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ORIGINAL ARTICLE

Prediabetes awareness, healthcare provider's advice, and lifestyle changes in American adults

Ike S. Okosun *, **Rodney Lyn**

Institute of Public Health, College of Health and Human Sciences, Georgia State University, Atlanta, GA 30302, United States

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KEYWORDS

Weight control;
Physical activity;
Fat/calories intake;
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Abstract *Purpose:* The purpose of this study was to examine whether persons who are aware of their prediabetes were more likely than persons with normal glycemia to report lifestyle changes (weight control, physical activity and fat/calories intake), and to determine the interactive effect of persons aware of their prediabetes and persons reporting doctor/health care provider's (DHCP) advice on overall lifestyle change.
Methods: Data from the 2005 to 2006 and 2007 to 2008 US National Health and Nutrition Examination Surveys were used for this investigation. Odds ratio from multiple logistic regression analysis was used to determine whether persons who are aware of their prediabetes were more likely than persons with normal glycemia to report lifestyle changes.
Results: Persons who are aware of their prediabetes were more likely than persons with normal glycemia to report increased weight control (OR = 1.72; 95% CI = 1.34–2.20) and physical activity (OR = 1.28; 95% CI = 1.02–1.61), and reduced fat/calorie intake (OR = 1.82; 95% CI = 1.41–2.34), after adjusting for age, BMI, persons reported DHCP advice, race/ethnicity, sex, education and household income. Persons who reported DHCP advice were more likely than persons who did not report DHCP advice to report increased weight control (OR = 1.87; 95% CI = 1.67–2.09) and physical activity (OR = 1.59; 95% CI = 1.43–1.78), and reduced fat/calorie intake (OR = 2.19; 95% CI = 1.96–2.46), after adjusting for confounders. There was no significant

* Corresponding author. Tel.: +1 404 413 1138.
E-mail address: iokosun@gsu.edu (I.S. Okosun).

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interaction between persons aware of their prediabetes and persons that reported DHCP advice with reported overall lifestyle change.

Conclusions: Creating diabetes risk awareness in at-risk groups and increased counseling of at-risk groups by doctors/health care providers may be the keys to prevent diabetes.

1. Introduction

Prediabetes is an impaired glucose tolerance (IGT) or impaired fasting glucose (IFG) condition in which blood glucose values are higher than normal, but not high enough to be classified as type 2 diabetes [1]. These glucometabolic abnormalities are associated with cardiovascular morbidity and mortality [1,2]. Prediabetes represents an intermediate stage of an altered glucose metabolism between normal glucose levels and diabetes [3,4]. Prediabetes is determined by using fasting plasma glucose (FPG) or oral glucose tolerance (OGTT) [5–7]. FPG is often performed after an overnight fast of at least 8 h, while OGTT is measured after overnight fasting and 75 g glucose in water. Prediabetes is defined as FPG between 100 and 125 mg/dl and/or 2 h FPG level in OGTT between 140 and 199 mg/dl [5–7]. The American Diabetes Association (ADA) and World Health Organization (WHO) have different definitions of IFG. ADA defines IFG by using values between 100 and 125 mg/dl, while WHO uses the values between 110 and 125 mg/dl [6,8]. However, authors have generally used ADA criteria. ADA has also recommended the use of hemoglobin A1C (HgA1c) to determine prediabetes [9]. HgA1C reflects time averaged blood glucose during the previous 2 and 3 months, and is used as a gold standard for long-term follow-up of glycemic control. ADA suggests an HgA1C range of 5.7–6.4% for defining prediabetes [9]. If not addressed, prediabetes can lead to type 2 diabetes [10]. Indeed, studies have shown that 33–65% of those with prediabetes may go onto develop overt type 2 diabetes within 6 years, compared to fewer than 5% in subjects with normal glycemia. [11].

