Does Knowing One's Elevated Glycemic Status Make a Difference in Macronutrient Intake?

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OBJECTIVE

To determine whether macronutrient intake differs by awareness of glycemic status among people with diabetes and prediabetes.

RESEARCH DESIGN AND METHODS

We used 24-h dietary recall and other data from 3,725 nonpregnant adults with diabetes or prediabetes aged ≥20 years from the morning fasting sample of the 2005–2010 National Health and Nutrition Examination Survey. Diabetes and prediabetes awareness were self-reported; those unaware of diabetes and prediabetes were defined by fasting plasma glucose (FPG) ≥126 mg/dL or HbA_{1c} ≥6.5% and FPG 100–125 mg/dL or HbA_{1c} of 5.7%–6.4%, respectively. Components of nutrient intake on a given day assessed were total calories, sugar, carbohydrates, fiber, protein, fat, and total cholesterol, stratified by sex and glycemic status awareness. Estimates of nutrient intake were adjusted for age, race/ethnicity, education level, BMI, smoking status, and family history of diabetes.

RESULTS

Men with diagnosed diabetes consumed less sugar (mean 86.8 vs. 116.8 g) and carbohydrates (mean 235.0 vs. 262.1 g) and more protein (mean 92.3 vs. 89.7 g) than men with undiagnosed diabetes. Similarly, women with diagnosed diabetes consumed less sugar (mean 79.1 vs. 95.7 g) and more protein (mean 67.4 vs. 56.6 g) than women with undiagnosed diabetes. No significant differences in macronutrient intake were found by awareness of prediabetes. All participants, regardless of sex or glycemic status, consumed on average less than the American Diabetes Association recommendations for fiber intake (i.e., 14 g/1,000 kcal) and slightly more saturated fat than recommended (>10% of total kcal).

CONCLUSIONS

Screening and subsequent knowledge of glycemic status may favorably affect some dietary patterns for people with diabetes.

For many individuals with diabetes, the most challenging part of treatment is deciding what to eat (1). The most recent position statement on nutrition therapy for people with diabetes states that ideally, individuals should be referred to a registered dietitian (RD) soon after a diabetes diagnosis and then for ongoing follow-up or receive a referral to a comprehensive diabetes self-management program that includes instruction on nutrition therapy (1). However, national data indicate that only one-half of people with diabetes report ever receiving some type of diabetes education (2), and possibly even fewer see an RD. For those who are at high risk for

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developing type 2 diabetes, primary prevention strategies include use of nutrition therapy and public health interventions, which may include modest weight loss and moderate-intensity physical activity (3,4). The American Diabetes Association (ADA) recommends reduced caloric and fat intake as well as increased consumption of fiber for those who are at high risk for developing type 2 diabetes (e.g., those with prediabetes or who are overweight/obese). One study found that carbohydrate and protein intake among the U.S. population with self-reported diabetes were within ADA recommendations from 1988 to 2004 but that total fat, saturated fat, and total cholesterol intake was higher than recommended (5).

Lack of awareness about diabetes or prediabetes status may constitute an additional barrier to an optimal diet. However, whether awareness of diabetes and prediabetes status affects preventive behaviors is not clear. Although detection of diabetes is recommended, ~27% of all people with diabetes are undiagnosed. This is unfortunate because interventions to reduce the risk of developing complications are effective (6). Awareness of having prediabetes is even lower, with only 11% of those aged ≥20 years reporting prediabetes awareness during 2009–2010 (7). Trends in nutrient intake among patients with diabetes have been published (5), but we are not aware of studies examining nutrient intake among those with prediabetes and, in particular, comparing those who are aware of their glycemic status, diabetes, or prediabetes with those who are not. Furthermore, we are not aware of national studies assessing macronutrient intake among diabetic patients who had visited a dietitian. In this study, we examined *1*) how nutrient intake differs by those who are aware of their glycemic status and by those who are not; *2*) nutrient intake among those with diabetes (1) and prediabetes (3) in light of the current ADA recommendations; and *3*) how nutrient intake differs among those with diagnosed diabetes who have visited a diabetes nurse educator, dietitian, or nutritionist as recommended by the ADA.

RESEARCH DESIGN AND METHODS

Survey Design and Population

As part of the National Health and Nutrition Examination Survey (NHANES) 2005–2010 of the National Center for Health Statistics, the Centers for Disease Control and Prevention collected data representative of the U.S. civilian noninstitutionalized population (8). Survey participants were interviewed at home and invited to a mobile examination center to undergo various examinations and laboratory measurements. The examination component comprised medical, dental, and physiological measurements as well as laboratory tests administered by highly trained medical personnel. The response rates for those who participated in the examinations during 2005–2010 ranged from 75.4% to 77.4% (8). Participants selected to undergo tests requiring fasting between 8 and 24 h had appointments in the morning group. We restricted the analysis to the 7,638 persons in the morning fasting group; 6,749 fasted from 8 to <24 h before the examination and had valid values for both fasting plasma glucose (FPG) and HbA_{1c} tests.

