Reproducibility and validity of dietary glycemic index, dietary glycemic load, and total carbohydrate intake in 141 Swedish men[1–3]

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ABSTRACT

Background: Although the associations of dietary glycemic index (GI) and dietary glycemic load (GL) with many chronic diseases have been examined in epidemiologic studies, information regarding the reproducibility and validity of these measures assessed with the use of food-frequency questionnaires (FFQs) is lacking.

Objective: We examined the reproducibility and validity of dietary GI and dietary GL and of carbohydrate intake as assessed by using an FFQ.

Design: Swedish men ($n = 141$) aged 40–74 y completed 2 FFQs 1 y apart and two 1-wk weighed diet records 6 mo apart. Dietary GI, dietary GL, and carbohydrate intake (starches and sugars) were calculated from both FFQs and diet records. We used intraclass correlations between the 2 FFQs to measure reproducibility and Pearson correlations between the diet records and the FFQs to assess the relative validity.

Results: Reproducibility of the FFQs was 0.66 (95% CI: 0.56, 0.75) for dietary GI, 0.61 (95% CI: 0.50, 0.71) for dietary GL, and 0.61 (95% CI: 0.50, 0.71) for carbohydrate. The correlations between the FFQs and diet records were 0.62 (95% CI: 0.45, 0.74) for dietary GI, 0.77 (95% CI: 0.56, 0.88) for dietary GL, and 0.76 (95% CI: 0.55, 0.88) for carbohydrate after adjustment for within-person variation in the FFQs and diet records.

Conclusion: In this sample of men, an FFQ measured dietary GI, dietary GL, and carbohydrate with reproducibility and validity similar to other commonly studied nutritional factors. *Am J Clin Nutr* 2007;85:548–53.

KEY WORDS Dietary glycemic index, dietary glycemic load, carbohydrate, food-frequency questionnaire, diet record

INTRODUCTION

Glycemic index (GI) and glycemic load (GL) are functional measures widely used to assess carbohydrate quality and quantity. GI measures the incremental blood glucose response to the carbohydrate contained in a food, expressed as a percentage of the response to a reference food, usually glucose or white bread (1). GL is the product of the GI and the carbohydrate content of the food and thus represents both the quantity and the quality of carbohydrate (2, 3). The concepts of GI and GL have been applied to studies that use food-frequency questionnaires (FFQs) to measure usual diet by calculating the average dietary GI and dietary GL (4). Investigators have examined, in epidemiologic studies, associations between dietary GI, dietary GL, and numerous chronic disorders including type 2 diabetes (4, 5), coronary heart disease (6), breast cancer (7, 8), colon cancer (9–11), stomach cancer (12), and gallstones (13). However, information regarding the reproducibility and validity of dietary GI and dietary GL is lacking. To determine how well an FFQ measures carbohydrate quality and quantity, we examined the reproducibility and validity of dietary GI and GL and of available carbohydrate intake in 141 middle-aged or older Swedish men.

PARTICIPANTS AND METHODS

Participants

Seven hundred ninety men aged 40–74 y and living in central Sweden were randomly sampled and invited to participate in a validation study of an FFQ developed for the Swedish population; 58% responded, and 161 men agreed to complete two 1-wk weighed diet records (DRs) and 2 FFQs. Of those men, 152 completed ≥13 d of DRs. We also excluded 11 participants who did not complete both FFQs, which left 141 men who were available for this analysis. The validation study was approved by the Ethics Committee at the Karolinska Institute.

Dietary assessment

An experienced dietitian instructed participants individually and in small groups about weighing and recording all foods consumed. Each participant was provided with an electronic scale, a set of standard household measures of volume, a diary, and detailed written instructions. Use of the electronic scale was encouraged when possible. The DRs were kept for two 1-wk periods ≈6 mo apart. After the return of each 1-wk DR, the dietitian reviewed the record and contacted the participant to

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resolve any ambiguities. The DRs were input into the MATS software package (version 2.2; Rudans Lättdata, Västerås, Sweden). For dishes not included in the MATS database, the dietitian obtained recipes from the participants and entered appropriate amounts of the component foods. We combined the 2 wk of DRs to decrease the within-person variation in food and nutrient intake and to capture seasonal variability.

