DIABETES TYPE AND COMPLIANCE WITH RECOMMENDED GUIDELINES FOR PHYSICAL ACTIVITY

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Diabetes Type and Compliance with Recommended Guidelines for Physical Activity

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Abstract

This study investigated the relationship between diabetes and meeting physical activity and muscle-strengthening guidelines by assessing three groups: (1) Type 2 diabetes, (2) pre-diabetes, and (3) no diabetes. A sample of 416,649 individuals, ages 18-99, who responded to the 2013 Behavioral Risk Factor Surveillance System survey, was used to examine compliance with aerobic and muscle strengthening exercise recommendations. Our hypothesis predicted that people with diabetes would exercise more than pre-diabetics or non-diabetics because they have a condition where exercise is a crucial part of disease management. This data analysis controlled for the effects of body mass index, age, sex, and chronic illnesses. Contrary to this hypothesis, as the disease severity increased, participation in physical activity and muscle strengthening activity decreased. Implications for research and behavioral health practices are discussed.

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List of Abbreviations

BMI	Body Mass Index
BRFSS	Behavioral Risk Factor Surveillance System
CDC	Centers for Disease Control
DRS	Diabetes Risk Score
MET	Metabolic Equivalents
PARC	Physical Activity Rotating Core
SAS	Statistical Analysis Software

List of Tables and Figures

Diabetes Type and Compliance with Recommended Guidelines for Physical Activity

In 2007, The Centers for Disease Control and Prevention (2008) estimated that 24 million Americans were affected by diabetes mellitus. There are three distinct types of diabetes: (1) Type 1 diabetes, (2) gestational diabetes, and (3) Type 2 diabetes. Type 1 diabetes is also referred to as insulin dependent diabetes mellitus. It is a deficiency of insulin production and treatment of the disease requires insulin replacement. Type 1 diabetes makes up 5% to 10% of all diabetes cases in America and is more likely to strike in childhood or before the age of 30 (Colberg et al., 2016). Gestational diabetes is elevated serum glucose in pregnant women who were not diabetic before pregnancy. Gestational diabetes occurs in 3% to 8% of all pregnancies and typically resolves after delivery. Type 2 diabetes is also referred to as non-insulin dependent diabetes mellitus and normally affects individuals after the age of 40 (Colberg et al., 2016). However, in recent years, Type 2 diabetes has become more prevalent among people 39 years of age and younger (Mertig, 2011). Type 2 diabetes is associated with lack of exercise and obesity which develops from poor eating habits (Klandorf & Stark, 2016).

The international standard of measuring blood glucose levels are used in terms of a molar concentration which is measured in millimoles per liter (mmol/L). Criteria for the diagnosis of diabetes mellitus for both Type 1 and Type 2 consist of classic symptoms of diabetes or hyperglycemic crisis with plasma glucose concentration greater than or equal to 11.1 mmol/L (≥ 200 mg/dL) or a fasting plasma glucose greater than or equal to 7.0 mmol/L (≥126 mg/dL). Fasting is defined as no caloric intake for at least 8 hours (Craig et al., 2014).

Pre-diabetes

Pre-diabetes, or borderline diabetes, is blood glucose levels that are elevated above normal but not sufficient to be diagnosed diabetes. The diagnostic criteria for pre-diabetes is an elevated fasting plasma glucose level of 100 mg/dL-125 mg/dL, a glycated hemoglobin (HbA) value of 5.7% to 6.4%, or an elevated plasma glucose level after an oral glucose tolerance test of 140-199 mg/dL (Tuso, 2014). People with pre-diabetes are at high risk for developing Type 2 diabetes mellitus (Zhou, Remsburg, Caufield, & Itote, 2012). The Centers for Disease Control (CDC) reported that in 2012 that among American adults age 20 and over, 37% met the criteria for borderline diabetes. This indicates that as many as 86 million Americans over age 20 are borderline diabetic. Risk factors for prediabetes for people under the age of 45 include being physically inactive, obesity, and hypertension or high cholesterol (National Diabetes Information Clearinghouse, 2012).