Glycemic Status Definitions

Participants were asked whether they had ever been told by a physician or other health professional that they had diabetes (other than during pregnancy). Based on their answer, 812 in the morning fasting group were classified as having diagnosed diabetes, and 310 who reported they did not have diabetes but had FPG ≥126 mg/dL or HbA_{1c} ≥6.5% (48 mmol/mol) were classified as having undiagnosed diabetes. The 2,603 participants without self-reported diabetes who had a FPG of 100–125 mg/dL or HbA_{1c} of 5.7%–6.4% (39–47 mmol/mol) were classified as having prediabetes. Participants were classified as being aware of their prediabetes (n = 236) if they *1*) answered yes to the question, "Have you ever been told by a doctor that you have prediabetes, borderline diabetes, impaired fasting glucose, impaired glucose tolerance, or that your blood sugar is higher than normal but not high enough to be called diabetes or sugar diabetes" or *2*) reported having prediabetes when asked whether they had diabetes. We excluded 3,024 participants who had normal glucose levels. The final sample size was 3,725 participants with diabetes or prediabetes (Supplementary Data).

Assessment of Macronutrient Intake

Participants were asked to complete two nonconsecutive 24-h dietary recalls, the first by a trained interviewer in the mobile examination center and the second by telephone 3–10 days later. The 24-h dietary recalls for NHANES 2005–2010 used the Automated Multiple-Pass Method (9), which increases the efficiency and accuracy of the 24-h recall by including standardized food-specific probing and follow-up questions and food models for estimating portion size. The 24-h recalls included weekdays and weekend days. Macronutrient values were assigned to foods by using the U.S. Department of Agriculture Food and Nutrient Database for Dietary Studies corresponding to each 2-year survey (10).

For the purpose of this analysis, dietary factors and macronutrients assessed were total caloric, total sugar, carbohydrate, fiber, protein, monounsaturated fat, polyunsaturated fat, saturated fat, total fat, and total cholesterol intake. Factors were also assessed as a percent of total caloric intake.

Covariates

Covariates used to adjust estimates were age, race or ethnicity, education level, smoking status (e.g., current by self-report or cotinine levels >10 ng/mL, former or never by self-report), family history of diabetes, and BMI calculated from measured height and weight (kg/m^2).

We also assessed the prevalence of participants with diagnosed diabetes who saw a diabetes nurse educator, dietitian, or nutritionist and examined differences in daily macronutrient intake by those who reported making such a visit within the past year, >1 year ago, and never, controlling for covariates mentioned previously and by sex. Among participants unaware of their diabetes and among those with prediabetes, we assessed the prevalence of blood glucose being tested in the past 3 years based on response to the question, "Have you had a blood test for high blood sugar or diabetes within the past 3 years?"

Statistical Analysis

We used SAS version 9.3 software (SAS Institute, Inc., Cary, NC) to combine data from each survey. Sampling weights that account for unequal probabilities of selection resulting from sample design, nonresponse, and planned oversampling of certain subgroups were calculated to make weighted results representative of the U.S. population. We used SUDAAN

version 11.0.0 (Research Triangle Institute, Research Triangle Park, NC) with 6-year combined sampling weights for the fasting 2005–2010 subsample for linear regression (i.e., PROC REGRESS) to produce adjusted estimates stratified by sex. We used one day (the initial 24-h recall) to compare mean intakes in subgroups of the study population. Adjusted risks presented are predicted margins estimated from the regression analyses.

Two subanalyses were conducted and are presented in the Supplementary Data. First, we assessed macronutrient intake among participants with diagnosed diabetes by HbA_{1c} level (<7% [53 mmol/mol]; 7%–7.9% [53–63 mmol/mol]; and ≥8% [64 mmol/mol]). Covariates in this analysis included age, sex, race, ethnicity, BMI, education level, duration of diabetes, self-reported use of diabetes medications, and smoking status, stratified by sex. Second, we assessed macronutrient intake by awareness of prediabetes stratified by BMI, controlling for race/ethnicity, age, sex, education level, smoking status, and family history of diabetes. This analysis could not be performed by diabetes awareness because of the small sample size.

RESULTS

Macronutrient Intake by Diabetes Awareness

More women than men were aware of their diabetes (78.4% vs. 65.0%) (Table 1). Among those with diabetes, the prevalence of high cholesterol or being on medication was significantly higher for men aware than for men unaware of their diabetes (53.9% vs. 44.0%). The average BMI was significantly lower for women aware of their diabetes compared with their unaware counterparts (33.3 vs. 34.8 kg/m^2).