The self-administered FFQ asked participants about their usual frequency of consumption of 96 foods and beverages over the previous year. Portion sizes were specified in commonly used units. The 8 possible responses ranged from "never" to "≥3 times/d." The same FFQ was administered on 2 occasions ≈1 y apart. The second FFQ was administered after the DRs and thus represented food consumption during the time period of interest. However, the answers provided in the second FFQ may have been influenced by the attention to diet required to complete the DRs. Therefore, we also compared the first FFQ (reflecting diet in the year before the DRs) and, to reduce random variability in completing the FFQ, the mean of the 2 FFQs to the DRs.

When the specified portion sizes from the FFQs were compared with measured portion sizes from the DRs, the measured portion sizes were found to vary by the participant's age. We calculated age-specific portion sizes from the DRs and multiplied the reported frequencies from the FFQs by the age-specific portion sizes to determine the quantity of each food consumed. Nutrient calculation for the FFQs and DRs was performed by using the nutrient-composition database from the Swedish Food Administration (14). Carbohydrate values were calculated as the total sugars plus total starches, and thus they measure available carbohydrate.

A database of GI and GL values was created primarily on the basis of the international table of FI and GL values for 2002 (15). We used white bread as the reference food. Food items for which a GI value had not been determined were assigned the GI value from a comparable food. For example, lasagna was assigned the GI value of cheese ravioli, and vegetable soup was assigned the GI value of minestrone. Dietary GI was calculated as the average GI of the carbohydrates consumed by using the formula

$$\text{Dietary GI} = \sum\nolimits_{\text{foods}} C \times F \times \text{GI} / \sum\nolimits_{\text{foods}} C \times F \qquad (1)$$

where C represents the quantity of carbohydrate (starches plus sugars) in an age-specific portion of food, F represents the frequency of consumption of the food per day, and GI represents the GI of the food when white bread is used as the standard. Dietary GL was calculated by using the formula

$$\text{Dietary GL} = \sum\nolimits_{\text{foods}} C \times F \times \text{GI} \qquad (2)$$

where the result is the product of dietary GI and carbohydrate. We adjusted dietary GI, dietary GL, and carbohydrate for energy by using the residuals method (16). Energy adjustment reduced the variability in carbohydrate intake and dietary GL but not dietary GI.

Statistical analysis

We evaluated the distributions of dietary GI, dietary GL, and carbohydrates for deviations from normality; because none of the factors was strongly skewed, we evaluated reproducibility and validity by using untransformed nutrients. We calculated the means and 95% CIs for total energy, carbohydrate, dietary GI, and dietary GL. Differences in means between the diet assessment methods were tested by using repeated-measures analysis of variance; if we found evidence for a difference, we performed pairwise tests by using the Bonferroni method to adjust for multiple comparisons. We used intraclass correlations and exact 95% CIs between the repeated FFQs to assess reproducibility (17, 18). To assess the validity of the FFQs with DRs as the standard, we calculated crude and energy-adjusted Pearson correlation coefficients. Because within-person, day-to-day variability in dietary intake and random errors in completing the FFQs weaken correlations (16), we calculated deattuenuated (ie, corrected) correlations and 95% CIs to estimate the results that would have been observed if we had a large number of measurements from each participant (19, 20).

In addition, we calculated the percentage of subjects who were classified in the same or adjacent quintile of dietary GI, dietary GL, or carbohydrate in 2 different diet assessments (termed *well classified*), and we calculated the percentage of subjects who were classified in one extreme quintile by using one diet assessment and in the opposite extreme quintile by using another diet assessment (termed *poorly classified*). We constructed exact 95% CIs around the estimates. We tested for associations between quintile classifications by using chi-square tests; we then calculated the contribution of each food to the dietary GL. For the 20 foods ranked highest in the DRs, we calculated the corresponding ranks from the FFQs, the percentage contribution estimated from each diet assessment, the intraclass correlations between the FFQs, and, because the distribution of the foods was strongly skewed, Spearman correlations between the FFQs and the DRs. We tested for differences in the contribution to the dietary GL between diet assessment methods by using repeated-measures analysis of variance, and, when evidence for differences was present, we performed pairwise comparisons with adjustment for multiple comparisons with the use of the Bonferroni method. We used SAS (version 9.1; SAS Institute, Cary, NC) and STATA (version 8.0; Stata Corporation, College Station, TX) software for analysis.