Prevention

Healthy dieting and exercise can prevent diabetes (Diabetes Prevention program, 2003). Using the Behavioral Risk Surveillance System data (BRFSS), researchers found that fewer than 40% of adults with pre-diabetes participated in regular physical activity, and fewer than 25% had an adequate intake of fruits and vegetables. Only 20% met the body weight recommendations. (Zhou, Remsburg, Caufield, & Itote, 2012).

When people become overweight, cells may become resistant to insulin; exercise reverses this effect. Exercise also contracts muscles which aids glucose transportation (Krucoff & Krucoff, 2004). Physical activity improves the body’s ability to use insulin and process glucose more effectively (The Diabetes Prevention Program Research Group, 2002).

The 2008 Physical Activity Guidelines for Americans are designed to improve health by establishing guidelines for sufficient physical activity. For significant health benefits, all adults should perform at least 150 minutes of moderate-intensity aerobic activity per week, or 75 minutes of vigorous-intensity aerobic activity per week. Adults should also perform muscle strengthening activities of moderate to high intensity that involve all major muscle groups at least 2 days per week. The American Diabetes Association (2003) promotes structured lifestyle intervention that includes at least 150 to 175 minutes of physical activity per week, and dietary energy restriction that results in weight loss of 5% to 7%. These lifestyle changes have demonstrated reductions of 40%–70% in the risk of developing type 2 diabetes among pre-diabetics (Colberg et al., 2016). Extensive research has demonstrated that exercise is the most effective way of preventing pre-diabetes from advancing to Type 2 diabetes (Zhao, Ford, Li, & Mokdad, 2008).

The largest study that investigated ways of preventing pre-diabetes from advancing to Type 2 diabetes suggested that the most effective preventive measures are regular exercise and proper diet when compared to Metformin, a medication that lowers serum glucose. The Diabetes Prevention program found that lifestyle modification and intervention, which includes weight loss goals and weekly aerobic activity, reduced the incidence of type 2 diabetes by 58% compared to 31% for the Metformin group (Gopalan, et al, 2015).

Compliance with Exercise Recommendations

The World Health Organization has defined medical compliance as the extent to which a person's behavior, such as taking medication, following a diet, or executing lifestyle changes, corresponds with agreed recommendations from a health care provider (World Health Organization, 2002). Affect has been thought to contribute to whether a person decides to comply with doctor's advice. Individuals who report being in a positive mood when being given a diagnosis, are more likely to have less anxiety about the diagnosis (Schuettler & Kiviniemi, 2006). Positive affect is associated with greater expectation of recovering from the diagnosis. They are also more likely to seek additional information on how to get better and follow treatment regimens (Schuettler & Kiviniemi, 2006). Over the years, patient compliance and non-adherence has been attributed to many factors such as hopelessness and lack of communication between the doctor and patient (Baumann, Tchicaya, Lorentz, & Le Bihan, 2016).

It is possible for people with prediabetes to forestall the development of Type 2 diabetes by lifestyle modification and/or medication. Weight reduction, increase in physical activity, and, eating balanced diets are effective countermeasures. However, these lifestyle modifications are often unsuccessful because of poor compliance of patients (McLellan, Wyne, Villagomez, & Hsueh, 2014). Individuals who exercise and practice healthy eating habits when diagnosed with prediabetes are more likely to adhere to lifestyle change recommendations. For example, veterans who were pre-diabetic were more likely to comply with exercise recommendations than non-veterans (Bouldin & Reiber, 2012). This may be because of their exposure to a culture of exercise and fitness in the American military.

True et al., (2015) compared two groups of pre-diabetic individuals randomly assigned as intervention group and control group. The intervention group received their baseline Diabetes Risk Score, making them aware of their risk to a diagnosis of diabetes. The Diabetes Risk Score (DRS), used in this study, predicted a 5-year risk of onset diabetes in pre-diabetic patients (True et al., 2015). The test consists of seven biomarkers that are independently associated with the risk of developing diabetes. The levels of these biomarkers in a fasting blood sample, combined with age and gender, are placed into a proprietary algorithm to generate a single numerical score from

1 to 9.9. Results consist of three risk strata, with low risk as DRS <4.5 moderate risk ≥4.5 and <8.0 and high risk ≥ 8.0 The risk scores correlate with actual percentage values included in the personalized DRS report, which indicate the probability of conversion to type 2 diabetes within 5 years (True et al., 2015).

