 (9.2-12.1) | 9.6 (8.3-10.9)[d] | .003 |
| Relative CHD risk[f] | 1.3 (1.1-1.4) | 1.2 (1.1-1.3)[a] | 1.5 (1.2-1.9) | 1.4 (1.0-1.7)[d] | .27 |

Jenkins et al. Arch Intern Med. 2012;172(21):1653-1660

[Method]

1. 121 T2DM, Toronto
2. High Wheat Fiber Diet(<u>GI=82</u>), Low-GI Legume Diet group(<u>GI=66</u>)
3. 3 months, 7-day food records

[Result]

1. The relative reduction in HbA1c after the <u>low-GI legume diet was greater than after the high wheat fiber diet by −0.2%</u>

# Meta

Thomas et al, Br J Nutr 2010;104:797-802

| Study or subgroup | Low-GI diet Mean | Low-GI diet SD | Low-GI diet Total | Control diet Mean | Control diet SD | Control diet Total | Weight (%) | Mean difference (IV, fixed) | Mean difference 95 % CI |
|---|---|---|---|---|---|---|---|---|---|
| Brand *et al.*[22] | 7 | 0·6 | 16 | 7·9 | 2 | 16 | 6·5 | –0·90 | –1·92, 0·12 |
| Giacco *et al.*[26] | 8·8 | 1 | 29 | 9·1 | 1·3 | 25 | 17·3 | –0·30 | –0·93, 0·33 |
| Komindr *et al.*[30] | 10·97 | 1·55 | 10 | 11·15 | 2·02 | 10 | 2·7 | –0·18 | –1·76, 1·40 |
| Gilbertson *et al.*[27] | 8 | 1 | 51 | 8·6 | 1·4 | 38 | 24·8 | –0·60 | –1·12, –0·08 |
| Jimenez-Cruz *et al.*[28] | 8·1 | 0·9 | 14 | 8·6 | 0·9 | 14 | 15·3 | –0·50 | –1·17, 0·17 |
| Rizkalla *et al.*[31] | 7·17 | 1·35 | 12 | 7·57 | 1·21 | 12 | 6·5 | –0·40 | –1·43, 0·63 |
| Jenkins *et al.*[33] | 6·64 | 1·65 | 106 | 6·89 | 2·04 | 104 | 26·9 | –0·25 | –0·75, 0·25 |
| Total (95 % CI) | | | 238 | | | 219 | 100·0 | –0·43 | –0·69, –0·17 |

Heterogeneity: $\chi^2 = 2{\cdot}02$, df = 6 ($P = 0{\cdot}92$); $I^2 = 0$ %.
Test for overall effect: $Z = 3{\cdot}26$ ($P = 0{\cdot}001$).

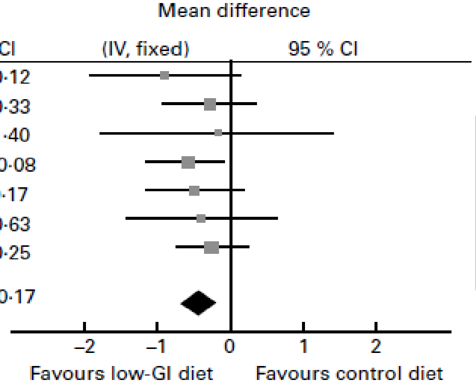



**Fig. 2.** Change in glycated Hb (% HbA1c) in people with diabetes on low-glycaemic index (GI) diet compared with that in people with diabetes on high-GI or other diet.

[Method]
1. 7 randomized controlled trials at least 4 weeks, 2. type 1 or type 2 diabetes

[Result]
1. significant decrease in HbA1c(-0.43%) with low-GI diet than with the control diet

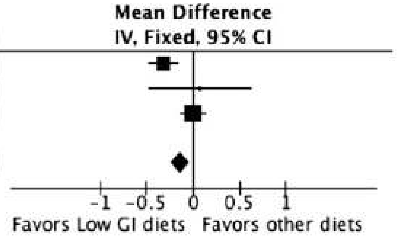
# Meta

Ajala et al. Am J Clin Nutr 2013;97:505–16

**B** Difference in low-GI versus other diets

| Study or Subgroup | Mean Difference | SE | Low GI Total | Other diets Total | Weight | Mean Difference IV, Fixed, 95% CI |
|---|---|---|---|---|---|---|
| Jenkins 2008 [34] | -0.32 | 0.0784 | 106 | 104 | 43.3% | -0.32 [-0.47, -0.17] |
| Ma 2008 [39] | 0.08 | 0.28 | 20 | 20 | 3.4% | 0.08 [-0.47, 0.63] |
| Wolever-2 2008 [38] | 0 | 0.0707 | 55 | 48 | 53.3% | 0.00 [-0.14, 0.14] |
| **Total (95% CI)** | | | **181** | **172** | **100.0%** | **-0.14 [-0.24, -0.03]** |