RESULTS

The mean (±SD) age of the study participants was 61.8 ± 9.5 y, and their average body mass index (BMI; in kg/m^2) was 27.0 ± 3.1. Fifteen percent of participants were current smokers, and 50% were former smokers. Mean reported energy intake, dietary GL, and carbohydrate intake were higher on the FFQs than on the DRs, and mean reported dietary GI was lower on the FFQs than on the DRs (Bonferroni-adjusted $P < 0.05$ comparing FFQs with DRs) (**Table 1**). The participants reported more bread intake on the FFQs (83 g white bread/d, 51 g crispbread/d, and 69 g whole-grain bread/d) than on the DRs (59 g white bread/d, 24 g crispbread/d, and 34 g whole-grain bread/d). The intraclass correlations between 2 FFQs administered ≈1 y apart were 0.66 (95% CI: 0.56, 0.75) for dietary GI, 0.61 (95% CI: 0.50, 0.71) for dietary GL, and 0.61 (95% CI: 0.50, 0.71) for carbohydrate (**Table 2**).

Correlations between the second FFQ and DR were similar to those between the first FFQ and DR. After deattenuation to adjust for within-person variation in the DRs and FFQs, energy-adjusted correlations between the mean of the 2 FFQs and the DRs were 0.62 (95% CI: 0.45, 0.74) for dietary GI, 0.77 (95% CI:

TABLE 1
Energy intake, dietary glycemic index, dietary glycemic load, and carbohydrate intake in 141 Swedish men[1]

	Diet record		FFQ1		FFQ2	
	Crude	Energy-adjusted[2]	Crude	Energy-adjusted	Crude	Energy-adjusted
Energy intake (kcal/d)	2230 (2150, 2309)		2404 (2276, 2531)		2435 (2314, 2556)	
Dietary glycemic index	78.6 (78.0, 79.3)	78.7 (78.0, 79.4)	76.4 (75.6, 77.1)	76.4 (75.6, 77.2)	76.4 (75.6, 77.2)	76.4 (75.7, 77.2)
Dietary glycemic load	211 (202, 221)	211 (206, 216)	239 (225, 253)	240 (233, 246)	243 (230, 256)	243 (237, 249)
Carbohydrate (g/d)	268 (257, 280)	268 (263, 273)	312 (295, 329)	313 (306, 320)	317 (301, 333)	318 (312, 323)

[1] All values are $\bar{x}$; 95% CI in parentheses. FFQ1, food-frequency questionnaire 1; FFQ2, food-frequency questionnaire 2. For all dietary factors, the mean of ≥1 diet assessment was significantly different from that of another $P < 0.001$ (repeated-measures ANOVA). Means from diet record were significantly different from those from FFQ1 and FFQ2, $P < 0.05$ (Bonferroni-adjusted); means from FFQ1 were not significantly different from those from FFQ2, $P >$ 0.05 (Bonferroni-adjusted).

[2] Energy adjustment was performed by using the residuals method (16).

0.56, 0.88) for dietary GL, and 0.76 (95% CI: 0.55, 0.88) for carbohydrate intake (Table 2 and **Figure 1**). The percentage of participants who were well characterized by the FFQs (in the same or adjacent quintile as in the DR) was 70% for dietary GI, 79% for dietary GL, and 74% for carbohydrate (**Table 3**). The percentage of participants who were misclassified from one extreme quintile to the other was 2% for dietary GI, 0% for dietary GL, and 1% for carbohydrate.

White bread contributed the most to the dietary GL—14% of the total dietary GL as assessed by the DRs (**Table 4**). Together, white bread, crispbread, and whole-grain bread accounted for 28% of the total dietary GL as measured by the DRs; cakes, pastry, sweet bread, coffee cake, biscuits, and crackers accounted for an additional 12%. White bread, crispbread, and whole-grain bread accounted for 40% of the dietary GL as measured by the FFQs. The intraclass correlations between the 2 FFQs for the foods with relatively large contributions to the dietary GL ranged from 0.21 for fried potatoes to 0.84 for oatmeal porridge. Spearman correlations between the mean of the FFQs and the DRs ranged from 0.24 for bananas to 0.82 for oatmeal porridge. Although the ranking of most foods was similar on the FFQs and DRs, intake of cakes and pastries was underreported on the FFQs.

