Diabetes Risk Reduction Behaviors Among U.S. Adults with Prediabetes

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Background: Diabetes can be prevented or delayed in high-risk adults through lifestyle modifications, including dietary changes, moderate-intensity exercise, and modest weight loss. However, the extent to which U.S. adults with prediabetes are making lifestyle changes consistent with reducing risk is unknown.

Purpose: This study aimed to study lifestyle changes consistent with reducing diabetes risk and factors associated with their adoption among adults with prediabetes.

Methods: In 2009, data were analyzed from 1402 adults aged ≥20 years without diabetes who participated in the 2005–2006 National Health and Nutrition Examination Survey and had valid fasting plasma glucose and oral glucose tolerance tests. The extent to which adults with prediabetes report that in the past year they tried to control or lose weight, reduced the amount of fat or calories in their diet, or increased physical activity or exercise was estimated and factors associated with the adoption of these behaviors were examined.

Results: Almost 30% of the U.S. adult population had prediabetes in 2005–2006, but only 7.3% (95% CI=5.5%, 9.2%) were aware they had it. About half of adults with prediabetes reported performing diabetes risk reduction behaviors in the past year, but only about one third of adults with prediabetes had received healthcare provider advice about these behaviors in the past year. In multivariate analyses, provider advice, female gender, and being overweight or obese were positively associated with all three risk reduction behaviors.

Conclusions: Adoption of risk reduction behaviors among U.S. adults with prediabetes is suboptimal. Efforts to improve awareness of prediabetes, increase promotion of healthy behaviors, and improve availability of evidence-based lifestyle programs are needed to slow the growth in new cases of diabetes.

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Introduction

Impaired glucose tolerance (IGT) and impaired fasting glucose (IFG) are conditions in which individuals have blood glucose levels that are higher than normal but not high enough to be classified as diabetes.[1] People with prediabetes have an increased risk of developing type 2 diabetes and cardiovascular disease.[2–4] Between 33% and 65% of those with IFG or IGT may go on to develop type 2 diabetes within 6 years, compared to less than 5% of those with normal blood glucose.[5]

Clinical trials[6–8] provide strong and consistent evidence that type 2 diabetes can be prevented or delayed in high-risk adults with dysglycemia through structured lifestyle modifications, including dietary changes, moderate-intensity exercise, and modest weight loss. Additional research is needed to determine the effect of lifestyle interventions on diabetes complications, particularly cardiovascular outcomes.[9] The results of these prevention trials, combined with epidemiologic studies showing a continuous progression of diabetes risk associated with levels of fasting and 2-hour glucose, led an American Diabetes Association (ADA)-convened expert committee[10] in 2003 to define prediabetes as IFG (fasting glucose, 100–125 mg/dL) or IGT (2-hour post-glucose load of 140–199 mg/dL).

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The successful prevention trials, in combination with subsequent practical trials implemented in community settings, suggest that if people with dysglycemia can be efficiently identified and made aware of their risk status, they may be referred to effective community programs to change their levels of physical activity, dietary intake, and weight.[11,12] Identification of high-risk states may also be useful to provide a stimulus for brief counseling by healthcare providers or for individuals to undertake self-directed behavior change, although the effectiveness of these latter approaches remains unclear.

Identification and awareness of prediabetes may be an important step in initiating effective lifestyle interventions. Knowledge of what lifestyle changes adults with prediabetes are currently making and factors associated with these changes may be useful in planning effective lifestyle interventions. The current study presents the first nationally representative data examining whether adults with prediabetes report that in the past year, they tried to control or lose weight, reduced the amount of fat or calories in their diet, or increased physical activity or exercise. In addition, factors associated with the adoption of these lifestyle changes were examined.

Methods

In 2009, data from the 2005–2006 National Health and Nutrition Examination Survey (NHANES) were used to describe the demographic and biologic characteristics of adults with and without prediabetes, examine whether adults with prediabetes report engaging in behaviors consistent with reducing diabetes risk, and examine factors associated with the adoption of these behaviors among people with prediabetes.