Evidence from many clinical trials indicates that type 2 diabetes can be delayed or prevented in the at-risk group through lifestyle changes, such as dietary changes, physical activity and weight loss [12–16]. International trials have demonstrated a 31–58% reduction in the incidence of type 2 diabetes for adults with IGT who participated in lifestyle change programs of weight reduction and increased physical activity compared with controls [13,17]. The landmark National Institute of Health Diabetes Prevention Program (NIH-DPP) also showed that modest weight loss and increase in physical activity are significantly associated with a delay in the onset of type 2 diabetes [18]. The NIH-DPP have been successfully translated into many communities, and it is generally accepted that if at-risk subjects, particularly those with prediabetes, are identified and advised of their risk status, they may make appropriate lifestyle changes that can delay or prevent the onset of type 2 diabetes.

Understanding lifestyle changes in subjects who are aware of their poor glycemic condition (Prediabetes) may be helpful in planning successful lifestyle interventions for delaying and preventing type 2 diabetes, as well as its associated sequelae. The purpose of this study was to examine whether persons who are aware of their prediabetes are more likely than persons with normal glycemia to report lifestyle changes, including weight control, physical activity and fat/calories intake. We also sought to determine the interactive effect of persons aware of their prediabetes, and reported doctor/health care provider's (DHCP) advice on overall reported lifestyle change. We hypothesize that subjects who are aware of their prediabetes would be more likely to report lifestyle changes, as well as seek DHCP advice, in order to prevent and delay the onset of type 2 diabetes, compared with subjects with normal glycemia. We also hypothesize an interaction between persons aware of their prediabetes and persons reporting DHCP advice that departs from multiplicativity in the relationship between persons aware of their prediabetes and persons reporting an overall lifestyle change.

2. Methods

2.1. Subjects and study design

Data from the 2005 to 2006 and 2007 to 2008 NHANES were used for this investigation and came from The United States National Center for Health Statistics (NCHS). Released in 2 years intervals starting in 1999, NHANES are multifaceted cross-sectional sampling designs administered to a representative sample of the civilian noninstitutionalized individuals within the US population. Participants in NHANES are interviewed in their homes, and subsequently receive a physical and laboratory examination in a mobile examination center. Descriptions of the plan and operation of the surveys are available on world wide web [19,20] and have also been described by other investigators [21,22]. The NHANES study protocols were approved by the institutional review board of NCHS. In NHANES, informed consent was obtained from subjects who were 18 years and older. Both 2005–2006 and 2007–2008 datasets were used in this study in order to increase our sample size.

Overall, over 20,497 persons completed the 2005–2006 and 2007–2008 NHANES. However, only 18–85 years old adults (n = 9966) who had values for age, height, weight, waist circumference, and tested for high-density lipoprotein cholesterol (HDL-C), total cholesterol, OGTT and FPG were eligible for this study. This study was restricted to persons participating in the NHANES morning fasting sample (n = 6238) and had a valid OGTT value (n = 4552). Eligibility for this study was also restricted to subjects with data on blood pressure, education and annual household income. In NHANES, height was measured with a fixed stadiometer with a vertical backboard and a moveable headboard. Weight was measured at a standing position, using a Toledo digital weight scale (Seritex, Carlstadt, New Jersey). Waist circumference was measured between the bony landmark, the lateral border of the ilium and the uppermost lateral border of the right ilium. The measurement was made at the end of a normal expiration and to the nearest 0.1 cm [19,20]. Other variables included in this study are gender, blood pressure, race/ethnicity, smoking and alcohol use.

In NHANES, blood samples were analyzed for HDL-C, total cholesterol, OGTT and FPG using standard procedures. In the surveys, three consecutive blood pressure readings were obtained, using the same arm. All blood pressure readings were obtained during examination visits using a standard protocol. In this study the average of the three systolic (SBP) and diastolic blood (DBP) pressure readings were used as the participants' systolic and diastolic blood pressure values [19,20].

2.2. Exclusions

Participants with diagnosed and undiagnosed diabetes were excluded from the analysis. Based on standard diagnostic criteria incorporating FPG and OGTT values, adults were classified as having undiagnosed diabetes (FPG of >126 mg/dL or 2 h plasma glucose of >200 mg/dL, ($n = 511$) [1,2]. Subjects with a history of diabetes ($n = 1272$) and pregnant women ($n = 1272$) were excluded from this analysis. Subjects with known medical conditions, such as congestive heart failure, coronary heart disease, angina/angina pectoris, heart attack, and stroke were also excluded. These medical conditions may be associated with studied lifestyle factors. Subjects who were excluded from this study were similar to those who were eligible in terms of age, gender, BMI, education and race/ethnicity.