DISCUSSION

In this study of Swedish men, the validity and reproducibility of dietary GI and dietary GL were similar to those of nutrients commonly studied in epidemiologic studies with the use of FFQs. For example, in the same validation study (21), intraclass correlation coefficients between 2 FFQs ranged from 0.54 for eicosapentaenoic acid to 0.85 for alcohol, and Spearman correlation coefficients between FFQs and fourteen 24-h recalls ranged from 0.44 for protein to 0.81 for alcohol. The percentage of men misclassified from one extreme quintile to the other was low (0–2%), and the percentage classified in the same or adjacent quintile was relatively high (70–79%), which suggests that the FFQs can distinguish between participants with high and low dietary GI, dietary GL, and carbohydrate. Correlations between the diet measurement tools for the foods that contribute to the dietary GL ranged from 0.24 to 0.82, which is a range similar to that found in prior validation studies (16), although we found in the current study that the intakes of cakes and pastries were severely underreported on the FFQs. Some additional evidence that FFQs can distinguish between people with high and low carbohydrate quality comes from a cross-sectional analysis of 185 women from the Nurses' Health Study, in which dietary GI and dietary GL were directly associated with plasma triacylglycerol concentrations (2).

Both total energy and carbohydrate intake were overestimated by the FFQs. Whereas some FFQs that have been validated in the United States consistently underestimate total energy and all of the macronutrients (16), several FFQs validated in European populations have been shown to overestimate total energy intake

TABLE 2
Reproducibility and validity of dietary glycemic index, dietary glycemic load, and carbohydrate in 141 Swedish men[1]

	FFQ1 vs FFQ2[2]		FFQ1 vs DR[3]		FFQ2 vs DR[3]		Mean of FFQs vs DR[3]	
	Crude	Energy-adjusted	Crude	Energy-adjusted	Crude	Energy-adjusted	Crude	Energy-adjusted
Dietary glycemic index	0.67 (0.57, 0.75)	0.66 (0.56, 0.75)	0.50 (0.36, 0.61)	0.49 (0.35, 0.61)	0.50 (0.36, 0.61)	0.50 (0.36, 0.61)	0.55 (0.42, 0.65)	0.54 (0.42, 0.65)
Dietary glycemic load	0.67 (0.56, 0.75)	0.61 (0.50, 0.71)	0.56 (0.43, 0.66)	0.56 (0.44, 0.67)	0.51 (0.38, 0.63)	0.62 (0.51, 0.71)	0.59 (0.47, 0.68)	0.66 (0.55, 0.74)
Carbohydrate (g/d)	0.68 (0.58, 0.76)	0.61 (0.50, 0.71)	0.54 (0.41, 0.65)	0.56 (0.43, 0.66)	0.51 (0.38, 0.62)	0.62 (0.50, 0.71)	0.57 (0.45, 0.67)	0.65 (0.54, 0.74)
Deattenuated correlations[4]								
Dietary glycemic index	—	—	0.54 (0.38, 0.67)	0.53 (0.37, 0.66)	0.54 (0.38, 0.67)	0.54 (0.38, 0.67)	0.62 (0.45, 0.75)	0.62 (0.45, 0.74)
Dietary glycemic load	—	—	0.57 (0.44, 0.68)	0.62 (0.45, 0.75)	0.53 (0.39, 0.64)	0.69 (0.51, 0.80)	0.63 (0.50, 0.74)	0.77 (0.56, 0.88)
Carbohydrate (g/d)	—	—	0.55 (0.42, 0.66)	0.62 (0.44, 0.75)	0.52 (0.39, 0.64)	0.68 (0.51, 0.81)	0.61 (0.48, 0.72)	0.76 (0.55, 0.88)

[1] DR, diet record; FFQ1, food-frequency questionnaire 1; FFQ2, food-frequency questionnaire 2. Energy adjustment was performed by using the residuals method (16).

