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Change in Food Choices Following a Glycemic Load Intervention in Adults with Type 2 Diabetes: Research and Professional Brief

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Abstract

The glycemic index (GI) reflects the postprandial glucose response of carbohydrate-containing foods, and the adoption of a lower GI diet may be beneficial in diabetes management. The purpose of this study was to evaluate change in food group intake by participants after completing an intervention that included instruction about carbohydrate and the GI using a quasi-experimental design. Recruitment occurred from February – August 2005 and September –December 2006. Individuals 40–70 years old with type 2 diabetes ≥ 1 year were randomly assigned to an immediate (n=55) or delayed (n=48) treatment group. A 9-week group-based intervention regarding the quantity and type of carbohydrate for diabetes management was provided. Three sets of 24-hour dietary recalls were used to assess food group intake. Foods were divided into nine main food groups and 166 subgroups based on the Dietary Guidelines for Americans 2005 and the United States Department of Agriculture's Food Guide Pyramid. Analysis of variance was used to examine between group differences and paired t-test compared maintenance of change for the immediate group. Change in dietary GI was significantly different between groups upon completion of the intervention by the immediate group ($P<.05$). Participants consumed significantly more servings of whole fruit and nonfat dairy products following the intervention and fewer servings of vegetable fats (all $P<.05$). Only whole fruit consumption significantly declined in the immediate group during the maintenance period ($P<.05$). Nutrition education can facilitate the adoption of a lower GI diet among free-living people with diabetes. Maintaining dietary change likely requires further intervention and support.

Keywords

glycemic index; nutrition assessment; type 2 diabetes mellitus; patient education

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Introduction

Nutrition therapy is an essential component of successful diabetes management and carbohydrate accounts for the largest percentage of energy intake (1–3). The glycemic index (GI) reflects the glycemic response for a fixed amount of carbohydrate, while the glycemic load (GL) reflects the total glycemic response by accounting for the quantity and type of carbohydrate consumed (4). Glycemic index may be beneficial in improving weight regulation, postprandial glucose and insulin excursions, and risk for cardiovascular disease (5–7). A meta-analysis found that lower GI diets improved glycemic control in people with diabetes (8). A lower GI/GL diet may provide modest additional benefit in diabetes management beyond that observed when total carbohydrate is considered alone (3). However, not all studies are in agreement (9–10), and further research is needed.

A dietary pattern that includes carbohydrate from fruits, vegetables, whole grains, legumes and lowfat dairy products is consistent with the Dietary Guidelines for Americans 2005 (11). Previous research found dietary GI was related to carbohydrate foods and the combination of foods consumed (12). For example, children with type 1 diabetes in the lowest GI quartile consumed significantly less carbohydrate as potato and white bread and more carbohydrate as dairy foods and whole grain breads (13). Those who consumed a low GI diet ate more carbohydrate from pasta, whole grain bread, and temperate-climate fruit and less carbohydrate from white bread and potatoes in another study (14). Mexican participants consumed more pinto beans, whole-meal wheat bread, pears, apples, apricots, oranges and nectarines during a low than high GI diet (15). In general, a dietary pattern which includes more fruits, vegetables, whole grains, legumes and dairy products includes lower GI foods (16) and is encouraged for good health than a dietary pattern which includes refined grains, sweets and desserts (11).

The findings regarding the dietary changes people with diabetes make to adopt a lower GI or GL diet following a nutrition intervention are limited. Therefore, the purpose of this study was to evaluate the changes in food group intake among participants following an educational intervention which addressed both the quantity and type of carbohydrate and included instruction in the glycemic index. It was hypothesized that servings of lower GI foods would increase and GL would decrease following the intervention.

Methods

Eligible participants were 40–70 years of age, diagnosed with type 2 diabetes for ≥ 1 year, and did not require insulin therapy for diabetes management. Physician practices, media advertisements, and the University newswire were used for study recruitment. Recruitment occurred in two phases from February – August 2005 and September – December 2006. The Institutional Review Board at the sponsoring institution approved all study methods and participants provided informed consent.