On a given day, men aware of their diabetes compared with men who were unaware consumed, on average, less sugar (mean 86.8 vs. 116.8 g), fewer carbohydrates (mean 235.0 vs. 262.1 g), more protein (mean 92.3 vs. 89.7 g), and significantly more protein as a percent of their daily total caloric intake (17.5% vs. 16.0%) (Table 2). On a given day, women aware of their diabetes compared with women who were unaware consumed less sugar (mean 79.1 vs. 95.7 g) while consuming more protein (mean 67.4 vs. 56.6 g) and protein as a percent of total caloric intake (17.6% vs. 15.6%). Additionally, the average consumption of total cholesterol on a given day was higher among women aware of their diabetes compared with women who were unaware (mean 250.4 vs. 187.0 mg). No statistically significant differences in daily total energy, fiber, or saturated fat intake were found by diabetes awareness status for men or women.

Macronutrient Intake by Prediabetes Awareness

More women than men were aware of their prediabetes (10.6% vs. 7.6%) (Table 1). The prevalence of high cholesterol

Table 1—Demographic and descriptive statistics among adults aged ≥20 years by awareness of glycemic status, NHANES 2005–2010

	Diabetes				Prediabetes			
	Male		Female		Male		Female	
	Aware	Unaware	Aware	Unaware	Aware	Unaware	Aware	Unaware
Participants [*n* (%)]	400 (65.0)	192 (35.0)	412 (78.4)	118 (21.6)	115 (7.6)	1,308 (92.4)	121 (10.6)	1,059 (89.4)
Age (years)	57.8 ± 1.0	58.1 ± 1.2	60.8 ± 0.9	63.5 ± 1.4	57.2* ± 1.5	49.1 ± 0.7	56.8 ± 1.9	54.8 ± 0.7
BMI (kg/m^2)	31.8 ± 0.5	32.1 ± 0.7	33.3* ± 0.4	34.8 ± 0.6	30.5 ± 0.7	29.3 ± 0.2	33.0* ± 0.8	32.3 ± 0.4
Race/ethnicity								
Non-Hispanic white	62.6 ± 3.9	69.2 ± 4.0	60.7 ± 4.1	63.2 ± 6.0	74.9 ± 4.7	69.8 ± 2.2	69.0 ± 5.1	70.5 ± 2.7
Non-Hispanic black	13.8 ± 2.4	13.2 ± 2.4	18.5 ± 2.4	18.7 ± 3.6	10.5 ± 2.3	10.8 ± 1.1	11.2 ± 2.7	13.0 ± 1.5
Mexican American	10.0 ± 1.8	11.3 ± 2.0	8.6 ± 1.7	9.1 ± 2.4	5.9 ± 1.9	9.6 ± 1.1	4.7 ± 1.3	7.7 ± 1.3
Other	13.6 ± 2.3	6.3 ± 1.8	12.1 ± 2.6	—	8.7 ± 3.3	9.8 ± 1.2	15.1 ± 4.4	8.8 ± 1.4
Smoking status								
Current	20.0 ± 2.5	21.8 ± 3.4	15.3 ± 2.5	17.2 ± 5.6	19.8 ± 4.6	26.5 ± 1.8	23.4 ± 4.9	20.3 ± 1.7
Former	48.5 ± 3.3	49.3 ± 3.9	45.0 ± 3.6	43.6 ± 6.2	37.6 ± 4.9	29.3 ± 1.9	31.4 ± 5.4	23.9 ± 2.1
Never	31.4 ± 2.6	29.0 ± 4.3	39.8 ± 2.9	39.2 ± 6.6	42.6 ± 4.9	44.2 ± 2.2	45.2 ± 5.6	55.8 ± 2.2
Family history of diabetes								
Yes	66.6 ± 3.0	48.3 ± 4.2	71.4 ± 2.1	53.1 ± 6.8	47.7 ± 4.8	33.3 ± 1.1	53.7 ± 3.7	36.0 ± 1.4
No	33.4 ± 3.0	51.7 ± 4.2	28.6 ± 2.1	46.9 ± 6.8	52.3 ± 4.8	66.7 ± 1.1	46.3 ± 3.7	64.0 ± 1.4
Total cholesterol								
<200 mg/dL	36.2 ± 2.7	35.5 ± 3.6	32.1 ± 3.2	32.0 ± 5.1	35.1 ± 5.3	42.9 ± 1.7	25.5 ± 5.2	34.6 ± 1.9
200–239 mg/dL	10.0 ± 2.4	20.5 ± 3.2	12.3 ± 2.1	18.6 ± 3.6	18.0 ± 3.7	29.1 ± 1.5	27.4 ± 5.6	27.5 ± 1.9
≥240 mg/dL or on medication	53.9* ± 3.3	44.0 ± 3.7	55.6 ± 3.8	49.4 ± 5.4	46.9* ± 4.5	28.1 ± 1.6	47.2 ± 6.1	37.9 ± 1.7
Made a visit to diabetes nurse educator, dietitian, or nutritionist								
Within the past year	39.5 ± 3.5	n/a	34.7 ± 2.7	n/a	n/a	n/a	n/a	n/a
>1 year ago	34.7 ± 3.8	n/a	30.2 ± 3.6	n/a	n/a	n/a	n/a	n/a
Never made a visit	25.8 ± 3.4	n/a	35.1 ± 3.5	n/a	n/a	n/a	n/a	n/a
Had blood glucose tested within the past 3 years	n/a	68.2 ± 3.6	n/a	65.9 ± 6.6	74.0* ± 5.5	45.8 ± 1.5	85.1* ± 4.2	51.5 ± 2.0