Survey Design and Population

The 2005–2006 NHANES was conducted by the National Center for Health Statistics (NCHS), CDC, to collect data representative of the U.S. civilian noninstitutionalized population.[13] Survey participants were interviewed at home and invited to a mobile examination center to undergo various examinations and laboratory measurements. Among the 6719 participants aged ≥20 years, 4979 (74.1%) completed the household interview and 4773 (71.0%) completed the examination.

Glycemic Status Definitions and Exclusions

During the home interview, participants were asked if they had ever been told by a doctor or other health professional that they had diabetes (other than during pregnancy). Based on this question, 509 respondents aged ≥20 years were classified as having diagnosed diabetes and excluded from analyses.

Survey participants were randomly assigned to either a morning or afternoon/evening examination session: 2050 individuals aged ≥20 years without diagnosed diabetes were examined during a morning session. After excluding people who fasted <8 or ≥24 hours (n=220) and people with invalid fasting plasma glucose (FPG) values (n=50), the FPG subsample comprised 1780 adults (87%). A valid oral glucose tolerance test (OGTT) 2-hour (plus or minus 15 minutes) measurement was obtained for 1508 (85%) of those in the FPG subsample. As a result of changes in laboratory equipment, a glucose regression equation (Y=0.9835×X) was applied to FPG and OGTT values to make the 2005–2006 data comparable to those from previous years.[13]

Based on standard diagnostic criteria[1] incorporating FPG and OGTT values and excluding pregnant women (n=11), adults were classified as having undiagnosed diabetes (FPG ≥126 mg/dL or 2-hour plasma glucose ≥200 mg/dL, n=106); prediabetes (FPG 100 to <126 mg/dL or 2-hour plasma glucose 140 to <200 mg/dL, n=531); and normal (FPG <100 mg/dL and 2-hour plasma glucose <140 mg/dL, n=860). Participants with undiagnosed diabetes were excluded from analyses. Analyses were limited to adults aged ≥20 years who did not have diagnosed or undiagnosed diabetes (n=1391).

Participants without diagnosed diabetes were asked, *Have you ever been told by a doctor or health professional that you have any of the following: prediabetes, impaired fasting glucose, impaired glucose tolerance, borderline diabetes or that your blood sugar is higher than normal but not high enough to be called diabetes or sugar diabetes?* Those answering positively to this question or who volunteered that they had prediabetes when asked about diabetes were classified as having a self-reported prediabetes condition.

Dependent Variables and Covariates

The major dependent variables were three risk reduction behaviors. After the statement *People often engage in activities to lower their risk for health problems or certain diseases*, all survey participants were asked if in the past 12 months, they had (1) *tried to control or lose weight*, (2) *reduced the amount of fat or calories in their diet*, and (3) *increased physical activity or exercise*. They were also asked whether they had been told by a doctor or other health professional in the past 12 months to perform each of these three risk reduction behaviors. In addition, they were asked if they had been screened for diabetes or high blood sugar in the past 3 years. Demographic factors such as gender, age, race/ethnicity, family history, and education level were also self-reported.

Biological factors such as BMI, blood pressure, waist circumference, total cholesterol, LDL, HDL, and triglyceride levels were obtained from examination and laboratory data. BMI was calculated from measured height and weight and classified as normal weight (<25 kg/m^2); overweight (25 to <30 kg/m^2); and obese (≥30 kg/m^2). Mean blood pressure was calculated from up to three blood pressure readings

taken from participants in a seated position. Hypertension was defined as a mean blood pressure ≥140/90 or current use of medication for hypertension. Details on the collection and handling of these measures are published on the NCHS website.[13]

Statistical Analyses

Chi-square tests and *t* tests were carried out to determine differences across groups. Multiple logistic regression was performed to model the three risk reduction behaviors among prediabetes participants by gender, age, race/ethnicity, BMI category, education level, family history, and physician advice to perform the behavior. Prior research[14–19] had identified these variables as predictors or correlates of risk reduction behaviors in the general population. Backward selection was used to obtain the best model for each behavior based on $p<0.05$. Finally, predictive margins were calculated based on the final models. Predictive margins are a type of standardization in which predicted values from the logistic regression model are averaged over the covariate distribution of the population.[20] This statistic has several advantages over the OR: It is not potentially biased if the outcome is not rare; a comparison group is not required; and it provides a measure of absolute difference rather than a relative difference. SAS, version 9.1 for Windows, was used for data management and SUDAAN 10 was used to obtain point estimates and SEs (using the Taylor series linearization), and to fit models.