The nutrition intervention included nine weekly group sessions led by the same dietitian and addressed GL by including instruction in the quantity (sessions 2–5) and quality (sessions 6–9) of carbohydrate. The curriculum content included: carbohydrate counting as a tool for managing carbohydrate quantity, the GI and factors which influence the postprandial glucose response as a tool for managing carbohydrate quality, and strategies for maintaining behavioral change. Each person received the number of carbohydrate choices included when 50–55% of energy was derived from carbohydrate. Participants were encouraged to select lower GI foods within their carbohydrate allotment and to spread their carbohydrate choices throughout meals and snacks. A specific goal regarding the number of low GI foods to consume/day was not provided, and a low carbohydrate diet was not prescribed.

The study used a quasi-experimental design in which participants were randomly assigned to an immediate or delayed group. Randomization assignment was generated by computer with the random seed chosen from a random numbers table. Following baseline assessment, the immediate group proceeded through the intervention. Participants in the delayed group served as a wait list control condition and were instructed to follow their usual dietary regimen. All participants completed a second round of data collection at the end of the nine weeks. This treatment-control period served as an efficacy trial of the intervention by comparing differences between the experimental and control conditions following implementation of the intervention for the immediate group. Following data collection, the delayed group proceeded through the same intervention. A third round of data collection occurred after the delayed group completed the intervention. An evaluation of the replication of the effects of the intervention was conducted by comparing outcomes before and after all participants completed the intervention. The third assessment for the immediate group at the 18-week time point served as a measure of dietary maintenance. There was no contact with study participants in the immediate group between the second and third assessment.

Participants' dietary intake was assessed via three sets of 24-hour dietary recalls by trained interviewers using the Minnesota Nutrition Data System for Research (NDS-R version 2006, Nutrition Coordinating Center, University of Minnesota, Minneapolis, MN). This data system provides the interface for an interactive telephone 24-hour interview using a multiple-pass method. Dietary recalls included two weekdays and one weekend day selected at random over a 2-week period. Telephone calls were unannounced to participants. Each person received a two-dimensional food portion visual (2D Food Portion Visual, Nutrition Consulting Enterprises, Framingham, MA) and was instructed to use common household measures to estimate portion sizes.

From the dietary records, foods were assigned to one of 166 subgroups within nine main food groups and subgroups were automatically generated from the NDS-R food/nutrient database. Assignment to food group in the NDS-R database is based on the United States Department of Agriculture Food Guide Pyramid and the Dietary Guidelines for Americans 2005 (11). Serving sizes were based on the Dietary Guidelines for Americans 2005 when available or the Food and Drug Administration's serving sizes (17) when foods were not part of current recommendations. Mixed dishes were disaggregated into ingredients for correct placement into subgroups. Food subgroups were combined into categories to examine dietary changes made following the intervention (eg, whole grains vs. refined grains). The NDS-R food/nutrient database categorizes whole grains using the following assumptions. If whole grain was the first ingredient on the label, the food was categorized as "whole grain." For foods with whole grain listed somewhere else on the ingredient list, the food was categorized as "partial whole grain," and foods with no whole grain ingredients were categorized as "refined grain." Number of servings consumed was based on the three day mean intake. Glycemic index values were obtained from published tables (16) and methodologies reported elsewhere were used for estimating the GI value of foods with unreported values (18–19). Average daily GI was calculated as [(grams of carbohydrate from food item/total daily grams of carbohydrate) × GI value of the food item]. Low GI foods are defined as having a value < 56, medium GI foods have a value of 56–69, and high GI foods have a value ≥ 70 (20). Glycemic load was calculated as [(grams of carbohydrate from food item × GI value of the food item)/100]. The GI and GL values were summed for each day and averaged across three days of intake.

The primary purpose of the study was to promote the adoption of a lower GL diet by lowering dietary GI while maintaining the percentage of energy from carbohydrate. To detect a medium effect size between groups for GI based on Cohen's criterion of 0.5 with 80% probability (21), the estimated sample size was 128 participants.