Data are mean ± SE unless otherwise indicated. n/a, not applicable because the question was not asked of the participants. *$P < 0.05$ comparing aware vs. unaware within sex.

or being on medication was significantly higher for men aware of their prediabetes than for men who were unaware (46.9% vs. 28.1%), and they were significantly older, on average, than those unaware of their status (57.2 vs. 49.1 years), but there was no difference in age by awareness among women. Among women with prediabetes, the average BMI of those aware of their prediabetes was significantly higher than among those who were unaware (33.4 vs. 32.3 kg/m^2). No significant differences in daily energy intake or macronutrient intake were found among those with prediabetes by awareness status, regardless of sex (Table 3).

Medical Care Visits

Although not statistically significant, more men aware of their diabetes than women saw a diabetes nurse educator, dietitian, or nutritionist within the past year (39.5% vs. 34.7%) or >1 year ago (34.7% vs. 30.2%), whereas more women than men never made such a visit (35.1% vs. 25.8%; $P = 0.18$) (Table 1). Participants who reported visiting a dietitian or diabetes nurse educator within the past year consumed significantly fewer calories on a given day than those who reported a visit >1 year ago or never made such a visit (1,704 ± 67 vs. 1,986 ± 65 and 1,934 ± 62 kcal/day, respectively). Those who reported visiting a dietitian or diabetes nurse educator within the past year consumed significantly less protein, total fat, saturated fat, monounsaturated fat, and total cholesterol on a given day than those who reported a visit >1 year ago ($P < 0.05$) (Table 4). Sixty-eight percent of men and 66% of women unaware of their diabetes reported having their blood glucose tested in the past 3 years, whereas 46% of men and 52% of women unaware of their prediabetes reported being tested.

Subanalyses

Women with lower HbA_{1c} (<7%) levels consumed, on average, significantly fewer total calories and carbohydrates and less protein, total fat, saturated fat, and monounsaturated fat than women with higher HbA_{1c} levels ($P < 0.05$) (Table 5). Men with lower HbA_{1c} (<7%) levels consumed, on average, significantly more fiber while consuming less protein, total fat, and saturated fat than men with higher HbA_{1c} levels ($P < 0.05$). Those with a healthy weight (BMI 18.6–24.9 kg/m^2) who were aware of their prediabetes consumed significantly less protein as well as saturated fat as a total percent of their caloric intake on a given day than those unaware of their prediabetes ($P < 0.05$) (Table 6).

Table 2—Macronutrient intake among adults aged ≥20 years by awareness of diabetes, NHANES 2005–2010