Results

It was found that 29.6% (95% CI=26.6%, 32.6%) of U.S. adults aged ≥20 years had prediabetes (i.e., IFG, IGT, or both) in 2005–2006. Only 7.3% (95% CI=5.5%, 9.2%) of those with prediabetes reported that they had been told that they had a prediabetes condition. Less than half (47.7%, 95% CI=43.0%, 52.4%) of adults with prediabetes reported a test for diabetes or high blood sugar in the past 3 years. Consistent with the recommendations for screening for diabetes published by the U.S. Preventive Task Force,[21] 45.9% (95% CI=39.6%, 52.1%) of all adults without diabetes but whose blood pressure exceeded 135/80 reported a test in the past 3 years. The proportion reporting a test was slightly higher (53.2%, 95% CI= 42.3%, 64.1%) among people with prediabetes.

Characteristics of Adults with and Without Prediabetes

Although adults with and without prediabetes were similar in race and ethnicity, adults with prediabetes were more likely than those without prediabetes to be male, older, and have lower educational attainment (Table 1). They were also somewhat more likely to report that an immediate family member had diabetes. Most biological characteristics or risk factors were either higher or less favorable in people with prediabetes. Compared to adults with normal glycemia, adults with prediabetes had higher BMI and waist circumference and also tended to have less favorable lipid and blood pressure levels.

Risk Reduction Behaviors and Their Covariates Among Adults with Prediabetes

When asked whether they had performed three risk reduction activities in the past 12 months, 52.2% of adults with prediabetes reported trying to control or lose weight, 54.7% reported reducing fat or calories, and 48.5% reported increasing physical activity (Figure 1). How awareness of prediabetes was associated with risk reduction behaviors could not be examined because of the small number of people who were aware of prediabetes. When asked about physician advice, 29.7% of adults with prediabetes reported that they had been told by their physician in the past year to control or lose weight; 31.9% reported being told to reduce fat or calories in their diet; and 34.2% reported being told to increase physical activity. However, about 17.5% (95% CI=13.8%, 21.2%) of adults with prediabetes had not received health care in the past year. When those not receiving care in the past year were excluded, reports of physician advice increased slightly: 34.6% (95% CI=27.5%, 41.7%) reported advice to control or lose weight; 36.8% (95% CI= 29.3%, 44.3%) reported advice to reduce fat or calories; and 39.4% (95% CI=30.7%, 48.1%) reported advice to increase physical activity. Among adults receiving advice, 75% reported trying to control or lose weight, 82% reducing fat or calories, and 71% increasing physical activity (Figure 1).

When physician advice, age group, gender, race/ethnicity, education level, BMI category, and family history were used in multivariate analyses of the three risk reduction behaviors, report of physician advice about each activity was strongly associated with reports of engaging in each of the three activities during the past year (Table 2). In addition, women were more likely than men to report engaging in each activity and, generally, those of normal BMI were less likely than overweight or obese adults to report engaging in each activity. Race/ethnicity was associated with reports of two of the activities—trying to control or lose weight and reducing fat and calories—with non-Hispanic whites being more likely than other race and ethnic groups to report these behaviors. Those with less than a high school education were least likely to report increasing physical activity in the past year and those with a family history of diabetes were least likely to report trying to control or lose weight. Age group was not an independent predictor of any of the three behaviors.