The control group did not receive a baseline DRS. Both groups participated in a 12 week program (Group Lifestyle Balance program), derived from the Diabetes Prevention program (True et al., 2015). This program consisted of an intensive lifestyle intervention with one-on-one coaching, dietary recommendations, exercise recommendations, and behavior modification. Following the intervention, the two groups did not differ in either attendance or adherence to the lifestyle modification program (True et al., 2015).

Gopalan, et al (2015) investigated whether adults who were aware of their pre-diabetic condition were more likely to engage in diabetes risk-reducing behaviors. Participants aware of their pre-diabetic health status were less likely to have visited the doctor in the past year compared to individuals who were not aware that they were pre-diabetic. Additionally, people who were aware of their pre-diabetic health status also had a higher mean of cardiovascular conditions and higher BMI compared to individuals who were not aware that they were pre-diabetic. There were no differences between the pre-diabetic aware and pre-diabetic unaware groups in any of the physical activity outcomes. Both groups reported engaging in about the same amount of physical activity weekly.

Although research has indicated that various preventive diabetes health programs for pre-diabetics can decrease the risk of Type 2 diabetes, the actual number of Type 2 diabetes cases is increasing. The National Diabetes Education weight loss program has developed an exercise curriculum specifically for people with prediabetes. Although preventive exercise programs are available, pre-diabetics may not participate in preventive diabetes health programs. Individuals with pre-diabetes may be unwilling or unmotivated to participate in any forms of exercise (Kuo et al., 2014).

The purpose of this study is to assess the differences in healthy lifestyle behaviors among diabetics, non-diabetics, and pre-diabetics. People with diabetes and prediabetes should exercise more than people who are not diabetic because exercise is known to be a part of effective disease management. Regular physical exercise is recommended to all people with prediabetes and diabetes. We hypothesized that there will be a dose-response relationship between diabetes status and meeting the physical activity and muscle-strengthening guidelines. Specifically, the odds of meeting these guidelines will be greater for people with diabetes compared to people with prediabetes. The odds of meeting these guidelines will be greater for people with prediabetes compared to people with no diabetes. The model will also control for the effects of age, sex, body-mass index, and number of chronic illnesses.

Method

Participants

The sample included 416,649 survey respondents from age 18-99 years who reported their diabetes status (i.e., diabetes, no diabetes or pre-diabetes) in a telephone survey to the Behavioral Risk Factor Surveillance System (BRFSS) of 2013. There were 351,394 participants who reported having no diabetes. There were 20,247 participants who reported having pre-diabetes. There were 45,008 participants who reported having diabetes (non-insulin users). Table 1 provides a summary of demographic information for the survey respondents.

Materials and Procedures

The Behavioral Risk Factor Surveillance System (BRFSS), is a state-based, cross-sectional, random digit dialing telephone survey of United States adults aged 18 -99 years, that is conducted annually by the Centers for Disease Control and state health departments to monitor health conditions across the nation. The BRFSS collects data in all 50 states, the District of Columbia, the US Virgin Islands, Puerto Rico, and Guam. Data were collected in English or Spanish. The 2013 BRFSS survey data were used for this study (National Center for Chronic Disease Prevention and Health Promotion, 2013).

The Physical Activity Rotating Core (PARC) is administered as a part of the BRFSS on odd calendar years. The PARC questions allow estimation of the number of the U.S. adults who meet recommended physical activity guidelines. It estimates the relative intensity of all reported activities to determine if the activity is of moderate or vigorous intensity. The PARC contains 5 questions within the BRFSS that ask about aerobic activity and one question that assesses muscle strengthening activity. Reported activities count toward meeting the aerobic physical activity guidelines if they are (1) aerobic activities, and (2) performed for at least 10 continuous minutes. The total minutes of aerobic activity per week for each reported activity is calculated for each respondent.