	Diabetes			
	Male		Female	
	Aware	Unaware	Aware	Unaware
Participants [*n* (%)]	400 (65.0)	192 (35.0)	412 (78.4)	118 (21.6)
Total energy (kcal)	2,167 ± 66	2,329 ± 94	1,621 ± 43	1,553 ± 61
Fiber (g)[a]	8.4 ± 0.3	7.6 ± 0.3	9.0 ± 0.3	9.1 ± 0.6
Sugar (g)	86.8* ± 4.4	116.8 ± 6.1	79.1* ± 3.8	95.7 ± 5.9
Carbohydrate (g)	235.0* ± 7.8	262.1 ± 11.3	188.1 ± 5.9	193.8 ± 11.2
% of total kcal	44.6 ± 0.8	46.1 ± 0.9	48.3 ± 0.8	51.0 ± 1.5
Protein (g)	92.3* ± 3.4	89.7 ± 44.1	67.4* ± 1.8	56.6 ± 2.5
% of total kcal	17.5* ± 0.3	16.0 ± 0.3	17.6* ± 0.5	15.6 ± 0.6
Total fat (g)	89.0 ± 3.8	92.3 ± 5.8	62.7 ± 2.5	57.0 ± 2.8
% of total kcal	36.4 ± 0.6	35.6 ± 0.9	34.9 ± 0.7	34.0 ± 1.2
Saturated fat (g)	27.7 ± 1.3	31.3 ± 2.6	20.3 ± 1.0	19.5 ± 1.2
% of total kcal	11.4 ± 0.3	11.9 ± 0.5	11.3 ± 0.4	11.6 ± 0.6
Monounsaturated fat (g)	33.5 ± 1.6	34.1 ± 2.2	23.3 ± 1.0	20.1 ± 1.1
Polyunsaturated fat (g)	20.0 ± 1.1	18.6 ± 1.2	13.6 ± 0.5	12.5 ± 0.8
Total cholesterol (mg)	341.1 ± 18.3	339.8 ± 24.5	250.4* ± 11.8	187.0 ± 13.9

Data are mean ± SE unless otherwise indicated. Means are adjusted for race/ethnicity, age, BMI, education level, smoking status, and family history of diabetes, stratified by sex. [a]The ADA recommendation for diabetes management and diabetes prevention among people with prediabetes who are obese is 14 g/1,000 kcal daily. *$P < 0.05$ comparing aware vs. unaware within sex.

CONCLUSIONS

This analysis of nationally representative survey data indicates that awareness of diabetes status is associated with some aspects of macronutrient diet composition measured by 24-h

Table 3—Macronutrient intake among adults aged ≥20 years by prediabetes awareness, NHANES 2005–2010

	Prediabetes			
	Male		Female	
	Aware	Unaware	Aware	Unaware
Participants [*n* (%)]	115 (7.6)	1,308 (92.4)	121 (10.6*)	1,059 (89.4)
Total energy (kcal)	2,659 ± 103	2,635 ± 30	1,814 ± 72	1,803 ± 18
Fiber (g)[a]	7.6 ± 0.3	7.1 ± 0.1	8.4 ± 0.4	8.4 ± 0.1
Sugar (g)	151.5 ± 12.2	139.2 ± 3.2	109.6 ± 6.1	100.8 ± 1.5
Carbohydrate (g)	313.9 ± 17.6	308.1 ± 4.6	235.4 ± 9.6	222.3 ± 2.6
% of total kcal	48.1 ± 1.4	47.9 ± 0.4	50.6 ± 1.6	50.2 ± 0.3
Protein (g)	100.9 ± 4.0	101.6 ± 1.6	68.1 ± 3.5	67.7 ± 0.8
% of total kcal	15.7 ± 0.7	15.9 ± 0.2	15.2 ± 0.5	15.4 ± 0.1
Total fat (g)	99.6 ± 3.9	98.3 ± 1.7	70.0 ± 4.1	67.8 ± 1.0
% of total kcal	33.6 ± 1.1	33.5 ± 0.3	33.8 ± 1.2	33.3 ± 0.2
Saturated fat (g)	32.7 ± 1.8	32.5 ± 0.6	22.2 ± 1.4	22.3 ± 0.4
% of total kcal	10.8 ± 0.5	11.0 ± 0.1	10.7 ± 0.4	10.9 ± 0.1
Monounsaturated fat (g)	37.1 ± 1.3	36.5 ± 0.6	25.6 ± 1.4	24.4 ± 0.4
Polyunsaturated fat (g)	20.8 ± 1.2	20.6 ± 0.4	16.5 ± 1.4	15.2 ± 0.2
Total cholesterol (mg)	373.5 ± 23.1	364.3 ± 8.3	212.4 ± 18.0	232.1 ± 4.5

Data are mean ± SE unless otherwise indicated. Means are adjusted for race/ethnicity, age, BMI, education level, smoking status, and family history of diabetes, stratified by sex. [a]The ADA recommendation for diabetes management and diabetes prevention among people with prediabetes who are obese is 14 g/1,000 kcal daily. *$P < 0.05$ comparing aware vs. unaware within sex.