Chi-square and analysis of variance were used to compare baseline group differences in demographic characteristics. Analysis of variance was used to compare baseline nutrient intakes, mean change in servings between groups for the treatment-control period, and mean change in servings for the pre-post intervention period. Paired t-test was used to examine change in servings from posttest to 18-week maintenance for the immediate group. All analyses were conducted using SAS (version 9.1, 2003, SAS Institute, Inc., Cary, NC), and the level of significance was set at $P<.05$.

Results and Discussion

Overall, 182 people were screened for study eligibility via telephone screening protocol. Forty-five of those screened did not meet eligibility criteria and 28 were not interested in participating after receiving more information about the study. One hundred nine people were enrolled and 100 participants completed all dietary measures. The sample characteristics and mean nutrient intakes of participants at baseline are presented in Table 1. There were no significant differences in demographic characteristics or nutrient intakes between the immediate (n=55) and delayed (n=48) treatment groups at baseline nor between those who did and did not complete all dietary measures.

This study examined the changes participants made following nutrition education regarding both the quantity and type of carbohydrate for diabetes management. Following the treatment-control period, there was a significant difference in intake of whole fruit, nonfat dairy products, vegetable fat, and dietary GI between groups (Table 2). The increase in whole fruit intake is similar to the increase in servings obtained in previous trials which targeted fruit and vegetable intake (22–23). Overall, the changes in dietary intake following the intervention were similar for the delayed as for the immediate group. A decrease in servings of tomato products (eg, spaghetti sauce) occurred in both groups following the intervention and was significantly greater in the immediate than delayed group ($P<.05$). These dietary changes represent the changes made in food choices when adopting a lower GI diet.

There was a significant decline in servings of whole fruit during the maintenance period in the immediate group and a significant increase in servings of eggs (Table 2). No other significant changes in intake were observed during the maintenance period.

While not statistically significant, other changes in food group servings occurred by participants in both groups following the intervention. For example, fewer servings of white potatoes, refined breads, and refined grain products and more servings of partial and whole grain products were reported (Table 2). The findings suggest participants were making small changes in consumption of these foods during the brief timeframe available. The Dietary Guidelines for Americans 2005 encourage consumption of fiber-rich, whole grain foods and recommend at least half the grains come from whole grains (11). A low GI diet likely includes more whole grain foods (13,15), which is consistent with dietary guidelines.

A significant increase in legumes, another high fiber, low GI food, did not occur in this study. Despite provision of legume recipes, participants did not report preparing those recipes. Greater emphasis on incorporating legumes is needed. People may need to sample legume dishes during intervention sessions and receive more guidance regarding legume preparation to increase legume intake.

A surprising finding of the study was the change in total and animal fat servings when instruction regarding dietary fat was not included during the study. Previous research found a lower GI diet was characterized by a lower fat and higher protein intake (12). Perhaps study participation prompted individuals to focus on information received previously regarding a healthful diet and the quality of their diet overall. Nutrition education may facilitate positive changes in food choices beyond the specific focus of an intervention, a beneficial result of nutrition education and counseling.

Some study limitations should be noted. First, the study was conducted in a primarily white, well educated sample. The impact of the intervention among a racially and economically diverse sample is not known. Second, the effect of providing a specific goal regarding the number of low GI foods to consume, similar to the goal given in the national Fruits and Veggies-More Matters campaign for fruit and vegetable intake (24), should be evaluated. Third, participants did not receive information regarding GI until week six of the 9-week intervention. Whether greater reductions in GI occur if GI were introduced earlier in the intervention should be determined. Finally, mean dietary GI was in the low to moderate range at baseline based on the GI categorization of food (20). The change in food selections that occur by participants with higher GI diets is not known from this study.

Conclusions

Free-living participants can make dietary changes following education regarding GI and GL. Participants selected more servings of whole fruits and nonfat dairy products and fewer servings of tomato-based products and vegetable fats following the intervention. The findings from this study identify the changes participants can readily make to lower dietary GI and can guide educators regarding the focus of intervention messages to facilitate dietary change. Further education and support is likely needed to help consumers make greater dietary changes and to facilitate goal setting and problem solving for maintenance of those changes. Future research is needed to obtain a comprehensive evaluation of the intervention on clinical outcomes in a diverse sample.