Heterogeneity: $Chi^2 = 9.80$, df = 2 ($P = 0.007$); $I^2 = 80\%$
Test for overall effect: $Z = 2.63$ ($P = 0.008$)




Difference in low-GI vs. 'other' diets. 'Other' diets compared were high fiber (Jenkins [35]), high GI (Wolever-2 [38]), ADA (Ma [39]).
Wolever-2 [38] is the comparison between the low-GI and high-GI arms of the study.

[Method]
1. 3 randomized controlled trials at least 6 month, 2. type 2 diabetes
[Objective]
:
[Result]
1. -0.14% decrease in HbA1c in subjects who consumed low-GI compared with control diets

| 2015 ADA | | 2011 ADA | |
|---|---|---|---|
| Substituting low **glycemic load** foods for higher glycemic load foods may modestly improve glycemic control. | C | For individuals with diabetes, the use of the **glycemic index and glycemic load** may provide a modest additional benefit for glycemic control over that observed when total carbohydrate is considered alone. | B |

# *Glycemic index or Glycemic load??*

Cross-sectional

[Method]

1. 227 obese Japanese
   (the Saku Control Obesity Program)
2. 3-day dietary records

[Result]

1. <u>GI was not associated with HbA1c</u>, but GL was positively associated with HbA1c

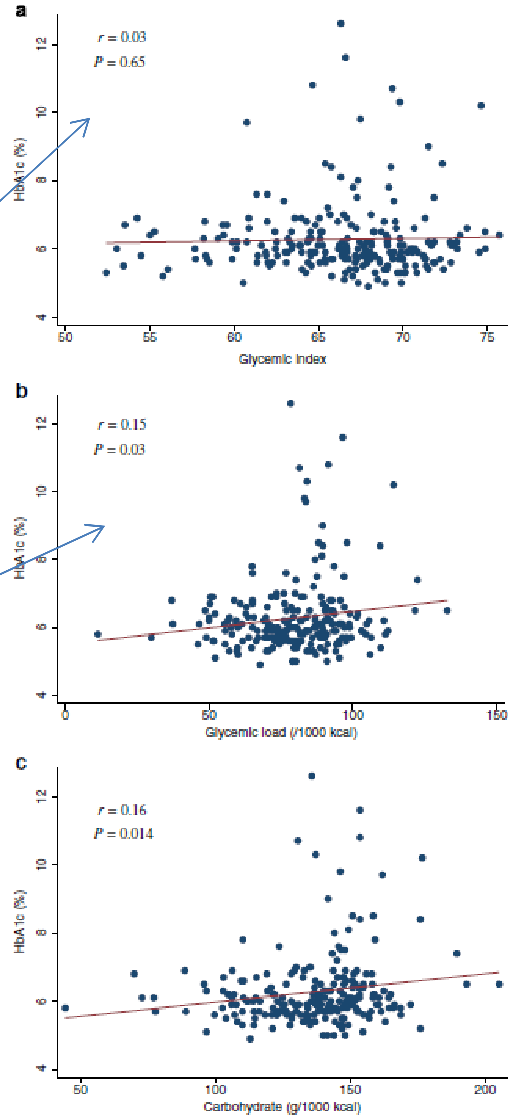



Figure 1 (See legend on next page.)