2.3. Definitions of dependent and independent variables

2.3.1. Dependent variables

The main dependent variables in this study are weight control, physical activity and fat/calories intake. During the NHANES home interview, participants were asked about risk reduction: to lower your risk for certain diseases, are you now doing any of the following: (a) controlling weight or losing weight? (b) Increasing your physical activity or exercise? (c) Reducing the amount of fat or calories in your diet? In this study, subjects answering yes to questions on weight, physical activity and fat/calorie questions were classified as engaging in weight control, increasing physical activity level and reducing fat/calorie intake, respectively. We also computed overall lifestyle change, defined as answering affirmatively to all the above three questions.

2.3.2. Independent variables

The main independent variable for this study is awareness of self prediabetes. During the NHANES home interview, participants without diagnosed diabetes were asked: have you ever been told by a DHCP 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? In this study, those answering in the affirmative or volunteering that they had prediabetes when asked about diabetes were classified as having an awareness of their prediabetes condition ($n = 353$). Subjects answering negatively to this question, and those with negative FPG and OGTT diabetes result, were classified as having normal glycemia ($n = 9613$). Person reported DHCP advice was computed based on four NHANES questions: to lower your risk for certain diseases, during the past 12 months have you ever been told by a DHCP to: (i) control your weight or lose weight? (ii) Increase your physical activity or exercise? (iii) Reduce the amount of fat or calories in your diet? (iv) Have you ever been told by DHCP that you have health conditions or a medical or family history that increases your risk for diabetes? Subjects answering positively to all the above questions were classified as having positive advice from DHCP.

In this study, race/ethnicity was categorized into four groups, consisting of non-Hispanic White, non-Hispanic Black, Mexican–American and others. Body mass index was calculated as weight in kilogram divided by height in meters squared. Education was categorized as less than high school, high school and college. Annual household income was grouped as less than $20,000, $20,000–$54,999 and $55,000 or greater.

2.4. Statistical analysis

Statistical programs available in SAS (release 9.2) and SUDAAN [23] were utilized in this analysis. To account for unequal probabilities of selection, oversampling and nonresponse, appropriate sample weights were utilized. Mean values of continuous variables were compared across glycemic status (prediabetes versus normal glycemia) using independent t-tests, while prevalent differences were determined using Pearson's $\chi 2$ tests. Multiple logistic regression analysis was used to test whether persons who are aware of their prediabetes were more likely than persons with normal glycemia to report lifestyle changes (weight control, increased physical activity and reduced fat/calories in diet). We compared persons aware of their prediabetes (Model I) and persons reported DHCP advice (Model II) with reported overall lifestyle change (combined participation in weight control, increased physical activity and reduced fat/calories in diet) as well as model that included both persons aware of their prediabetes and persons reported DHCP advice (Model III). We also tested for the interaction between persons aware of their prediabetes and persons reported DHCP advice (Model IV). In all models, statistical adjustments were made for age, BMI, race/ethnicity, sex, education and household income. In all analyses, $P < .05$ and 95% confidence intervals were used to determine statistical significance.

3. Results

The basic demographic, anthropometric and clinical characteristics of eligible subjects for this study are described in Table 1. Overall, subjects who were aware of their prediabetes were older, taller and presented higher values of weight, waist circumference, SBP and HDL-C compared to normal glycemia subjects ($P < .05$). Subjects who were aware of their prediabetes were obese (mean BMI = 31 kg/m^2) while the normal glycermia subjects were overweight (mean BMI = 28 kg/m^2). Although subjects who were aware of their prediabetes and persons with normal glycemia condition were similar in terms of education and annual household income, subjects who are aware of their prediabetes had more females.