Table 1. Demographic and biological characteristics of adults with prediabetes and adults with normal glycemia, NHANES 2005–2006 (% or M [SE])

Characteristics	Prediabetes (*n*=531)	Normal glycemia (*n*=860)	*p*-value (chi-square or *t*-test)
Gender			
Male	58.9 (2.8)	43.4 (1.2)	
Female	41.1 (2.8)	56.6 (1.2)	**0.0003**
Age (years)			
20–39	23.0 (2.9)	51.6 (2.5)	
40–59	45.9 (3.2)	36.1 (2.3)	
≥60	31.1 (4.0)	12.3 (1.4)	**<0.0001**
M	51.9 (1.2)	41.3 (0.8)	**<0.0001**
Race/ethnicity			
NH white	71.7 (3.6)	72.7 (2.4)	
NH black	9.6 (1.7)	11.2 (1.7)	
Mexican-American	8.3 (1.5)	7.5 (1.2)	0.3439
Education			
<High school	19.7 (2.5)	13.0 (1.5)	
High school	26.4 (2.1)	24.4 (1.8)	
≥High school	54.0 (3.0)	62.6 (2.8)	**0.0075**
Family history of diabetes			
Yes	43.5 (2.7)	36.6 (2.3)	
No	56.5 (2.7)	63.4 (2.3)	**0.0455**
Weight			
Normal	19.5 (1.5)	43.4 (1.9)	
Overweight	35.3 (2.4)	30.2 (1.7)	
Obese	45.2 (3.1)	26.4 (1.3)	**<0.0001**
Mean BMI	30.9 (0.4)	27.0 (0.2)	**<0.0001**
Mean waist circumference (cm)	103.7 (0.8)	92.7 (0.6)	**<0.0001**
Hypertension[a]			
Yes	38.3 (2.5)	17.1 (1.3)	
No	61.7 (2.5)	82.9 (1.3)	**<0.0001**
Systolic BP			
<120	64.1 (2.6)	81.5 (1.3)	
120–139	16.1 (2.1)	11.2 (1.1)	
140–159	15.2 (1.6)	5.6 (0.9)	
≥160	4.6 (0.6)	1.6 (0.4)	**<0.0001**
M	126.1 (1.0)	117.5 (0.7)	**<0.0001**
Diastolic BP			
<80	78.4 (1.4)	85.9 (1.6)	
80–89	17.6 (1.4)	11.3 (1.4)	
90–99	3.6 (0.9)	2.5 (0.7)	
≥100	0.4 (0.2)	0.2 (0.2)	**0.0021**
M	70.0 (0.5)	68.7 (0.7)	0.0903
Total cholesterol			
<200	49.6 (3.7)	56.5 (2.1)	
200–239	32.5 (2.6)	29.7 (1.9)	
≥240	17.9 (2.2)	13.8 (1.6)	0.1638
M	202.2 (2.4)	196.1 (2.1)	**0.0191**
LDL			
<100	27.5 (2.4)	37.0 (2.4)	
100–129	33.5 (2.8)	32.2 (1.8)	
130–159	27.1 (2.0)	20.8 (1.8)	
160–189	8.6 (1.4)	8.0 (1.2)	
≥190	3.3 (1.0)	1.9 (0.8)	**0.0133**
M	120.2 (1.7)	113.9 (1.8)	**0.0024**
HDL			
<40	15.9 (1.7)	11.0 (1.5)	
40–59	56.9 (2.8)	49.6 (1.5)	
≥60	27.2 (1.8)	39.4 (1.4)	**<0.0001**
M	52.7 (0.6)	57.4 (0.6)	**<0.0001**
Triglycerides			
<150	63.1 (1.9)	76.6 (1.7)	
150–199	17.5 (1.7)	10.6 (1.2)	
200–499	18.2 (1.4)	11.8 (0.9)	
≥500	1.1 (0.7)	1.0 (0.3)	**0.0001**
M	128.9 (3.6)	104.2 (2.0)	**0.0006**

Note: Table includes racial/ethnic groups not shown separately. Boldface indicates significance ($p<0.05$).