Table 4—Macronutrient intake among adults aged ≥20 years with diagnosed diabetes by visits to a dietitian or diabetes nurse educator, NHANES 2005–2010

	Visited a dietitian or diabetes nurse educator		
	Within past year	>1 year ago	Never
Participants [*n* (%)]	297 (37.0)	237 (32.3)	272 (30.7)
Total energy (kcal)	1,704* ± 67	1,986 ± 65	1,934 ± 62
Fiber (g)[a]	9.0 ± 0.4	8.6 ± 0.3	8.5 ± 0.4
Sugar (g)	77.0 ± 5.9	85.3 ± 4.3	85.7 ± 5.7
Carbohydrate (g)	198.9 ± 9.8	213.2 ± 7.3	216.6 ± 9.7
% of total kcal	47.5 ± 1.1	44.3 ± 0.9	47.6 ± 1.4
Protein (g)	73.3** ± 3.6	86.0 ± 4.2	78.6 ± 3.5
% of total kcal	18.1 ± 0.5	17.6 ± 0.6	17.0 ± 0.5
Total fat (g)	66.8** ± 3.8	83.2 ± 4.2	75.0 ± 3.8
% of total kcal	34.7 ± 0.8	37.0 ± 0.8	35.0 ± 1.1
Saturated fat (g)	20.5** ± 1.2	26.9 ± 1.7	24.2 ± 1.5
% of total kcal	10.8 ± 0.3	12.0 ± 0.5	11.3 ± 0.5
Monounsaturated fat (g)	29.6** ± 1.5	31.8 ± 1.6	28.0 ± 1.5
Polyunsaturated fat (g)	15.8 ± 1.0	17.2 ± 1.2	16.2 ± 0.8
Total cholesterol (mg)	259.9** ± 16.7	326.1 ± 16.5	293.8 ± 21.1

Data are mean ± SE unless otherwise indicated. Means are adjusted for race/ethnicity, age, sex, BMI, education level, smoking status, and family history of diabetes. [a]The ADA recommendation for diabetes management and diabetes prevention among people with prediabetes who are obese is 14 g/1,000 kcal daily. *$P < 0.05$ compared with >1 year ago and never made a visit. **$P < 0.05$ compared with >1 year ago.

dietary recall. On a given day, people with diagnosed diabetes consume less sugar and fewer total carbohydrates (among men only) than those with undiagnosed diabetes, which may be indicative of healthy behavior modification because of the potential impact of carbohydrate intake on glycemic management and postprandial glucose levels (11). However, regardless of glycemic status or sex, the average consumption of fiber and saturated fat were not within ADA recommendations. There were no significant differences in total fat intake on a given day by awareness of glycemic status, but women aware of their diabetes consumed significantly more total cholesterol than those unaware. Those aware of their diabetes consumed significantly more protein on a given day than those unaware. Additionally, those aware of their diabetes who visited a diabetes nurse educator or dietitian in the past year consumed significantly fewer calories and less protein, total fat, saturated fat, monounsaturated fat, and total cholesterol on a given day than those who had not made such a visit. However, in general, awareness of prediabetes was not associated with macronutrient intake. Finally, we found in a subanalysis that lower consumption of calories on a given day was associated with lower levels of HbA_{1c} among participants aware of their diabetes.

On a given day, the findings show that a lower intake of sugar and carbohydrates combined with higher intake of protein among those aware of their diabetes may be one consistent pattern with the current ADA recommendations. Because evidence is inconclusive for an ideal amount of carbohydrate intake for people with diabetes, the ADA does not recommend a specific limit but states that "the amount of carbohydrates and available insulin may be the most important factor influencing glycemic response after eating and should be considered when developing the eating plan" (1). A contributing factor to the difference in sugar consumption may

Table 5—Macronutrient intake among adults aged ≥20 years with diagnosed diabetes by HbA_{1c} level, NHANES 2005–2010