Table 2 compares subjects who were aware of their prediabetes and normal glycemia subjects according to persons who reported doctor's advice, lifestyle changes made in the past one year, current lifestyle changes and other known diabetes risk factors. As is shown, more subjects who were aware of their prediabetes were advised to eat less fat, reduce weight and engage in exercise, compared with subjects with normal glycemia ($P < .001$). More subjects who were aware of their prediabetes

Table 1 Basic characteristics of studied population of subjects who are aware of their prediabetes and subjects with normal glycemia.

Variables	Prediabetes (353)	Normal Glycemia (9613)	*P*-value
Age (y)	54.4 ± 17.3	44.4 ± 19.3	< .001
Height (cm)	166.2 ± 9.7	167.8 ± 10.1	.006
Weight (kg)	84.9 ± 20.3	79.0 ± 20.3	< .001
Body mass index (kg/m^2)	30.8 ± 7.0	28.0 ± 6.4	< .001
Waist circumference (cm)	102.8 ± 15.0	95.7 ± 15.5	< .001
Diastolic BP (mmHg)	69.6 ± 13.0	69.1 ± 19.4	.554
Systolic BP (mmHg)	125.2 ± 18.0	120.3 ± 17.4	< .001
HDL-Cholesterol (mg/dl)	52.3 ± 14.7	54.1 ± 16.3	.043
Total cholesterol (mg/dl)	202.0 ± 40.7	195.7 ± 42.7	.081
Gender (%)			< .001
Male	35.4	48.9	
Female	64.6	51.1	
Race/ethnicity (%)			.039
NH White	52.1	47.1	
NH Black	19.5	21.6	
Mexican American	14.4	19.5	
Others	12.9	11.5	
Education (%)			.202
Less than high school	26.1	27.8	
High school	20.9	24.0	
College	53.0	48.3	
Annual household income (%)			.769
Less than $20,000	19.6	20.9	
$20,000–$54,999	40.0	38.4	
$55,000+	40.3	40.8	

HDL-C, high-density lipoprotein cholesterol; NH, non-Hispanic, BP, blood pressure.

Table 2 Reported doctor's advice, lifestyle changes and known risk factors by persons aware of their prediabetes and normal glycemic status in American adults.

Variables	Prediabetes	Normal glycemia	P-value
Doctors advice			
To eat less fat for cholesterol	88.3	77.8	.001
To reduce weight for cholesterol	69.8	50.9	< .001
To exercise more for cholesterol	78.2	61.5	< .001
Told have health risk for diabetes	43.6	10.6	< .001
Lifestyle changes in past year			
To control weight	49.6	17.7	< .001
To increase physical activity	59.1	24.2	< .001
To reduce fat/calories in diet	58.5	20.6	< .001
On going lifestyle changes			
Controlling weight	67.1	44.0	< .001
Increasing physical activity	55.7	43.3	< .001
Reducing fat/calories in diet	69.1	43.3	< .001
Other known risk			
High blood pressure	52.4	25.0	< .001
High cholesterol	59.2	38.5	< .001
Current smokers	50.0	60.2	.007
Current alcohol drinkers	62.6	71.5	.082

(43.6%) were provided information about health risks for diabetes compared with normal glycemia subjects (10.6%). Weight control, increased physical activity and reduced fat/calories in the past year were more common in the subjects who are aware of their prediabetes compared with normal glycemia subjects ($P < .001$). More subjects who were aware of their prediabetes reported ongoing weight control, increased physical activity and reduced fat/calories intake, compared to normal glycemia subjects ($P < .001$). The prevalence of high blood pressure and high cholesterol was higher in subjects who were aware of their prediabetes while smoking rate was higher in the normal glycemia subjects ($P < .01$).

In Fig. 1, we compared rates of reported overall lifestyle change in subjects who are aware of their prediabetes with

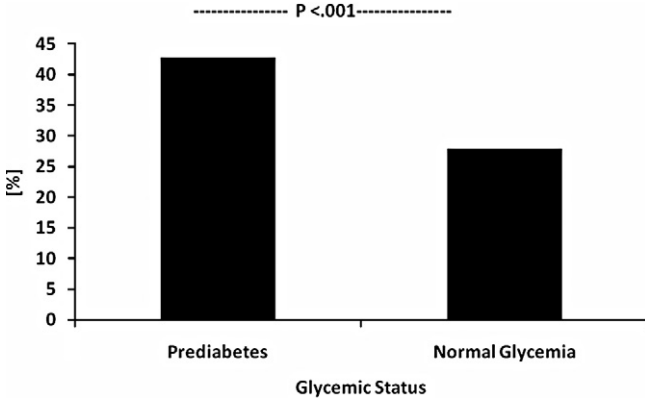

Figure 1 Overall lifestyle change in persons aware of their prediabetes state and normal glycemia American adults.