PARC asks the number of times an exercise is performed (frequency), the length of time in which the exercise was performed (duration), and how much work is being performed, or the magnitude of the effort required to perform that exercise (intensity). PARC questions include, “How many times per week, per month, per year did you take part in this activity?” (2013 BRFSS, p. 38).

The PARC method estimates the intensity of each reported activity to determine if the activity is of moderate or vigorous intensity for each respondent. The intensity takes into account the respondent's maximal oxygen uptake (or their exercise capacity) which is estimated based on their sex and age. The first step is estimating the maximal oxygen uptake. The maximal oxygen uptake is the body's capacity to transport and use oxygen during a maximal exertion involving dynamic contraction of large muscle groups. There are specific age and sex equations that estimate the maximal oxygen uptake. In the equations, the maximal oxygen uptake is expressed in metabolic equivalents (MET). One metabolic equivalent is the rate of energy expenditure while sitting still. PARC uses an oxygen uptake of 3.5 milliliters per kilogram of body weight per minute. The second step is determining the criterion MET values for moderate and vigorous intensity activities. The minimum intensity for vigorous intensity for vigorous activities is 60% of maximal oxygen uptake. Independent of maximal oxygen uptake, based on evidence-based recommendations, the criterion for moderate intensity activities is ≥3 METs. The third step is determining if the intensity for each reported activity is moderate or vigorous. There is a comparison between the respondent's criterion MET values from step 2 to the MET values that are ascribed to each reported activity using the standard MET value that is listed in the Compendium of Physical Activities (Centers for Disease Control and Prevention 2008).

The Physical Activity Guidelines for Americans states all adults should do muscle strengthening activities in addition to aerobic activities. Muscle strengthening activities should be of moderate or high intensity, involve all major muscle groups, and be performed 2 or more days a week. Individuals who met the muscle strengthening guidelines reported performing muscle-strengthening activities at least 2 times per week. Individuals who met both the aerobic activity guidelines and the muscle strengthening guidelines reported the adequate amount of time and intensity to both muscle strengthening activities and aerobic activities (Centers for Disease Control and Prevention 2008).

Measures

The criterion variable used in this study is diabetes status in which survey respondents are categorized as having diabetes, prediabetes, or no diabetes based on self-report. Questions asked as part of the 2013 BRFSS were used to form the three groups. Two questions were used to establish the type 2 diabetes sample. One question asked, “Have you ever been told you have diabetes?” (2013 BRFSS, p. 18). Adults who answered yes were included in the diabetes sample. To further filter the sample to only include type 2 diabetics we used the second question, “Are you now taking insulin?” (2013 BRFSS, p. 49). Respondents who answered yes to this question were removed from the original sample of respondents who answered yes to having diabetes. Our sample of type 2 diabetics is non-insulin users. Adults who responded no to the question, “Have you ever been told you have diabetes”, were included in the no diabetes and no pre-diabetes sample (n= 351,394). The pre-diabetes sample was determined by affirmative responses to the question, “Have you ever been told by a doctor or other health professional that you have pre-diabetes or borderline diabetes?” (2013 BRFSS, p. 48). Respondents who answered yes (n= 20,247) were included in the pre-diabetes sample excludes women reporting gestational diabetes). The three-category criterion variable has an ordinal structure with respect to severity of diabetes.

The independent variables are compliance with aerobic and muscle strengthening exercise recommendations as specified in the Physical Activity Rotating Core (PARC, Centers for Disease Control and Prevention, 2008). The PARC asks 6 questions. Based on the answers, respondents are classified into 6 categories, (1) inactive, (2) insufficiently active (3) active, (4) highly active, (5) meet muscle-strengthening guideline, and (6) meets aerobic and muscle-strengthening guidelines. “During the past month, other than your regular job, did you participate in any physical activities or exercises such as running, calisthenics, golf, gardening, or walking for exercise”, is asked (yes/no) (2013 BRFSS, p. 35). If the response is no, they are considered inactive. There are three questions that evaluate if respondents fall into the (2) insufficiently active, (3) active, or (4) highly active category. “What type of physical activity or exercise did you spend the most time doing during the past month, how many times per week or per month did you take part in this activity, and when you took part in this activity, for how many minutes or hours did you usually keep at it” (2013 BRFSS, p. 36- 38). Respondents who report greater than 0 minutes and less than or equal to 149 minutes of aerobic activity per week are considered insufficiently active. Respondents who report at least 150 minutes per week of moderate-intensity activity, or at least 75 minutes per week of vigorous-intensity activity, or an equivalent combination of moderate and vigorous-intensity activity totaling more than 150 minutes per week are considered active. Respondents who report 300 minutes per week of moderate-intensity activity, greater than 150 minutes per week of vigorous-intensity activity, or an equivalent combination of moderate and vigorous-intensity activity totaling more than 300 minutes per week and considered highly active.