*Nutrition & Metabolism 2012, 9:79*

# *Glycemic index or Glycemic load??*

**Table 2.** Multivariate-adjusted ORs (95% CI) of elevated fasting serum glucose (> 130 mg/dl) and HbA 1c (> 8.6%) according to quartile categories of glycemic load and glycemic index, carbohydrate and fiber intakes

| | *FSG* | | | | | *HbA1c* | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Quartile of intake* | | | | $P_{trend}$[a] | *Quartile of intake* | | | | $P_{trend}$[a] |
| *Glycemic load* | | | | | | | | | | |
| Range of index | < 129.6 | 129.6–171.2 | 171.3–212.0 | > 212.0 | | < 129.6 | 129.6–171.2 | 171.3–212.0 | > 212.0 | |
| No. of cases with hyperglycemia | 102 | 100 | 119 | 119 | | 90 | 97 | 96 | 95 | |
| Age-, sex- and energy-adjusted model[b] | 1 | 1.01 (0.62–1.67) | 1.97 (1.07–3.61) | 2.20 (0.97–5.01) | 0.03 | 1 | 1.41 (0.87–2.29) | 1.73 (0.99–3.03) | 2.29 (1.07–4.89) | 0.03 |
| Multivariable-adjusted model 1[c] | 1 | 1.09 (0.64–1.85) | 2.15 (1.13–4.08) | 2.58 (1.08–6.15) | 0.02 | 1 | 1.52 (0.89–2.58) | 2.07 (1.12–3.83) | 3.05 (1.33–7.03) | 0.008 |
| Multivariable-adjusted model 2[d] | 1 | 1.15 (0.67–1.97) | 2.42 (1.26–4.67) | 3.00 (1.22–7.33) | 0.007 | 1 | 1.67 (0.98–2.84) | 2.42 (1.29–4.54) | 3.94 (1.66–9.31) | 0.002 |
| *Glycemic index* | | | | | | | | | | |
| Range of index | < 54.1 | 54.1–58.7 | 58.8–63.5 | > 63.5 | | < 54.1 | 54.1–58.7 | 58.8–63.5 | > 63.5 | |
| No. of cases with hyperglycemia | 105 | 109 | 113 | 113 | | 89 | 98 | 96 | 95 | |
| Age-, sex-, and energy-adjusted model[b] | 1 | 1.16 (0.72–1.86) | 1.25 (0.78–2.02) | 1.18 (0.72–1.92) | 0.46 | 1 | 1.28 (0.81–2.01) | 1.27 (0.81–2.00) | 1.30 (0.82–2.05) | 0.28 |
| Multivariable-adjusted model 1[c] | 1 | 1.30 (0.78–2.16) | 1.38 (0.83–2.29) | 1.41 (0.84–2.38) | 0.19 | 1 | 1.43 (0.87–2.40) | 1.39 (0.85–2.28) | 1.42 (0.86–2.35) | 0.20 |
| Multivariable-adjusted model 2[d] | 1 | 1.32 (0.79–2.21) | 1.34 (0.80–2.25) | 1.31 (0.75–2.26) | 0.33 | 1 | 1.51 (0.91–2.50) | 1.45 (0.88–2.39) | 1.52 (0.90–2.59) | 0.14 |
| *Carbohydrate* | | | | | | | | | | |
| Range of intake (% energy) | < 50.4 | 50.4–55.5 | 55.6–60.3 | > 60.3 | | < 50.4 | 50.4–55.5 | 55.6–60.3 | > 60.3 | |
| No. of cases with hyperglycemia | 106 | 107 | 116 | 111 | | 78 | 100 | 100 | 100 | |
| Age-, sex- and energy-adjusted model[b] | 1 | 1.11 (0.69–1.78) | 1.44 (0.88–2.34) | 1.26 (0.78–2.05) | 0.23 | 1 | 1.76 (1.12–2.76) | 1.76 (1.12–2.77) | 1.74 (1.10–2.75) | 0.02 |
| Multivariable-adjusted model 1[e] | 1 | 1.12 (0.68–1.87) | 1.54 (0.91–2.59) | 1.47 (0.86–2.51) | 0.09 | 1 | 1.94 (1.18–3.18) | 2.08 (1.26–3.44) | 2.27 (1.35–3.83) | 0.002 |
| Multivariable-adjusted model 2[d] | 1 | 1.13 (0.68–1.87) | 1.54 (0.91–2.59) | 1.47 (0.86–2.51) | 0.09 | 1 | 1.91 (1.16–3.14) | 2.10 (1.27–3.46) | 2.32 (1.37–3.92) | 0.001 |
| *Fiber* | | | | | | | | | | |
| Range of intake (g) | < 17.5 | 17.5–23.0 | 23.1–30.2 | > 30.2 | | < 17.5 | 17.5–23.0 | 23.1–30.2 | > 30.2 | |
| No. of cases with hyperglycemia | 115 | 113 | 101 | 111 | | 99 | 106 | 83 | 90 | |
| Age-, sex- and energy-adjusted model[b] | 1 | 0.82 (0.50–1.35) | 0.51 (0.30–0.85) | 0.53 (0.29–0.96) | 0.02 | 1 | 1.17 (0.73–1.87) | 0.63 (0.39–1.02) | 0.72 (0.41–1.25) | 0.12 |
| Multivariable-adjusted model 1[c] | 1 | 0.76 (0.45–1.30) | 0.52 (0.30–0.92) | 0.53 (0.28–0.99) | 0.04 | 1 | 1.14 (0.68–1.89) | 0.70 (0.41–1.19) | 0.81 (0.44–1.50) | 0.36 |