[a]Blood pressure ≥140/90 or current use of prescription medication for hypertension

BP, blood pressure; HDL, high-density lipoprotein; LDL, low-density lipoprotein; *n*, unweighted sample size; NA, not applicable; NH, non-Hispanic; NHANES, National Health and Nutrition Examination Survey

Discussion

In 2005–2006, almost 30% of the U.S. adult population had prediabetes, but more than 90% were unaware of their prediabetes status. Although prevention trials have shown that

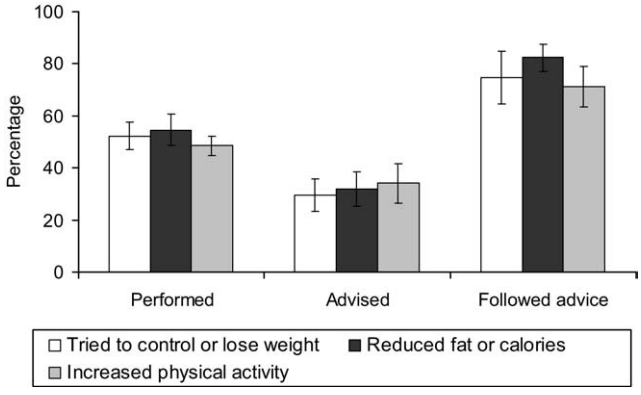

Figure 1. Percentage of people with prediabetes who either performed risk-reducing behaviors, received physician advice about behaviors, or followed that advice in the past year; National Health and Nutrition Examination Survey, 2005–2006

diabetes can be prevented or delayed among adults at high risk through modest weight loss and increased physical activity,[6–8] only about half of U.S. adults with prediabetes reported that in the past year they tried to control or lose weight, reduced the amount of fat or calories in their diet, or increased physical activity or exercise. Adoption of these risk reduction behaviors could be improved in the majority of people with prediabetes, but particularly among those groups who reported these behaviors less frequently (i.e., men, non-Hispanic blacks, and normal-weight people).

Identification and awareness of prediabetes status is potentially important for the initiation of several different avenues of prevention, with the strongest evidence currently existing for structured lifestyle interventions applied to high-risk individuals. In addition to the previously described major randomized controlled prevention trials,[6–8] practical community trials have provided encouraging findings. One study[11] used lay staff of a Young Men's Christian Association to deliver a group-based 16-session intensive lifestyle intervention program to people at high risk for diabetes. Participants achieved weight-loss levels that are consistent with those observed in the most effective randomized trials (a mean 6% reduction from baseline over 1 year). Another study[22] utilized professional dietetic staff from local healthcare providers to deliver a group-based 16-session intensive lifestyle intervention to adults at high risk for diabetes and cardiovascular disease: At 4 months, 45% of participants achieved ≥7% weight loss, a rate very similar to those seen in the successful Diabetes Prevention Program clinical trial.

Consistent with other studies,[14–19] the present study suggests that physician advice is associated with reporting adoption of healthy behaviors. The proportion of adults with prediabetes who reported performing each of the three risk reduction behaviors was higher if they reported receiving physician advice concerning the behavior in the past year. However, also consistent with other studies that found low levels of physician advice about diet, physical activity, and other lifestyle changes,[14,17,18,23,24] the current study found that only about one third of adults with prediabetes reported that they had received such advice in the past year. Although reasons for physicians not providing this advice cannot be determined in the present study, prior research[25–28] suggests that lack of time and reimbursement for preventive services, lack of physician training or poor knowledge of obesity management and nutrition, lack of knowledge of successful strategies to help patients and of community resources, and perceived futility of patients' efforts to make changes may be factors influencing these low levels of physician advice.

In spite of a correlation between risk behaviors and physician advice, physician advice alone is unlikely to be sufficient for long-term maintenance of risk reduction and healthy behaviors. Indeed, studies indicate that physician advice may have only a short-term impact on healthy behaviors,[19,29,30] suggesting that such advice may be more influential in initiating than in maintaining healthy behaviors. Prevention promotion by physicians and other health professionals may be more effective if part of a larger process within healthcare systems and communities to promote behavior change, and pragmatic approaches for linking primary care with effective community-based approaches are needed.[31]

Finally, there may be important collateral benefits of enhanced identification of prediabetes, as people with previously unrecognized diabetes, poorly controlled blood pressure, and hyperlipidemia may be efficiently identified. The analyses showed that compared to people without prediabetes, adults with prediabetes were more likely to have higher levels of well-known cardiovascular disease risk factors, including higher mean weight, waist circumference, systolic blood pressure, and triglyceride levels as well as a higher prevalence of hypertension. This means that efficient identification of prediabetes may lead to opportunities for better cardiovascular risk factor management along with initiation of preventive behaviors to lower diabetes risk.