[2] Intraclass correlation; exact 95% CIs in parentheses (all such values). All intraclass correlations were significantly different from zero, $P < 0.001$.

[3] Pearson correlation; 95% CIs in parentheses (all such values). All Pearson correlations were significantly different from zero, $P < 0.001$.

[4] Statistically adjusted to reduce the attenuating effects of within-person variation in DRs and random error in FFQs (19, 20).

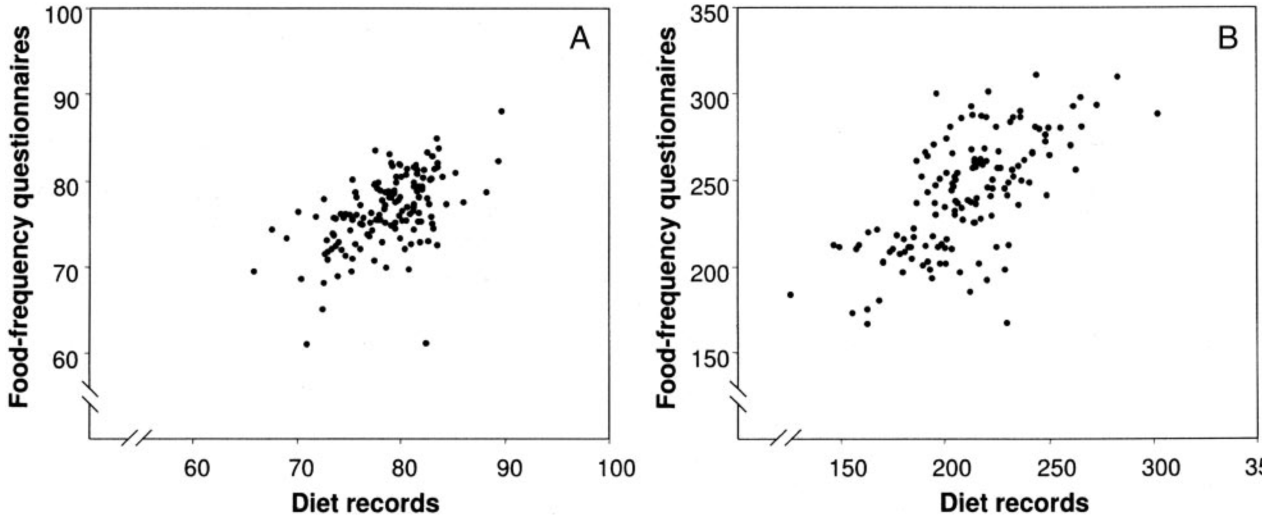

FIGURE 1. Mean dietary glycemic index (A) and dietary glycemic load (B) for each participant, based on 2 food-frequency questionnaires or two 1-wk diet records. The values were energy-adjusted by using the residuals method (16). Correlations between the food-frequency questionnaires and diet records were 0.54 (95% CI: 0.42, 0.65) for dietary glycemic index and 0.66 (95% CI: 0.55, 0.74) for dietary glycemic load. After deattenuation (ie, correction) to estimate the association that would be observed if there were many measurements for each subject, the correlations were 0.62 (95% CI: 0.45, 0.74) for dietary glycemic index and 0.77 (95% CI: 0.56, 0.88) for dietary glycemic load (19, 20).

(22–25). In the Swedish population in the current study, the reported consumption of bread was higher on the FFQs than the DRs, which appeared to drive the higher estimated energy and carbohydrate intakes. The difference in reporting of bread intake may have been due to faulty recall or to changes in diet induced by recording food consumption. However, the ranking of carbohydrate consumption by DRs and FFQs appeared to be consistent ($r = 0.76$).