Abbreviation: OR, odds ratio. [a]Calculated in a separate regression model with median intake in each quartile as a continuous variable and the same group of covariates specified for the corresponding model. [b]Adjusted for age (< 50, 50–55, 55.1–60, 60.1–65, > 65), sex, energy intake (kcal). [c]Age-, sex- and energy-adjusted model further adjusted for duration of diabetes (< 5, 5–10, 10.1–15, > 15 year), smoking (yes or no), physical activity (METs-h/day), body mass index (⩽ 25, 25.1–27, 27.1–30, 30.1–35, ⩾ 35 kg/m²), vitamin/mineral supplementation (yes or no), total hypoglycemic medication, blood pressure-lowering drug (yes or no) and lipid-lowering drug (yes or no). [d]Multivariable-adjusted model 1 further adjusted for protein intake (% energy) and fiber intake (g). [e]Same as (c) in addition to fiber intake (g).

Cross-sectional

*Eur J Clin Nutr 2014;68:459-63*

[Method]
1. 640 type 2 diabetic patients aged 28–75 years, Tehran

[Result]
1. for the highest vs the lowest quartile of GL was 2.58 for elevated FSG and was 3.05 for elevated HbA1c
2. <u>GI was not significantly associated</u> with either elevated FSG or HbA1c

· Conclusion

1. ADA 권고 대로, 당지수가 아닌 당부하지수의 개념으로

2. 식품의 생산지, 조리 방법, 함께 섭취하는 식품,
또 환자 개별적 특성에 따라 결과가 달라질 수 있는
당부하지수의 태생적 한계

# Dietary fiber

**Table 1.** Components of dietary fiber according to the American Association of Cereal Chemists [22].

| |
|---|
| **Non Starch Polysaccharides and Oligosaccharides** |
| Cellulose |
| Hemicellulose |
| Arabinoxylans |
| Arabinogalactans |
| Polyfructoses |
| Inulin |
| Oligofructans |
| Galacto-oligosaccharides |
| Gums |
| Mucilages |
| Pectins |
| **Analagous carbohydrates** |
| Indigestible dextrins |
| Resistant maltodextrins |
| Resistant potato dextrins |
| Synthesized carbohydrates compounds |
| Polydextrose |
| Methyl cellulose |
| Hydroxypropylmethyl cellulose |
| Resistant starches |
| **Lignin substances associated with the NSP and lignin complex** |
| Waxes |
| Phytate |
| Cutin |
| Saponins |
| Suberin |
| Tannin |

Nutrients 2010, 2, 1266-1289

R Crossover

**TABLE 3.** METABOLIC VARIABLES DURING THE LAST WEEK OF THE STUDY PERIODS (DAYS 38 THROUGH 42).*

| VARIABLE | ADA DIET | HIGH-FIBER DIET | DIFFERENCE BETWEEN DIETS (95% CI) | P VALUE† |
|---|---|---|---|---|
| Energy intake (kcal/day) | 2308±236 | 2308±236 | — | 1.00 |
| Weight (kg) | 90.7±13.3 | 90.5±12.7 | −0.2 (−1.1 to 0.6) | 0.60 |
| Dose of glyburide (mg/day) | 10.0±8.7 | 10.0±8.7 | — | 1.00 |
| Plasma glucose (mg/deciliter)‡ | 142±36 | 130±38 | −13 (−24 to −1) | 0.04 |
| Urinary glucose (g/day) | | | | |
| Mean | 2.3±4.3 | 1.0±1.9 | — | — |
| Median§ | 0.76 | 0.0 | −0.23 (−1.83 to −0.03) | 0.008 |
| Glycosylated hemoglobin (%) | 7.2±1.3 | 6.9±1.2 | −0.3 (−0.6 to 0.1) | 0.09 |

*Plus–minus values are means ±SD. ADA denotes American Diabetes Association, and CI confidence interval.