The question that assessed muscle-strengthening activity is, “During the past month, how many times per week or per month did you do physical activities or exercises to STRENGTHEN your muscles? Do NOT count aerobic activities like walking, running, or bicycling. Count activities using your own body weight like yoga, sit-ups or push-ups and those using weight machines, free weights, or elastic bands” (2013 BRFSS, p. 42). The respondent is categorized in the (5) meet muscle-strengthening guideline if they report participation in muscle-strengthening activities at least 2 times per week. Respondents who report participating in muscle-strengthening activities at least 2 times per week AND at least 150 minutes per week of moderate-intensity activity, or at least 75 minutes per week of vigorous-intensity activity, or an equivalent combination of moderate-intensity and vigorous-intensity activity totaling at least 150 minutes per week are categorized as (6) meets aerobic and muscle strengthening guidelines (Centers for Disease Control and Prevention 2008). From the 6 categories, the respondents are placed in additional categories as either meeting or not meeting the 2008 Physical Activity Guidelines.

The analysis included covariates typically associated with Diabetes. Control covariates included age, sex, body mass index, and chronic illness. Covariates were age (in years) with 13 categories ranging from ages 18 to 99. Sex is coded as male or female. The body mass index is a calculated variable that is categorized into four groups, (1) underweight, (2) normal weight, (3) overweight, and (4) obese. The person's weight is taken in kilograms and divided by height in meters squared. The number of chronic illnesses variable is the total number of chronic illnesses reported by the respondent besides diabetes and prediabetes. These chronic illnesses include heart attack, asthma, and stroke. Values range from 0 to 3 with respective number of chronic illness. Participants would have the value 2 if they have two other chronic illnesses.

Statistical Analysis and Model

This is a population representative cross-sectional design based on responses to survey questions. The dependent variable is diabetes status, which forms three ordinal categories (diabetes, prediabetes, no diabetes). The categories are ordinal because they span a range of diabetes severity. The independent variables are compliance with recommended standards of physical and muscle strengthening exercise. Data were analyzed using SAS PROC SURVEYLOGISTIC with the model statement constructed to reflect the ordinal criterion variable diabetes status (no diabetes-prediabetes-diabetes). The SURVEYLOGISTIC model accounts for sample stratification and clustering, and was weighted to better approximate population parameters (Centers for Disease Control and Prevention 2008). An alpha level of 0.05 was used.

Results

Model Validity: Testing Proportional Odds Assumption

The score test of the proportional odds assumption is significant ($p < .0001$). This means that the coefficients associated with each predictor are different across all logits and indicates that the odds ratios are not constant across adjacent ordinal dependent variable categories. The score test is not conservative and is most informative when it signals that the proportional odds assumption is met (The SAS Institute, 1995). Two separate binary logistic regression models were run comparing the combined no diabetes and prediabetes groups to the diabetes group, and next comparing the combined prediabetes and diabetes groups to the no diabetes group. The differences in regression coefficients across the two models ranged from -.006 to .113. Excluding the variable with the largest difference in coefficients did not result in a model that yielded a nonsignificant test of the proportional odds assumption. We ran the model as using a multinomial regression that determines separate slopes for each logit but the results were consistent with those provided by the ordinal logistic regression. We decided to interpret the results of the ordinal logistic regression despite the violation of the proportional odds assumption.