Strengths and Limitations

The major strengths of the present study are that the data are representative of the U.S. population, and the biological risk factor data were collected using standardized laboratory and physical measurements. However, there are also a number of limitations. First, because of the cross-sectional nature of the data, only associations, not causality, can be examined. Second, the data on risk reduction behaviors and physician advice were based on self-reports and, thus, may be influ-

enced by the accuracy of recall and by social desirability bias. Further, the introduction to the risk reduction questions which states that people often engage in activities to lower their risk of disease could have substantially biased subsequent responses. Prospective studies of interventions and policies to promote and maintain healthy lifestyles are needed. These studies would benefit from more objective measures of behaviors and outcomes. Third, because of the OGTT sample size and the low level of awareness among adults with prediabetes, the possible association between awareness of prediabetes and adoption of the lifestyle changes could not be examined. Additional years of NHANES may enable this examination. Finally, a number of other important questions were not addressed by the current study, including who and why people are screened for diabetes and prediabetes, why and when physicians provide lifestyle counseling, and whether and what type of counseling is effective.

Table 2. Multivariate-adjusted prevalence of selected risk reduction behaviors among adults with prediabetes, NHANES 2005–2006 (predicted marginal [95% CI])

Characteristics	Tried to control/ lose weight	Reduced fat/ calories	Increased physical activity
Physician advice			
Yes	**71.0** (60.2, 81.9)	**81.2** (75.1, 87.3)	**67.9** (59.4, 76.3)
No (ref)	44.2 (37.6, 50.9)	42.3 (35.1, 49.5)	38.4 (32.9, 44.0)
Gender			
Male (ref)	46.0 (40.1, 51.9)	46.6 (41.6, 51.6)	43.2 (38.4, 48.0)
Female	**61.1** (54.1, 68.1)	**66.1** (56.2, 75.9)	**56.0** (49.0, 62.9)
Race			
NH white (ref)	53.8 (48.4, 59.2)	56.7 (49.4, 64.0)	—
NH black	**40.6** (31.9, 49.3)	**45.7** (39.2, 52.1)	—
Mexican-American	**39.4** (33.0, 45.8)	51.5 (43.0, 59.9)	—
Other	62.7 (48.0, 77.4)	50.3 (35.7, 64.9)	—
BMI			
Normal (ref)	34.0 (24.5, 43.5)	44.7 (30.7, 58.6)	37.4 (27.7, 47.1)
Overweight	**58.3** (50.2, 66.4)	**60.5** (52.5, 68.4)	50.1 (44.0, 56.2)
Obese	**55.4** (49.4, 61.3)	53.2 (48.0, 60.3)	**51.8** (45.5, 58.1)
Education			
<High school (ref)	—	—	38.6 (27.7, 47.5)
High school	—	—	**51.1** (43.6, 58.1)
≥High school	—	—	50.7 (45.7, 55.7)
Family history of diabetes			
Yes	**44.5** (37.6, 51.3)	—	—
No (ref)	58.1 (50.2, 66.1)	—	—

Note: Boldface indicates significant difference with reference group at $p<0.05$.
NH, non-Hispanic; NHANES, National Health and Nutrition Examination Survey; —, not in final model

Public Health Implications

Only a small percentage of U.S. adults with prediabetes are aware that they are at high risk of developing type 2 diabetes and only about half made behavioral changes in the past year consistent with reducing diabetes risk. The majority did not receive any advice about diabetes risk reduction behaviors from their healthcare provider in the past year. Reversing the national trends in diabetes incidence is likely to require multiple tiers of interventions, including increased promotion of risk reduction behaviors and healthy lifestyles for people at risk as well as increased availability of evidence-based programs in communities for people at high risk. More efficient identification and awareness of risk on the part of patients, their providers, healthcare systems, and health payers are likely to be a key first step to implementing these changes.

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