†An analysis of variance was used to compare the two diets, except for urinary glucose, for which the Wilcoxon signed-rank test was used.

‡The values are averages of plasma glucose concentrations measured at 7 and 11 a.m. and at 4 and 8 p.m. each day for five days during hospitalization. To convert values for plasma glucose to millimoles per liter, multiply by 0.056.

§The values are averages of five daily urine collections during hospitalization.

N Engl J Med 2000;342:1392-8

[Method]

1. randomized crossover study,
2. ADA diet = total 24 g; 8 g of soluble fiber and 16 g of insoluble fiber
   High-fiber diet = total 50 g; 25 g of soluble fiber and 25 g of insoluble fiber
3. 6 weeks

[Result]

1. The mean plasma glucose was lower when patients completed the high-fiber diet than when they completed the ADA diet
2. But, not in HbA1c

RCT

Table 2—*Metabolic parameters at the end of the study in type 1 diabetic patients by intention-to-treat analysis or after the exclusion of noncompliant individuals*

| | Intention to treat | | | | Compliant to diet | | | |
|---|---|---|---|---|---|---|---|---|
| | LF | Δ (%) | HF | Δ (%) | LF | Δ (%) | HF | Δ (%) |
| *n* | 25 | — | 29 | — | 22 | — | 24 | — |
| $HbA_{1c}$ (%) | 9.1 ± 1.3 | 3.4 | 8.8 ± 1.0 | 0 | 9.1 ± 1.4 | 5.8 | 8.6 ± 0.9* | −2.0 |
| Mean daily plasma glucose (mmol/l) | 14.5 ± 4.5 | −6.5 | 11.8 ± 3.3* | −9.0 | 14.7 ± 4.1 | 0 | 11.2 ± 2.9† | −15.0 |
| Triglyceride (mmol/l) | 0.87 ± 0.28 | 0.8 | 0.86 ± 0.44 | −0.4 | 0.86 ± 0.30 | 3.5 | 0.90 ± 0.48 | 0 |
| Cholesterol (mmol/l) | 5.1 ± 1.2 | 4.0 | 4.7 ± 0.9 | 0 | 5.0 ± 1.3 | 3.0 | 4.7 ± 0.8 | −0.6 |
| HDL cholesterol (mmol/l) | 1.4 ± 0.4 | 2.8 | 1.5 ± 0.3 | 0.8 | 1.4 ± 0.4 | 2.0 | 1.5 ± 0.4 | 0 |
| Hypoglycemic events ($n \cdot patient^{-1} \cdot month^{-1}$) | 1.5 ± 1.2 | — | 0.7 ± 0.7† | — | 1.7 ± 1.2 | — | 0.8 ± 0.7† | — |
| Body weight (kg) | 65.5 ± 10.9 | 0.9 | 66.7 ± 10.2 | 0.9 | 64 ± 11 | 0.5 | 67 ± 11 | 1.1 |
| Insulin dose (U/day) | 42.1 ± 12.7 | −1.4 | 47.6 ± 16.5 | −0.6 | 43.7 ± 12.3 | −8.0 | 48.4 ± 16.6 | 1.7 |

Data are means ± SD, unless otherwise indicated. †$P < 0.05$; **$P < 0.01$. Δ (%), change from baseline.

Giacco et al. Diabetes Care 23:1461–1466, 2000

[Method]

1. 63 type 1 diabetic patients, Naples
2. High fiber(HF) diet= 39.1g/d
   Low fiber(LF) diet = 15.0g/d
3. 24 weeks, 7-day food records

[Result]

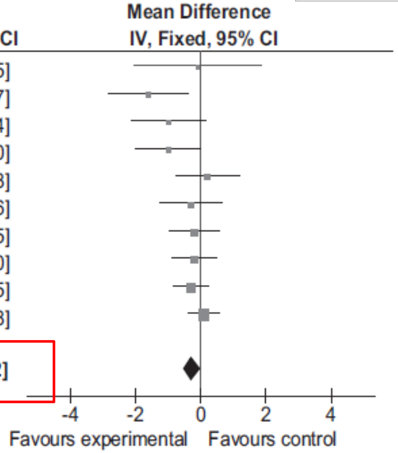
1. HbA1c was significantly lower after the HF diet than after the LF diet

# Meta

Figure 3. Forest plot for glycosylated hemoglobin.