Ordinal Logistic Regression Results

Table 2 presents the Type III analysis of effects for predictor variables and covariates. Wald chi-square tests indicated that each covariate is significantly related to diabetes while controlling for the effects of other variables in the model. The covariates being age, body mass index, sex, number of chronic illnesses, physical activity and muscle strengthening activity are all significantly related to diabetes status.

Table 3 presents the adjusted odds ratios and the 95% confidence intervals for model covariates. In general, younger age is associated with less diabetes, and men are less likely to be diabetic than women. For every year you age, there is a 5% increase in the odds of advancing towards diabetes. The largest discrepancy between men and women is in the prediabetes group (46% vs. 54%). Both increasing BMI and number of chronic diseases are associated with increased likelihood of diabetes.

Our hypothesis predicted that people with diabetes would exercise more than pre-diabetics or non-diabetics because they have a condition where exercise is crucial to disease management. Contrary to this hypothesis, as the disease severity increases, participation in physical activity and muscle strengthening activity decreases. The results presented in Table 4 indicate that 11.4% of diabetics meet the recommended guidelines for physical activity and muscle-strengthening activity. Among pre-diabetics, 14.8% met both physical and muscle-strengthening guidelines, and 21.5% of non-diabetics meet both exercise guidelines. Table 5 presents the adjusted odds ratios and 95% confidence intervals for participation in physical activity and muscle strengthening activity. Moving from the no diabetes to the prediabetes to the diabetes categories, and compared to those who meet both exercise guidelines, the odds of not meeting both the physical activity and muscle strengthening guidelines increase. People with diabetes are more likely to meet only the physical activity guidelines (OR = 1.23, 95% CI= 1.16 – 1.31), are more likely to meet only the muscle-strengthening guidelines (OR = 1.13, 95% CI = 1.03 – 1.24), and are more likely to meet neither guideline (OR = 1.6, 95% CI = 1.51 – 1.7). Compared to those who meet the physical activity guideline only, people with diabetes are more likely to meet neither physical activity nor muscle strengthening guidelines (OR = 1.3, 95% CI = 1.25 – 1.36). Compared to those who meet the muscle-strengthening guideline only, people with diabetes were more likely to meet neither guideline (OR = 1.4, 95% CI = 1.3 to 1.54). Reported odds ratios are adjusted for the effects of model covariates.

Only 35.4% of the diabetic population met the requirements for either the physical activity guidelines or the muscle strengthening guidelines but did not meet both 2008 Physical Activity guidelines for Americans (See Table 6). 53.5% reported no exercise. This means that 88.9% of the diabetics within our sample are not meeting the Physical Activity guidelines for Americans.

Discussion

The goal of this study was to assess the differences in compliance to national physical activity and muscle strengthening activity guidelines among diabetics, pre-diabetics, and non-diabetics. The 2008 Physical Activity guidelines report that exercise participation reduces the risk of various adverse health outcomes including diabetes (Centers for Disease Control and Prevention, 2008).

For persons with prediabetes, exercise plays a significant role in the preventing progression to Type 2 diabetes (Diabetes Prevention Program, 2003). For persons who have been diagnosed with Type 2 diabetes, exercise helps control blood sugar levels and prevents organ damage (Diabetes Prevention program, 2003). We hypothesized that as the severity of diabetes increases, exercise engagement would increase as well. Results indicated that meeting both physical activity and muscle strengthening guidelines became less likely advancing from the non-diabetic group to the pre-diabetic group and from the pre-diabetic to the diabetic group. This study controlled for the effects of covariates including body mass index, sex, age, and chronic illnesses other than diabetes.

Lifestyle modification, specifically exercise, is effective in the management of diabetes. Physical exercise is also effective in the prevention of diabetes for non-diabetics, and in the prevention of pre-diabetics progressing to Type 2 diabetes (Colberg et al., 2016). However, compliance with exercise participation fitting within the 2008 Physical Activity Guidelines is often poor (McLellan, Wyne, Villagomez, & Hsueh, 2014). Based on their results, there is a need for increased compliance with physical activity guidelines among American adults in order to prevent and manage diabetes. Increased compliance with recommended exercise guidelines is particularly needed among adults who have been diagnosed with diseases that can be managed through behavioral change.