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Table 1

Characteristics of the study sample and mean energy and nutrient intakes at baseline

Variable	Immediate Group (n=55) %	Delayed Group (n=48) %	P-value
Female	60.0	52.1	0.42
White	92.7	93.8	0.87
Married	72.7	70.8	0.99
College degree	69.1	43.8	0.41
Employed full-time	60.0	63.8	0.56
Previous diabetes education	71.2	74.0	0.51
Self-monitoring of blood glucose	83.1	75.5	0.26
Mean (±SD)[a] days/week	1.8 (±1.2)	1.7 (±1.3)	0.72
Mean (±SD)[a] times/day	1.0 (±0.2)	1.1 (±0.4)	0.35
	Mean (±SD)	**Mean (±SD)**	**P-value**
Age (years)	58.6 (±7.7)	59.8 (±7.3)	0.41
Years diagnosed with diabetes	4.7 (±4.8)	4.7 (±3.9)	0.99
Body mass index (kg/M^2)	33.4 (±6.9)	34.0 (±6.0)	0.63
Energy (kcal)	1780.1 (±537.9)	1837.0 (±531.5)	0.59
Carbohydrate (% of energy)	44.6 (±9.0)	45.6 (±10.4)	0.59
Protein (% of energy)	18.6 (±3.2)	18.3 (±3.8)	0.67
Total fat (% of energy)	38.4 (±7.3)	36.2 (±8.3)	0.17
Saturated fat (% of energy)	12.3 (±3.2)	12.3 (±3.0)	0.98
Polyunsaturated fat (% of energy)	8.6 (±2.5)	7.6 (±3.2)	0.09
Monounsaturated fat (% of energy)	14.5 (±3.2)	13.5 (±3.4)	0.14
Cholesterol (mg/1000 kcal)	187.5 (±91.0)	166.3 (±84.1)	0.23
Total fiber (g/1000 kcal)	11.0 (±3.2)	10.4 (±3.2)	0.34
Insoluble fiber (g/1000 kcal)	8.0 (±2.6)	7.5 (±2.7)	0.39
Soluble fiber (g/1000 kcal)	2.9 (±0.8)	2.7 (±0.8)	0.35
Total sugars (g/1000 kcal	42.5 (±3.2)	45.3 (±13.6)	0.32
Added sugars (g/1000 kcal)	22.5 (±13.8)	24.2 (±10.6)	0.50
Carbohydrate (total grams)	196.0 (±67.1)	209.0 (±65.0)	0.32
Glycemic index[b]	56.4 (±6.1)	54.9 (±5.7)	0.19

Variable	Immediate Group (n=55) %	Delayed Group (n=48) %	P-value
Glycemic load[c]	108.5 (±39.9)	113.4 (±37.3)	0.52

[a]Mean ± standard deviation (SD) values

[b]Glycemic index (GI) = (grams of carbohydrate from food item/total daily grams of carbohydrate) X GI of the food item; summed for all foods to get daily GI; averaged over 3 days of intake. GI values are based on glucose as the reference with glucose = 100.

[c]Glycemic load (GL) = (GI value of the food X grams of carbohydrate from the food)/100; summed for all foods to get daily glycemic load; averaged over 3 days of intake.

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Table 2

Mean ± standard deviation (SD) change in food group and selected food subgroup servings by study period