Several limitations of this analysis deserve further consideration. Because errors in DRs are thought to be correlated with errors in FFQs less than with those in 24-h recalls or other instruments that rely on memory of food consumption, DRs are often used to validate FFQs (16). However, errors in the databases used to convert food intakes into nutrient intakes or quality measures can be shared by DRs and FFQs, which leads to potentially biased estimates of validity. In the current study, both methods of dietary assessment relied primarily on the international table of GI and GL values for 2002 (15) for GI values. The assessment of GI and GL is a relatively new and rapidly developing area of food science. The Swedish versions of many foods have not been tested, which is a potential problem because foods with the same names, including brand-name packaged foods, may differ between countries (15). Furthermore, some have questioned the usefulness of GI tables of single foods to predict

TABLE 3
Percentages of 141 Swedish men well and poorly classified by the food-frequency questionnaires[1]

	FFQ1 vs FFQ2		FFQ1 vs DR		FFQ2 vs DR		Mean of FFQs vs DR	
	Crude	Energy-adjusted	Crude	Energy-adjusted	Crude	Energy-adjusted	Crude	Energy-adjusted
	%		%		%		%	
Well classified[2]								
Dietary glycemic index	79 (72, 86)[3]	79 (72, 86)	68 (60, 76)	70 (61, 77)	70 (61, 77)	71 (63, 78)	72 (64, 80)	70 (61, 77)
Dietary glycemic load	85 (78, 91)	77 (70, 84)	72 (64, 80)	75 (67, 82)	76 (68, 83)	75 (67, 82)	78 (70, 85)	79 (72, 86)
Carbohydrate (g/d)	84 (77, 90)	77 (70, 84)	70 (61, 77)	75 (67, 82)	73 (65, 80)	72 (64, 80)	74 (66, 81)	74 (66, 81)
Poorly classified[4]								
Dietary glycemic index	1 (0, 4)	1 (0, 4)	1 (0, 5)	1 (0, 5)	2 (0, 6)	2 (0, 6)	2 (0, 6)	2 (0, 6)
Dietary glycemic load	1 (0, 5)	1 (0, 4)	1 (0, 5)	0 (0, 3)	2 (0, 6)	0 (0, 3)	1 (0, 5)	0 (0, 3)
Carbohydrate (g/d)	1 (0, 5)	1 (0, 4)	1 (0, 4)	1 (0, 4)	3 (1, 7)	1 (0, 4)	2 (0, 6)	1 (0, 4)

[1] DR, diet record; FFQ1, food-frequency questionnaire 1; FFQ2, food-frequency questionnaire 2. Energy adjustment was performed by using the residuals method (16).

[2] Participants classified in the same or adjacent quintile. When quintile assignments by 2 diet assessment methods were cross-tabulated, the observed cell counts differed significantly from the cell counts that would have been expected if the diet assessment methods were not associated ($P < 0.001$ for all comparisons, chi-square tests).

[3] 95% CI in parentheses (all values).

[4] Participants were classified in one extreme quintile by one diet assessment and in the opposite extreme quintile by the other diet assessment.

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TABLE 4
Contribution to the dietary glycemic load (GL), reproducibility, and validity of 20 foods measured in 141 Swedish men[1]