Personality constructs such as delay discounting and time perspective have been shown to have small incremental effects on exercise over and above other personality characteristics (Daugherty & Brase, 2010). People generally prefer immediate rewards to future rewards, and delay discounting is the difference between the magnitude of future incentives relative to the value of an immediate reward. With respect to time perspective, present-minded people are more likely to seek immediate pleasures over long term, larger rewards. Future-minded people are more likely to focus on the long-term benefits of their actions. Both delay discount and time perspective is significantly associated with a variety of health behaviors, including exercise (Daugherty & Brase, 2010). To be a beneficial activity, exercise requires a regular and sustained commitment of time, and effort. Regular exercise may bring short-term negative consequences (e.g., fatigue, discomfort, injury, sense of failure) that overwhelm any appreciation of long term benefits. Thus, the rewards of exercise may not be valued by people who discount future rewards relative to those in the present, and by those who are present-minded. These dynamics may help explain why maintaining regular exercise routines are difficult for anyone. Individuals with prediabetes, Type 2 diabetes, or elevated risk of these conditions may be asymptomatic, unaware of their condition, and fail to appreciate the long term health consequences of unmanaged disease. Thus, diabetes may not function as a salient or powerful cue for exercise.

In 2007, The Exercise is Medicine Initiative (EIM) was implemented to help shift organized medicine to use an exercise prescription as a standard part of disease prevention and medical treatment paradigm for all patients (Sallis, 2015). There has been an increase in prevalence of chronic diseases, all of which are associated with behavioral and lifestyle factors, including the lack of exercise or inactivity. It has been recommended that medical professionals prescribe exercise as they would any other medical treatment. Exercise is extremely effective and also the least expensive form of medication (Sallis, 2015). The existing care standards for people with diabetes indicate that people with prediabetes should receive lifestyle-change counseling and a support program to help increase physical activity (American Diabetes Association, 2011). A collaborative initiative, supported by physicians, exercise, and behavioral health professionals would be beneficial to patients who are diagnosed with chronic illnesses in order to increase compliance with recommended exercise standards. The routine prescribing of exercise with effective monitoring for adherence should become the model for disease prevention and management.

Limitations/Future Directions

Because the BRFSS is based on self-report, variables such as BMI is calculated based on reported height and weight. All responses to the BRFSS survey are subject to possible recall and self-reporting biases. The pre-diabetes group likely represents an underestimate of this problem because prediabetes is often asymptomatic and many people may be unaware of their status (Cowie, et. al., 2009). However, Pierannunzi, Hu, & Balluz (2013) have shown that the BRFSS is comparable to other national surveys in its reliability and has a great deal of information that supports the validity of its data. Because this study is cross-sectional, it is unclear if the lack of physical activities causes diabetes, if diabetes or associated factors (i.e., obesity) causes lack of physical activity, or if both variables operate to influence each other. We cannot establish cause and effect due to the non-temporal element of the BRFSS. The results indicate that the majority of Americans do not meet the physical activity and muscle strengthening guidelines. Failure to meet these guidelines has implications for diabetes prevention and management and the reduction of diabetes-related morbidity and mortality.

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Table 1 Participant Characteristics (Total N= 416,649)