Food Group	Efficacy Change[a] (Treatment-Control Period) Mean (±SD)		Replication Change[b] (Pre-Post Intervention Period) Mean (±SD)		Maintenance Change[c] (Follow-Up Period) Mean (±SD)
	Immediate Group (n=55)	Delayed Group (n=48)	Immediate Group (n=55)	Delayed Group (n=46)[d]	Immediate Group (n=54)[e]
Fruits	0.08 (±1.85)	−0.45 (±1.33)	0.08 (±1.85)	0.13 (±0.96)	−0.36 (±1.16)[†]
Fruit juice (100% juice & frozen concentrate)	−0.10 (±0.59)	−0.04 (±0.44)	−0.10 (±0.59)	−0.02 (±0.35)	0.04 (±0.55)
Whole fruit (fresh, frozen, cooked/canned, dried)	0.40 (±1.35)[*]	−0.28 (±0.97)[*]	0.40 (±1.35)	0.19 (±0.88)	−0.38 (±1.02)[†]
Vegetables	−0.68 (±2.01)	−0.37 (±1.72)	−0.68 (±2.01)	−0.23 (±2.33)	−0.54 (±2.12)
Green/yellow vegetables (eg, broccoli, carrots, sweet potato)	0.10 (±0.67)	−0.04 (±0.60)	0.10 (±0.67)	0.04 (±0.80)	−0.03 (±0.86)
Tomato (includes raw, sauce, paste, salsa)	−0.26 (±1.01)	−0.36 (±0.75)	−0.26 (±1.01)[*]	−0.21 (±0.50)[*]	0.07 (±0.56)
Potatoes (all white, including fried)	−0.29 (±1.09)	0.04 (±0.73)	−0.29 (±1.09)	−0.26 (±0.63)	0.15 (±0.79)
Legumes (cooked, dried beans)	−0.04 (±0.36)	−0.05 (±0.34)	−0.04 (±0.36)	0.01 (±0.47)	0.01 (±0.42)
Meat	0.20 (±2.90)	−0.07 (±2.96)	0.20 (±2.90)	−0.26 (±3.21)	−0.02 (±2.70)
Meat, fish, poultry, regular fat	−0.31 (±2.14)	0.17 (±1.74)	−0.31 (±2.14)	−0.12 (±1.97)	−0.09 (±1.91)
Meat, fish, poultry, lean	0.33 (±2.09)	−0.46 (±2.08)	0.33 (±2.09)	0.29 (±2.03)	−0.10 (±2.30)
Eggs	−0.22 (±0.71)	−0.05 (±0.53)	−0.22 (±0.71)	0.00 (±0.54)	0.25 (±0.58)[†]
Nuts and seeds	0.34 (±1.57)	0.33 (±2.62)	0.34 (±1.57)	−0.40 (±2.57)	−0.26 (±1.72)
Grains	−0.05 (±2.21)	−0.12 (±2.35)	−0.05 (±2.21)	−0.79 (±2.58)	0.05 (±2.43)
Whole grain breads (eg, loaf, rolls, quick breads)	0.00 (±1.01)	−0.01 (±0.63)	0.00 (±1.01)	0.04 (±0.87)	−0.13 (±0.85)

Food Group	Efficacy Change[a] (Treatment-Control Period) Mean (±SD)		Replication Change[b] (Pre-Post Intervention Period) Mean (±SD)		Maintenance Change[c] (Follow-Up Period) Mean (±SD)
	Immediate Group (n=55)	Delayed Group (n=48)	Immediate Group (n=55)	Delayed Group (n=46)[d]	Immediate Group (n=54)[e]
Partial whole grain breads (eg, oatmeal, multigrain bread)	0.13 (±0.89)	−0.04 (±0.55)	0.13 (±0.89)	0.20 (±0.73)	0.08 (±1.08)
Refined breads (eg, white bread, flour tortilla)	−0.39 (±1.58)	−0.22 (±1.73)	−0.39 (±1.58)	−0.52 (±1.45)	0.05 (±1.55)
Whole grain cereals (eg, Total, Raisin Bran, Shredded Wheat)	0.09 (±0.73)	0.12 (±0.61)	0.09 (±0.73)	0.01 (±0.63)	0.00 (±0.58)
Partial whole grain cereals (eg, Basic 4, Smart Start)	−0.01 (±0.53)	−0.06 (±0.24)	−0.01 (±0.53)	0.19 (±0.53)	−0.00 (±0.46)
Refined cereals (eg, Rice Krispies, Special K)	0.02 (±0.16)	0.01 (±0.19)	0.02 (±0.16)	−0.01 (±0.19)	−0.01 (±0.18)
All whole grains (eg, pasta, crackers, snack bars)	0.24 (±1.31)	0.05 (±1.05)	0.24 (±1.31)	0.10 (±1.14)	−0.08 (±1.38)
Partial whole grains	0.11 (±0.96)	−0.12 (±0.66)	0.11 (±0.96)	0.44 (±0.88)	0.21 (±1.13)
Refined grains	−0.48 (±2.44)	0.00 (±2.45)	−0.48 (±2.44)	−1.24 (±2.45)	0.16 (±2.09)
Dairy (milk, cheese, yogurt, dairy dessert)	0.07 (±0.90)	−0.13 (±1.23)	0.07 (±0.90)	−0.10 (±1.19)	0.24 (±1.08)
Whole fat	−0.00 (±0.59)	−0.09 (±0.61)	−0.00 (±0.59)	−0.01 (±0.60)	0.06 (±0.58)
Reduced fat	−0.03 (±0.47)	0.11 (±0.53)	−0.03 (±0.47)	−0.08 (±0.64)	−0.01 (±0.46)
Nonfat	0.12 (±0.46)*	−0.06 (±0.39)*	0.12 (±0.46)	0.02 (±0.40)	0.04 (±0.51)
Fat	−0.67 (±2.23)*	0.44 (±2.52)*	−0.67 (±2.23)	−0.47 (±2.26)	0.46 (±1.98)
Animal fat (butter, shortening, cream)	−0.31 (±1.05)	0.03 (±1.67)	−0.31 (±1.05)	−0.48 (±1.24)	0.24 (±1.48)
Vegetable fat (margarine, oil, salad dressing)	−0.36 (±1.94)*	0.41 (±1.96)*	−0.36 (±1.94)	0.01 (±1.80)	0.23 (±1.91)
Sweets	−0.07 (±0.92)	0.07 (±2.04)	−0.07 (±0.92)	0.04 (±1.83)	0.55 (±2.05)