normal glycemia subjects. As shown there was a statistically significant difference between subjects who were aware of their prediabetes and normal glycemia with respect to overall lifestyle change defined by combined persons reported ongoing weight control, increased physical activity and reduced fat/calories intake. The rate of overall lifestyle change in subjects who were aware of their prediabetes was 42.8% compared with 27.9% in normal glycemia subjects ($P < .001$).

We fitted lifestyle specific logistic regression models, adjusting for age, BMI, persons reported DHCP advice, race/ethnicity, sex, education and household income (Table 3). In each model, persons who were aware of their prediabetes were more likely than persons with normal glycemia to report increased weight control, increased physical activity and reduced fat/calorie intake. The odds ratios for reported weight control, increased physical activity and reduced fat/calorie intake were 1.72, 1.68 and 1.82, respectively. In each model, persons who reported DHCP advice were also more likely to report increased weight control, increased physical activity, and reduced fat/calorie intake as indicated by odds ratios of 1.87, 1.59 and 2.19, respectively. High school and college education, household income of $20,000–$54,999 and over $55,000 were also associated with increased odds of reported weight control, increased physical activity and reduced fat/calorie intake. Compared to non-Hispanic White, being of non-Hispanic Black race/ethnicity was associated with decreased odds of reported weight control, increased physical activity and reduced fat/calories. Compared to non-Hispanic White, Mexican and other racial/ethnic groups had decreased odds of reported fat/calorie intake.

To determine the effect of persons reported DHCP advice on the relationship between persons aware of their prediabetes and persons reported overall lifestyle change (Table 4), we compared models containing persons aware of their prediabetes (Model I) and persons reported DHCP advice (Model II) as independent variables, and models containing both persons aware of their prediabetes and persons reported DHCP advice (Model III) as independent variables. Statistical adjustments were made for age, BMI, race/ethnicity, sex, education and household income. As is shown in Table 4 (Model III), adjusting for persons reported DHCP advice attenuated the relationship between persons aware of their prediabetes and overall lifestyle change by 11.8%. We also fitted interaction between persons aware of their prediabetes and reported DHCP advice (Model IV). No statistical significant association was found for the interaction between persons aware of their prediabetes and persons reported DHCP advice with overall lifestyle change.

4. Discussion

The prevalence of type 2 diabetes is on the increase, and has reached an epidemic proportion in the US and many other countries. The prevalence of prediabetes is also increasing in the US, and it is estimated that 57 million Americans have

Table 3 Relationship between persons aware of their prediabetes and reported weight control, increased physical activity and reduced fat/calories in American adults.

Variables	Weight control		Increased physical activity		Reduced fat/calories	
	OR	95% CI	OR	95% CI	OR	95% CI
Prediabetes	1.72	1.34–2.20	1.68	1.42–2.61	1.82	1.41–2.34
Age	0.98	0.97–0.99	0.98	0.97–1.00	0.98	0.97–0.99
BMI	0.94	0.93–0.95	0.96	0.95–0.97	0.94	0.93–0.95
DHCP advice	1.87	1.67–2.09	1.59	1.43–1.78	2.19	1.96–2.46
Race/ethnicity[*]						
NH Black	0.88	0.78–0.99	0.67	0.60–0.75	0.78	0.69–0.88
Mexicans	1.10	0.97–1.26	0.93	0.82–1.06	0.73	0.64–0.84
Others	0.97	0.84–1.13	0.92	0.80–1.07	0.84	0.72–0.97
Sex[**]	0.73	0.67–0.79	0.80	0.73–0.87	0.60	0.55–0.66
Education[**#]						
High school	1.62	1.44–1.82	1.71	1.52–1.92	1.71	1.51–1.93
College	1.40	1.25–1.57	1.40	1.26–1.57	1.40	1.25–1.57
Household income[**##]						
$20,000–$54,999	1.50	1.13–1.70	1.26	1.11–1.43	1.56	1.37–178
$55,000+	1.21	1.09–1.34	1.16	1.05–1.28	1.22	1.10–1.35

OR, odds ratio from logistic regression analysis; CI, confidence intervals; reference groups, *, **, **#, **## are NH White male, less than high school education, and less than $20,000, respectively; NH, non-Hispanic; DHCP, doctors/health care professional.