Variables	No Diabetes (N= 351,394)		Prediabetes (N=20,247)		Diabetes (N=45,008)	
	N	Weighted Percent	N	Weighted Percent	N	Weighted Percent
Sex						
Male	144,371	48.9%	8,091	46.2%	19,046	49.1%
Female	207,023	51.0%	12,156	53.7%	25,962	50.8%
Race						
White	276,996	65%	14,720	68.4%	32,683	58%
Black	23,554	10.2%	2,158	14.1%	4,940	14.4%
Other Race (Non-Hispanic)	14,150	5.8%	1,121	4.3%	2,050	6.3%
Multi-racial	6,337	1.3%	564	1.2%	858	1.3%
Hispanic	25,337	15.6%	1,375	9.9%	3,782	18%
Don’t know/ Refused	5,009	1.8%	309	1.7%	695	1.9%
Employment Status						
Employed wages	158,538	50.3%	6,752	39.1%	10,805	29%
Self-employed	31,010	8.7%	1,333	7.1%	2,220	5.7%
Out of work (1 or more years)	9,722	3.6%	657	4.8%	1,228	3.6%
Out of work (less than 1 year)	9,151	3.7%	466	3.2%	764	2.3%
Home-maker	22,907	6.7%	1,109	5.8%	2,506	6.8%
Student	10,561	6.7%	249	2.4%	196	0.7%
Retired	88,392	14.4%	7,264	26%	20,107	35.2%
Unable to work	19,809	5.1%	2,363	11%	7,029	16.2%
Refused	1,294	0.4%	54	0.3%	152	0.4%
Education Level						
Never attended school	381	0.2%	19	0.1%	94	0.5%
Elementary	7,533	4%	586	4.3%	2,154	9.1%
Some High School	17,234	9%	1,237	10%	3,674	13.1%
High School Graduate	96,635	27.3%	6,203	30.9%	15,201	30.4%
Some College	96,532	31.3%	5,756	31.5%	12,460	29.6%
College Graduate	132,419	27.7%	6,413	22.9%	11,326	17.2
Refused	650	0.2%	33	0.1%	98	0.3%

Table 1 Participant Characteristics (Continuation)

Variables	No Diabetes (N= 351,394)		Prediabetes (N=20,247)		Diabetes (N=45,008)	
	N	Weighted Percent	N	Weighted Percent	N	Weighted Percent
Body Mass Index						
Underweight	6,525	2.1%	171	0.8%	266	0.6%
Normal	124,109	37.2%	3,677	18.5%	6,214	14.1%
Overweight	123,398	36.1%	6,732	34.3%	13,888	32.3%
Obese	82,143	24.5%	8,785	46.1%%	22,573	53%
Chronic Illness						
One	44,490	11.3%	4,125	19.5%	10,884	23.2%
Two	4,463	0.8%	661	2.6%	2,396	4.4%
Three	417	0%	62	0.2%	317	0.6%
None	299,898	87.7%	15,231	77.5%	31,056	71.8%

Table 2 Type 3 Analysis of Effects

Effect	Degrees of Freedom	Wald Chi-Square	*p*
Physical Activity	1	54.12	<.0001
Muscle Strengthening	1	116.33	<.0001
Physical Activity x Muscle Strengthening Interaction	1	7.56	<.0001
Age	1	5597.18	<.0001
Body Mass Index	1	3659.31	<.0001
Sex	1	46.03	<.0001
Chronic Illnesses	3	1005	<.0001

Table 3 Adjusted Odds Ratios and 95% Confidence Interval for Outcome Variable

Variable	**Adjusted Odds Ratios**	**95% Confidence Interval**
Age	.953	.952 - .954
Body Mass Index	1	1 - 1
Sex		
Women	---	---
Men	.88	.85 - .91
Chronic Illness		
None	---	---
One	.58	.55 - .6
Two	.34	.31 - .38
Three	.22	.17 - .28

Table 4 Disease Severity and Physical Activity/Muscle Strengthening Activity

Diabetes Status	No Exercise	Muscle Strengthening only	Physical Activity only	Both
No Diabetes	38.6%	9.9%	30%	21.5%
Prediabetes	47.4%	7.1%	30.8%	14.8%
Diabetes	53.5%	6.2%	29.2%	11.4%

Table 5 Comparison of Physical Activity and Muscle Strengthening Groups

Comparison of Groups		**Odds Ratios**	**95% Confidence Interval**
PA – MS	PA Only	1.24	1.16 – 1.31
PA – MS	MS Only	1.14	1.03 – 1.24
PA – MS	No PA and No MS	1.62	1.51 -1.7
PA Only	No PA and No MS	1.31	1.25 – 1.37
MS Only	No PA and No MS	1.42	1.31 – 1.55

note. PA = Physical Activity criterion met; MS = Muscle Strengthening criterion met.

Figure 6 The 2008 Physical Activity Guidelines