Food Group	Efficacy Change[a] (Treatment-Control Period) Mean (±SD)		Replication Change[b] (Pre-Post Intervention Period) Mean (±SD)		Maintenance Change[c] (Follow-Up Period) Mean (±SD)
	Immediate Group (n=55)	Delayed Group (n=48)	Immediate Group (n=55)	Delayed Group (n=46)[d]	Immediate Group (n=54)[e]
Sugar	−0.14 (±0.70)	−0.05 (±0.94)	−0.14 (±0.70)*	0.18 (±0.94)*	0.09 (±0.51)
Beverages	−0.28 (±1.16)	−0.04 (±1.72)	−0.28 (±1.16)	−0.35 (±1.46)	0.19 (±1.64)
Miscellaneous	0.06 (±1.51)	−0.07 (±2.06)	0.06 (±1.51)	−0.31 (±1.69)	−0.11 (±1.80)
Sauces and Condiments (eg, catsup, mustard, soy sauce)	−0.16 (±1.18)	0.08 (±0.88)	−0.16 (±1.18)	−0.04 (±0.87)	0.01 (±1.05)
Glycemic Index[f]	−2.08 (±5.11)*	1.71 (±5.31)*	−2.08 (±5.11)	−2.80 (±6.07)	0.83 (±5.70)
Glycemic Load[g]	−8.99 (±32.27)	−3.33 (34.31)	−8.99 (±32.27)	−11.87 (±32.37)	2.01 (±34.56)

[a] Comparison of change in servings between treatment groups using analysis of variance from baseline to the post-intervention assessment for the immediate group. The delayed group served as a wait list control condition.

[b] Comparison of change in servings using analysis of variance between treatment groups immediately before and after the intervention.

[c] Change in servings for the immediate group using paired t-test from the post-intervention period to the 18-week follow-up period

[d] Two participants in this group failed to provide dietary recall at time 2 and could not be included in this comparison.

[e] One participant in this group failed to provide dietary recall at time 2 and could not be included in this analysis.

[f] Glycemic index (GI) = (grams of carbohydrate from food item/total daily grams of carbohydrate) X GI of the food item; summed for all foods to get daily GI; averaged over 3 days of intake. GI values are based on glucose as the reference with GI = 100.

[g] Glycemic load (GL) = (GI value of the food X grams of carbohydrate from the food)/100; summed for all foods to obtain the daily GL; averaged over 3 days of intake.

* Significant difference in change between groups for this time period using analysis of variance ($p<.05$)

† Significant change within immediate group using paired t-test ($p<.05$)