	Diagnosed diabetes					
	Male			Female		
	HbA_{1c} <7.0	HbA_{1c} 7–7.9	HbA_{1c} ≥8.0	HbA_{1c} <7.0	HbA_{1c} 7–7.9	HbA_{1c} ≥8.0
Participants [*n* (%)]	198 (50.4)	81 (22.5)	120 (27.1)	214 (55.7)	102 (25.6)	92 (18.6)
Total energy (kcal)	2,064 ± 110	2,174 ± 106	2,309 ± 89	1,498 ± 60*	1,771 ± 78	1,701 ± 148
Fiber (g)[a]	9.1 ± 0.4*	7.5 ± 0.5	7.7 ± 0.4	8.7 ± 0.4	9.2 ± 0.5	9.7 ± 0.5
Sugar (g)	88.0 ± 6.5	79.7 ± 7.4	86.2 ± 8.3	72.6 ± 4.6	89.1 ± 7.6	80.4 ± 7.0
Carbohydrate (g)	225.8 ± 11.9	232.0 ± 11.7	249.1 ± 11.4	173.5 ± 7.3*	208.1 ± 13.1	190.3 ± 17.4
% of total kcal	46.8 ± 1.1*	43.6 ± 1.3	42.4 ± 1.3	48.7 ± 1.1	48.1 ± 1.5	47.1 ± 1.9
Protein (g)	83.1 ± 5.1*	95.1 ± 7.6	103.4 ± 4.9	60.3 ± 2.1*	74.6 ± 4.5	76.2 ± 7.9
% of total kcal	17.3 ± 0.6	17.4 ± 0.6	17.9 ± 0.7	17.8 ± 0.7	17.5 ± 0.8	19.0 ± 1.1
Total fat (g)	75.9 ± 5.2*	93.9 ± 6.0	100.6 ± 5.4	57.3 ± 3.2*	67.1 ± 3.9	65.6 ± 8.6
% of total kcal	34.3 ± 1.0*	37.5 ± 1.1	37.7 ± 0.9	34.5 ± 0.9	34.7 ± 1.3	34.5 ± 1.3
Saturated fat (g)	24.4 ± 1.7*	29.0 ± 1.8	30.9 ± 1.8	18.3 ± 1.3*	21.7 ± 1.3	22.1 ± 3.5
% of total kcal	11.0 ± 0.3	11.8 ± 0.5	11.5 ± 0.5	11.1 ± 0.4	11.3 ± 0.6	11.2 ± 0.7
Monounsaturated fat (g)	27.7 ± 2.0	35.7 ± 2.5	39.1 ± 2.4	21.1 ± 1.2*	25.1 ± 1.7	24.5 ± 3.3
Polyunsaturated fat (g)	17.3 ± 1.4	21.0 ± 1.9	21.7 ± 1.9	12.8 ± 0.8	14.3 ± 1.1	13.0 ± 1.3
Total cholesterol (mg)	313.2 ± 24.4	372.4 ± 40.2	354.9 ± 28.1	227.3 ± 15.8	251.7 ± 21.7	291.4 ± 31.4

Data are mean ± SE unless otherwise indicated. Means are adjusted for race/ethnicity, age, BMI, education level, duration of diabetes, self-reported use of diabetes medications, and smoking status, stratified by sex. [a]The ADA recommendation for diabetes management and diabetes prevention among people with prediabetes who are obese is 14 g/1,000 kcal daily. *$P < 0.05$ comparing HbA_{1c} levels within sex.

Table 6—Macronutrient intake among adults aged ≥20 years by prediabetes awareness and BMI, NHANES 2005–2010

	Prediabetes					
	Healthy weight (BMI 18.6–24.9 kg/m^2)		Overweight (BMI 25.0–29.9 kg/m^2)		Obese (BMI ≥30.0 kg/m^2)	
	Aware	Unaware	Aware	Unaware	Aware	Unaware
Participants [*n* (%)]	30 (4.7)	520 (95.3)	82 (9.5)	850 (90.5)	119 (10.8)	934 (89.2)
Total energy (kcal)	2,103 ± 245	2,119 ± 64	2,180 ± 116	2,261 ± 52	2,260 ± 95	2,156 ± 38
Fiber (g)[a]	8.7 ± 1.4	8.3 ± 0.3	8.4 ± 0.6	7.7 ± 0.2	8.1 ± 0.4	7.4 ± 0.2
Sugar (g)	147.4 ± 18.7	113.2 ± 4.6	111.3 ± 9.8	131.2 ± 5.1	130.1 ± 8.4	115.4 ± 2.6
Carbohydrate (g)	291.7 ± 32.0	257.8 ± 9.8	251.1 ± 17.1	277.2 ± 8.3	276.9 ± 13.1	253.8 ± 5.3
% of total kcal	55.1 ± 2.9	49.7 ± 0.9	47.8 ± 1.5	49.3 ± 0.5	49.0 ± 1.0	47.9 ± 0.5
Protein (g)	68.7 ± 13.6	80.0 ± 2.9	82.1 ± 5.2	86.4 ± 2.5	86.8 ± 3.6	84.9 ± 2.0
% of total kcal	12.6 ± 1.1*	15.5 ± 0.3	15.4 ± 0.6	15.4 ± 0.2	15.6 ± 0.4	16.0 ± 0.2
Total fat (g)	74.8 ± 9.9	78.9 ± 3.2	82.0 ± 6.0	85.6 ± 2.4	91.8 ± 4.6	84.6 ± 1.9
% of total kcal	31.4 ± 1.2	32.5 ± 0.6	33.6 ± 1.4	33.4 ± 0.4	35.9 ± 0.9	34.8 ± 0.4
Saturated fat (g)	22.0 ± 3.4	25.8 ± 1.2	26.0 ± 2.3	28.6 ± 1.0	30.1 ± 1.7	27.8 ± 0.7
% of total kcal	9.2 ± 0.6*	10.4 ± 0.2	10.5 ± 0.5	11.0 ± 0.2	12.0 ± 0.5	11.4 ± 0.2
Monounsaturated fat (g)	28.5 ± 3.9	29.0 ± 1.3	30.6 ± 2.3	31.4 ± 0.9	33.4 ± 1.7	30.9 ± 0.7
Polyunsaturated fat (g)	18.6 ± 2.4	17.1 ± 0.7	17.9 ± 1.4	18.1 ± 0.4	20.4 ± 2.0	18.3 ± 0.5
Total cholesterol (mg)	214.7 ± 30.3	277.7 ± 15.1	316.2 ± 35.1	317.2 ± 13.2	311.9 ± 21.3	317.9 ± 9.1