		Rank			Proportion of GL contribution						
Food	GI[2]	DR	FFQ1	FFQ2	DR	FFQ1	FFQ2	FFQ1 vs FFQ2[3]	FFQ1 vs DR[4]	FFQ2 vs DR[4]	Mean FFQs vs DR[4]
						%		%	%	%	%
White bread (59 g/d from DRs)	100	1	1	1	14.1 (12.7, 15.6)[5,6]	17.4 (14.7, 20.0)	16.5 (13.5, 19.7)	0.54 (0.41, 0.65)	0.55 (0.42, 0.66)	0.65 (0.54, 0.73)	0.68 (0.58, 0.76)
Boiled potato (116 g/d from DRs)	97	2	4	4	10.5 (9.6, 11.4)[7]	8.1 (7.2, 9.1)	7.3 (6.6, 8.0)	0.42 (0.28, 0.55)	0.38 (0.23, 0.52)	0.34 (0.19, 0.48)	0.40 (0.26, 0.53)
Crispbread (24 g/d from DRs)	95	3	2	2	7.0 (6.1, 8.0)[7]	13.4 (11.4, 15.4)	12.4 (10.6, 14.2)	0.71 (0.62, 0.78)	0.47 (0.33, 0.59)	0.60 (0.49, 0.70)	0.57 (0.45, 0.68)
Whole-grain bread (34 g/d from DRs)	79	4	3	3	6.8 (5.1, 8.6)[7]	9.3 (7.1, 11.5)	11.4 (9.0, 13.9)	0.68 (0.58, 0.76)	0.44 (0.29, 0.56)	0.48 (0.34, 0.60)	0.50 (0.36, 0.61)
Sweet bread or coffee cake (26 g/d from DRs)	83	5	6	7	5.6 (4.7, 6.5)[7]	3.9 (3.0, 4.7)	3.8 (3.0, 4.7)	0.73 (0.64, 0.80)	0.58 (0.46, 0.68)	0.59 (0.47, 0.69)	0.66 (0.55, 0.75)
Sugar (11 g/d from DRs)	97	6	5	5	4.8 (3.8, 5.9)[7]	6.3 (4.9, 7.6)	6.0 (4.7, 7.4)	0.74 (0.66, 0.81)	0.77 (0.69, 0.83)	0.74 (0.66, 0.81)	0.80 (0.73, 0.85)
Soft drinks (118 g/d from DRs)	86	7	7	6	4.0 (3.2, 4.9)[8]	3.5 (2.6, 4.4)	4.3 (3.3, 5.3)	0.34 (0.19, 0.48)	0.49 (0.35, 0.60)	0.43 (0.29, 0.56)	0.51 (0.38, 0.62)
Jam or marmalade (23 g/d from DRs)	73	8	12	13	3.6 (3.0, 4.2)[7]	2.0 (1.6, 2.3)	2.0 (1.7, 2.4)	0.49 (0.36, 0.61)	0.43 (0.29, 0.56)	0.51 (0.37, 0.62)	0.53 (0.40, 0.64)
Cake or pastry (24 g/d from DRs)	84	9	39	32	3.5 (3.0, 4.0)[7]	0.4 (0.3, 0.5)	0.6 (0.4, 0.7)	0.41 (0.26, 0.54)	0.34 (0.18, 0.48)	0.35 (0.19, 0.48)	0.43 (0.29, 0.56)
Müsli or cereal (12 g/d from DRs)	87	10	9	8	3.2 (2.4, 4.1)[8]	3.0 (2.3, 3.7)	2.8 (2.2, 3.6)	0.66 (0.56, 0.75)	0.69 (0.59, 0.77)	0.61 (0.49, 0.70)	0.70 (0.60, 0.77)
Biscuits or crackers (9 g/d from DRs)	96	11	14	11	2.7 (2.1, 3.2)[6]	1.7 (1.3, 2.2)	2.1 (1.6, 2.6)	0.64 (0.53, 0.73)	0.42 (0.28, 0.55)	0.48 (0.34, 0.60)	0.54 (0.41, 0.65)
Pancakes or waffles (20 g/d from DRs)	109	12	11	12	2.4 (2.0, 2.9)[8]	2.0 (1.6, 2.4)	2.0 (1.7, 2.3)	0.46 (0.32, 0.58)	0.56 (0.44, 0.67)	0.55 (0.42, 0.65)	0.60 (0.49, 0.70)
Fried potato (26 g/d from DRs)	85	13	20	17	2.2 (1.8, 2.6)[7]	1.3 (1.0, 1.5)	1.3 (1.0, 1.6)	0.21 (0.05, 0.36)	0.23 (0.07, 0.38)	0.34 (0.18, 0.48)	0.30 (0.14, 0.44)
Banana (27 g/d from DRs)	75	14	22	24	2.1 (1.7, 2.5)[7]	0.9 (0.7, 1.1)	0.8 (0.6, 1.0)	0.38 (0.24, 0.52)	0.19 (0.02, 0.34)	0.23 (0.07, 0.38)	0.24 (0.08, 0.39)
Rice (18 g/d from DRs)	94	15	13	14	2.0 (1.5, 2.6)[8]	1.8 (1.4, 2.1)	1.9 (1.5, 2.2)	0.75 (0.67, 0.81)	0.50 (0.36, 0.61)	0.50 (0.36, 0.61)	0.55 (0.42, 0.65)
Oatmeal porridge (39 g/d from DRs)	91	16	10	10	1.9 (1.4, 2.5)[8]	2.1 (1.6, 2.6)	2.1 (1.6, 2.6)	0.84 (0.78, 0.88)	0.77 (0.70, 0.83)	0.80 (0.73, 0.85)	0.82 (0.75, 0.86)
Pasta (24 g/d from DRs)	65	17	16	15	1.7 (1.4, 2.0)[8]	1.6 (1.4, 1.8)	1.7 (1.5, 2.0)	0.57 (0.45, 0.67)	0.29 (0.13, 0.44)	0.39 (0.23, 0.52)	0.42 (0.27, 0.55)
Apples or pears (53 g/d from DRs)	53	18	18	18	1.6 (1.4, 1.9)[7]	1.3 (1.1, 1.5)	1.3 (1.1, 1.5)	0.57 (0.45, 0.67)	0.49 (0.36, 0.61)	0.62 (0.51, 0.72)	0.64 (0.53, 0.73)
Low-alcohol beer (164 g/d from DRs)	51	19	25	27	1.6 (1.2, 2.0)[7]	0.7 (0.6, 0.9)	0.7 (0.6, 0.9)	0.75 (0.67, 0.81)	0.63 (0.52, 0.72)	0.52 (0.39, 0.63)	0.62 (0.50, 0.71)
Fruit stew or soup (33 g/d from DRs)	77	20	15	16	1.5 (1.1, 2.0)[8]	1.7 (1.2, 2.1)	1.4 (1.0, 1.8)	0.50 (0.36, 0.61)	0.46 (0.32, 0.59)	0.49 (0.36, 0.61)	0.55 (0.42, 0.65)