Table 4 Relationship between persons aware of their prediabetes and reported overall lifestyle change in American adults.

Variables	Model I		Model II		Model III		Model IV	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Prediabetes	1.44	1.14–1.81	–	–	2.27	1.31–2.61	1.73	1.41–1.84
Age	0.98	0.97–0.99	0.99	0.98–1.00	0.99	0.98–1.00	0.99	0.98–1.00
BMI	0.94	0.93–0.95	0.94	0.93–0.95	0.94	0.93–0.95	0.94	0.93–0.95
DHCP	–	–	1.86	1.66–2.09	1.94	1.64–2.06	1.94	1.64–2.08
Race/ethnicity[*]								
NH Black	0.78	0.69–0.88	0.76	0.67–0.87	0.76	0.67–0.87	0.76	0.67–0.87
Mexicans	0.93	0.80–1.08	0.92	0.79–1.06	0.92	0.79–1.06	0.92	0.79–1.06
Others	0.82	0.70–0.96	0.82	0.70–0.96	0.82	0.70–0.96	0.82	0.70–0.96
Sex[**]	0.66	0.60–0.72	0.65	0.59–0.71	0.65	0.59–0.72	0.65	0.59–0.72
Education[**#]								
High School	1.86	1.63–2.12	1.83	1.61–2.09	1.83	1.60–2.09	1.83	1.60–2.09
College	1.52	1.35–1.72	1.52	1.35–1.72	1.52	1.34–1.72	1.52	1.34–1.72
Household income[**##]								
$20,000–$54,999	1.69	1.46–1.96	1.64	1.41–1.90	1.64	1.41–1.90	1.64	1.41–1.90
$55,000 +	1.21	1.09–1.35	1.19	1.06–1.32	1.19	1.06–1.32	1.19	1.06–1.32
DHCP[*] prediabetes	–	–	–	–	–	–	1.49	0.89–1.74

Overall lifestyle change; defined as combined participation in weight control, increased physical activity and reduced fat/calories in diet; DHCP, doctors/health care professionals; OR, odds ratio from logistic regression analysis; CI, confidence intervals; reference groups, *, **, **#, **## are NH White male, less than high school education, and less than $20,000, respectively; NH, non-Hispanic; Model 1, unadjusted DHCP advice; Model II, unadjusted for prediabetes; Model III, adjusted for DHCP advice; Model IV, fitted for interaction between DHCP and prediabetes.

prediabetes [24]. Because prediabetes is often unrecognized, it is a major public health concern, and its intervention is essential. People with prediabetes have an increased risk of progression to overt type 2 diabetes [11,25–27]. On average, the rate of progression from prediabetes to type 2 diabetes is approximately 5% per year [26]. Effective behavioral changes are now available to retard the progression of prediabetes to overt type 2 diabetes [25]. Indeed, studies show that type 2 diabetes can be delayed or prevented through self-effacing weight loss and increased physical activity [12–16,18,28]. A report using 2006 National Health Interview Survey indicates that among US subjects who have been told that they have prediabetes, 68% attempted to lose or control weight, 55% increased physical activity or exercise, 60% reduced dietary fat or calories intake and 42% were engaged in all three activities [29]. Therefore, early detection and awareness of self prediabetes condition and understanding factors that are associated with lifestyle changes in subjects who are aware of their prediabetes may be helpful in planning successful lifestyle interventions in at-risk groups.