Data are mean ± SE unless otherwise indicated. Means are adjusted for race/ethnicity, age, sex, education level, smoking status, and family history of diabetes, stratified by BMI. [a]The ADA recommendation for diabetes management and diabetes prevention among people with prediabetes who are obese is 14 g/1,000 kcal daily. *$P < 0.05$ comparing aware vs. unaware within BMI.

be that adults with undiagnosed diabetes consume more sugar from sugar-sweetened beverages than adults with diagnosed diabetes (12).

Because there is limited research regarding optimal dietary cholesterol intake in people with diabetes and because cardiovascular disease is a common cause of death among individuals with diabetes (13), the ADA recommends the same nutrition guidelines as for the general population to manage cardiovascular disease risk factors, including reducing saturated fat intake to 10% of calories and aiming for <300 mg dietary cholesterol per day. Overall, participants with diabetes and prediabetes consumed slightly higher levels of saturated fat on a given day than recommended, and men consumed more cholesterol than recommended, regardless of glycemic status. Furthermore, men aware of their glycemic status were significantly more likely to have high cholesterol or to be on medication than their unaware counterparts. One unexpected finding was that women aware of their diabetes status consumed significantly more cholesterol on a given day than those unaware. One reason may be that these women were more focused on limiting carbohydrates, specifically sugars, and controlling the amount of fat they consumed without paying as much attention to the type of fat. This explanation may also account for why they did not consume less saturated fat or consume more mono- and polyunsaturated fat on a given day than those unaware of their diabetes status. Although average consumption of cholesterol on a given day was higher among women aware of their diabetes or prediabetes, the levels were still well within the recommended limits. Furthermore, the proportion of women aware of their diabetes taking antihypercholesterolemia medication or with high total serum blood cholesterol levels was not significantly higher than their unaware counterparts.

For prevention of diabetes among people with prediabetes, the ADA recommends physical activity and individualized medical nutrition therapy, preferably from an RD familiar with the components of diabetes medical nutrition therapy (3). We found that among participants with diagnosed diabetes who visited a dietitian within the past year, the average consumption of total calories on a given day was lower and that total fat, saturated fat, and total cholesterol intake was lower than among those who had not made such a visit. This finding suggests that at least one visit a year to a dietitian for diabetic patients may be beneficial. One study found that a physician's referral to a dietitian is a strong predictor of making such a visit among diabetic patients (14). Consequently, because the proportion aware of their prediabetes status was quite low (≤11%) and those with prediabetes, on average, were obese, diabetes screening and primary prevention counseling could be improved because only one-half of the present study participants with prediabetes reported having been tested for diabetes in the past 3 years.

This study had strengths and potential limitations. Strengths of the analysis include the large nationally representative sample. A primary limitation is the cross-sectional design; we could not control for duration of diabetes because we did not know the duration of diabetes for the undiagnosed group. Duration of disease may affect behavior (15). Additionally, nutrient intake data were based on self-report, and although studies have shown that the dietary collection methods adopted after NHANES III accurately report energy intake in normal-weight subjects (9,16), people who are overweight, obese, or weight conscious may underreport their energy intake (9,17). Moreover, we do not know whether adults with diabetes may differentially report dietary intake, and we are not aware of a validation

analysis to know how sensitive or specific the question we used to identify a previous report of prediabetes was.

The present results suggest that knowledge of glycemic status may favorably affect some dietary patterns for patients with diabetes, but a similar benefit was not observed with prediabetes awareness. Patients with diagnosed diabetes may be more concerned about their illness and, thus, more likely to receive education (2) and support from dietitians (18), but knowledge of prediabetes status does not elicit the same kind of attention. More-intensive identification and referral of adults with prediabetes to primary prevention that addresses and promotes changes to dietary habits and consumption may be beneficial. Additionally, nutrition recommendations for patients with diabetes have changed over time (19), with new recommendations sometimes contradicting previous recommendations (20). Thus, the promotion of ongoing education and nutrition therapy for patients with prevalent diabetes, as well as for those who have received a new diagnosis, may help to improve dietary modification and glycemic management.

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