[1] GI, glycemic index; DR, diet record; FFQ1, food-frequency questionnaire 1; FFQ2, food-frequency questionnaire 2.
[2] GI assigned to the food item.
[3] Intraclass correlation coefficient; exact 95% CI in parentheses (all such values). All correlations were significantly different from zero, $P < 0.05$.
[4] Spearman correlation coefficient; 95% CI in parentheses (all such values). All correlations were significantly different from zero, $P < 0.05$.
[5] 95% CI in parentheses (all such values).
[6] At least one contribution (by %) to dietary GL was significantly different from another, $P < 0.05$ (repeated-measures ANOVA). Bonferroni-adjusted $P < 0.05$ comparing DR with FFQ1 and $P > 0.05$ comparing DR with FFQ2 and FFQ1 with FFQ2.
[7] At least one contribution (by %) to dietary GL was significantly different from another, $P < 0.05$ (repeated-measures ANOVA). Bonferroni-adjusted $P < 0.05$ comparing DR with FFQ1 and DR with FFQ2 and $P > 0.05$ comparing FFQ1 with FFQ2.
[8] Contributions (by %) did not differ significantly, $P > 0.05$ (repeated-measures ANOVA).

the GI of mixed meals (26, 27), in part because GI values can depend on food variety and cooking technique and because concerns exist that the accompanying fat and protein affect the GI of carbohydrates. However, the GI of mixed breakfast meals calculated by using GI tables was shown to predict glycemic response (28), and, in a recent clinical trial, participants had higher average blood glucose concentrations over the course of a day while consuming diets with higher calculated GI and GL (29). Errors in the calculation of nutrients and other dietary factors that result from variety and preparation do not seem to be confined to the determination of GIs for carbohydrate containing foods; variability in nutrient content caused by growing conditions and varieties has long been recognized to affect the accuracy of food databases. In addition, the generalizability of these estimates may be limited, because the current study evaluated one particular FFQ designed for use in Sweden and included only men, and because some foods, such as crispbread, that made a large contribution to the dietary GL in the current study are not commonly consumed in other populations. Validation studies in other populations would add valuable information on this topic.

In summary, the reproducibility and validity of dietary GI and dietary GL measured using a FFQ in this population were within the range of commonly studied nutritional factors. This study lends support to the practice of using FFQs to estimate dietary GI and dietary GL.

CWW created the glycemic index and glycemic load database; EBL and CWW analyzed the data; EBL drafted the manuscript; all authors participated in manuscript revisions and approved the final draft; AW and SL were responsible for the overall conduct of the study; and SL participated in the development of the glycemic index and glycemic load database. None of the authors had a financial or personal conflict of interest.

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