Our study showed that 88%, 70% and 78% of subjects who are aware of their prediabetes were advised by doctors to eat less fat/calories, reduce weight and increase physical activity, respectively. Despite suffering from prediabetes, only 44% were told by doctors about the health risk for diabetes. Fifty percent, 59.1% and 58.5% of subjects who were aware of their prediabetes reported engagement in weight control, increased physical activity, reduced fat/calorie intake, respectively, in past year. Subjects who were aware of their prediabetes also made significant ongoing lifestyle changes as indicated by 67%, 56% and 69% reported weight control, increased physical activity, reduced fat/calorie intake, respectively. The overall rates of lifestyle change defined by reported ongoing participation in weight control, physical activity and reduced fat/calorie intake was 42.8% in subjects who are aware of their prediabetes compared to 27.9% in subjects who have normal glycemia.

The result of this investigation shows that persons who were aware of their prediabetes were more likely than persons with normal glycemia to report increase weight control (OR = 1.72; 95% CI = 1.34–2.20), increased physical activity (OR = 1.68; 95% CI = 1.42–2.61), and reduced fat/calorie intake (OR = 1.82; 95% CI = 1.41–2.34), after adjusting for age, BMI, persons reported DHCP advice, race/ethnicity, sex, education and household income. Persons who reported DHCP advice were more likely than those did not report DHCP advice to report increased weight control and increased physical activity, and reduced fat/calorie intake after adjusting the persons aware of their prediabetes, age, BMI, race/ethnicity, sex, education and household income. Increased educational attainment and household income were also associated with increased odds of reported weight control, increased physical activity and reduced fat/calorie intake. Increased age, BMI, non-Hispanic Black race/ethnicity and female gender were each independently associated with decreased odds of reported weight control, increased physical activity, reduced fat/calorie intake, after adjusting for other covariates. No statistically significant association was found for interaction between persons aware of their prediabetes and reported DHCP advice with reported overall lifestyle change.

The finding from this study suggesting a positive association between persons who reported doctor's advice and lifestyle change is consistent with other studies [30–33]. The low level of reported doctor's advice on the health risks for diabetes for subjects who know they have prediabetes as shown in this study is also consistent with findings by Ma et al. [32]

and Forman-Hoffman et al. [33]. Using the 1992–2000 National Ambulatory Medical Care and National Hospital Ambulatory Medical Care surveys, Ma et al. [32] found diet and physical activity counseling below expectations during outpatient visits by adults with an elevated cardiovascular risk. Using focus group, Forman-Hoffman et al. [33] found a lack of obesity training during medical school and residency was associated with lower rates of discussing diet and exercise with obese patients. The finding of positive association between awareness of self prediabetes status and lifestyle change in this study is similar to the finding by Geiss et al. [34] who used only the 2005–2006 NHANES.

4.1. Study strength and limitations

The major strength of this study lies in the use of NHANES, which represents the best available data, given that the sampling scheme is representative of the national population. The physical measurements and biological risk factors in NHANES were collected using standardized methods. The training program and quality control procedures instituted in the surveys give added credibility to the data. However, an important limitation must be taken into account in the interpretation of the results from this study. Since lifestyle behaviors and DHCP advice were self-reported, one cannot rule out recall and social desirability biases.

4.2. Practice implications of findings

Findings from this study have some public health and practice implications. First, although we only examined a small proportion of persons who are aware of their prediabetes, their adoption of risk reduction behaviors are suboptimal. The National Institutes of Health's 1998 guidelines recommended that health care professionals advise at-risk patients to lose weight [35]. However, in this study only 70% of the study population of subjects who are aware of their prediabetes was counseled to lose weight by DHCP. This finding suggests the need to identify barriers to counseling in population of subjects who are aware of their prediabetes and need for aggressive screening for prediabetes. Screening for prediabetes may help to reverse the national trends in diabetes incidence in the light of epidemiologic evidence suggesting pharmacological and behavioral effectiveness in retarding the progression or delay of prediabetes to overt type 2 diabetes [14,36].

5. Conclusion

Creating diabetes risk awareness among stakeholders may be the key to promoting healthy behavior to stem diabetes in at-risk groups. Increased counseling of at-risk subjects by doctors/health care providers may also help to promote healthy behaviors to delay or prevent the onset of type 2 diabetes.

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