| Study or Subgroup | Fiber Mean | Fiber SD | Fiber Total | Control Mean | Control SD | Control Total | Weight | Mean Difference IV, Fixed, 95% CI |
|---|---|---|---|---|---|---|---|---|
| Karlander 1991 | 6.9 | 1.3 | 5 | 7 | 1.8 | 5 | 1.6% | -0.10 [-2.05, 1.85] |
| Ziai 2005 | 8.9 | 0.9 | 21 | 10.5 | 2.3 | 15 | 4.1% | -1.60 [-2.83, -0.37] |
| Cho 2005 | 7.3 | 1.2 | 15 | 8.3 | 1.9 | 15 | 4.8% | -1.00 [-2.14, 0.14] |
| Uusitupa 1989 | 8.4 | 1.2 | 20 | 9.4 | 1.9 | 19 | 6.2% | -1.00 [-2.00, 0.00] |
| Holman 1987 | 8.1 | 2 | 29 | 7.9 | 1.8 | 29 | 6.5% | 0.20 [-0.78, 1.18] |
| Chandalia 2000 | 6.9 | 1.2 | 13 | 7.2 | 1.3 | 13 | 6.7% | -0.30 [-1.26, 0.66] |
| Feldheim 2003 | 5.2 | 0.5 | 11 | 5.4 | 1 | 8 | 10.9% | -0.20 [-0.95, 0.55] |
| Jenkins 2002 | 7.2 | 1 | 23 | 7.4 | 1.4 | 23 | 12.5% | -0.20 [-0.90, 0.50] |
| Chuang 1992 | 6.9 | 0.8 | 16 | 7.2 | 0.8 | 16 | 20.2% | -0.30 [-0.85, 0.25] |
| Hagander 1988 | 5.3 | 0.6 | 14 | 5.2 | 0.7 | 14 | 26.6% | 0.10 [-0.38, 0.58] |
| **Total (95% CI)** | | | **167** | | | **157** | **100.0%** | **-0.26 [-0.51, -0.02]** |

Heterogeneity: Chi² = 11.39, df = 9 (P = 0.25); I² = 21%
Test for overall effect: Z = 2.09 (P = 0.04)




Post et al. Am Board Fam Med 2012;25:16 –23

[Method]
1. 10 randomized trials, 2. type 2 diabetes

[Result]
1. fiber intervention was more effective on HbA1c than placebo, with an overall reduction <u>in HbA1c by fiber of 0.26%</u>

Meta

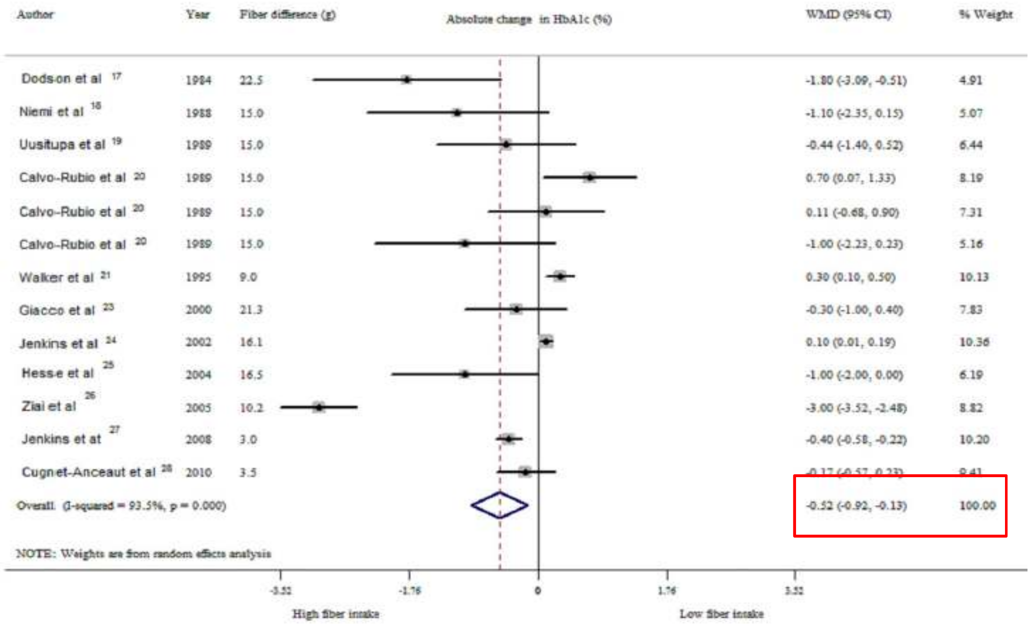


*Figure 4* **Forest plot diagram of the effect of fiber intake on HbA1c.**

Silva et al. Nutrition Reviews (2013):71(12):790–801

[Method]
1. 11 randomized controlled trials
2. patients with diabetes

[Result]
1. HbA1c absolute values decreased by 0.55% in patients who consumed high-fiber diets as compared to control diets

27.2g/d

In Korea

Table 1. Dietary nutrient intake and overall percentage of KNDP p...

| Nutrients | Intake | | | ...han recommendation | % Meeting recommendation | % Above recommendation | $P^{\ddagger}$ |
|---|---|---|---|---|---|---|---|
| Energy (kcal/day) | 1,757.5 ± 423.2 | | | | | | |
| Men | 1,870.7 ± 403.5 | | | | | | |
| Women | 1,615.4 ± 404.3 | < 0.001 | | | | | |
| Protein (% energy) | 17.3 ± 3.4 | | 15-20 | 24.2 | 58.5 | 17.3 | |
| Men | 17.6 ± 3.2 | | | 19.9 | 61.9 | 18.2 | |
| Women | 16.9 ± 3.5 | < 0.001 | | 29.5 | 54.3 | 16.1 | < 0.001 |
| Fat (% energy) | 21.9 ± 7.3 | | ≤ 25 | | 68.8 | 31.2 | |
| Men | 22.8 ± 7.2 | | | | 65.0 | 35.0 | |
| Women | 20.7 ± 7.3 | < 0.001 | | | 73.7 | 26.3 | < 0.001 |
| Carbohydrate (% energy) | 60.9 ± 8.9 | | 50-60 | 10.6 | 35.3 | 54.1 | |
| Men | 59.6 ± 8.6 | | | 12.5 | 38.7 | 48.8 | |
| Women | 62.4 ± 9.2 | < 0.001 | | 8.2 | 31.0 | 60.8 | < 0.001 |
| Dietary fiber (g/1,000 kcal) | 15.5 ± 4.8 | | ≥ 12 | 24.7 | 75.3 | | |
| Men | 14.7 ± 4.6 | | | 30.1 | 69.9 | | |
| Women | 16.4 ± 4.9 | < 0.001 | | 17.8 | 82.2 | | < 0.001 |
| Saturated FA (% energy) | 3.5 ± 2.7 | | ≤ 7 | | 91.5 | 8.5 | |
| Men | 3.7 ± 2.8 | | | | 90.6 | 9.4 | |
| Women | 3.3 ± 2.4 | < 0.001 | | | 92.6 | 7.4 | 0.08 |
| Cholesterol (mg) | 258.3 ± 187.9 | | ≤ 200 | | 46.4 | 53.6 | |
| Men | 288.2 ± 198.5 | | | | 39.7 | 60.3 | |
| Women | 221.0 ± 166.4 | < 0.001 | | | 54.9 | 45.1 | < 0.001 |

Data are mean ± SD and percent unless otherwise indicated. FA, fatty acids. *$P$ value obtained by the Student t test or Mann-Whitney U test as appropriate for comparison of nutrient intake between men and women; †Recommended dietary intake adapted from the 2011 Treatment Guideline for Diabetes of the Korean Diabetes Association (14); ‡$P$ value obtained by chi-squared test to compare the rate of achievement of recommendation for each nutrient between men and women.

Kim et al, J Korean Med Sci. 2012;27:1188-1195

· Conclusion

1. 현실적인 식이섬유소 섭취량을 고려하면 보충제로 12~23g/d 추가 섭취가 필요

2. 하지만 굳이 보충제로 식이섬유소를 추가 섭취해야 할 정도로 고식이섬유소 섭취가 혈당 조절에 확실히 효과가 있는지 불명확함

# Home Take Message

1. 이상적인 탄수화물 섭취%(대량영양소 섭취%) 근거는 없음

2. 탄수화물의 질(glycemic load, 식이섬유소) 또한 위의 부재를 완벽하게 보완해주지 못함

3. 탄수화물 섭취가 특히 많은 한국인은 서양 데이터 기준으로 특이 케이스임

4. 한국인을 대상으로 한 RCT 연구가 필요함