AN EXAMINATION OF PREDIABETES, TYPE 2 DIABETES, AND ASSOCIATED FACTORS AMONG ADULTS IN THE UNITED STATES

by

Willie Rajvong

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Thesis Committee:

Chair: Dr. Andrew Owusu

Dr. Angela Bowman

Dr. Bethany Wrye

ABSTRACT

This study aimed to examine the association between type-2 diabetes, prediabetes, and associated factors. The 2015-2016 NHANES datasets were analyzed using complex sample tables and logistic regression. Individuals with BMI classification of overweight, and obesity classes 1 through 3 were more likely to have type 2 diabetes or prediabetes than normal weight; smoking 11 – 20 cigarettes were more likely to have type 2 diabetes than those who smoked 1 – 10 cigarettes; consuming alcohol were less likely to have type 2 diabetes than those not consuming alcohol; meeting recommendations for moderate work-related or vigorous leisure-time physical activity were less likely to have prediabetes than those who did not; consuming ≥ 51g of sugar daily were less likely to have type 2 diabetes than those who consumed ≤ 50g sugar daily. Future research should examine possible cause and effect relationships between factors.

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Chapter I

INTRODUCTION

Diabetes is an epidemic that is affecting the lives of over 30 million adults in the United States. Diabetes is a chronic metabolic disease that impairs the body's ability to release insulin and regulate blood glucose levels (Centers for Disease Control [CDC], 2018). There are three different types of diabetes: type 1, type 2, and gestational diabetes. Type 1 diabetes is characterized by the inability to produce insulin and is typically developed at birth, type 2 diabetes is characterized by insulin resistance and typically develops later in life, and gestational diabetes occurs in pregnant women. Insulin is a hormone produced by the pancreas, which functions as a key to let glucose from the food we consume pass from the blood stream into the cells in the body to produce energy (The International Diabetes Federation [IDF], 2018). Type 2 diabetes is the most common form of diabetes and accounts for 90 – 95% of all diagnosed cases of diabetes. Type 2 diabetes most frequently occurs in adults over the age of 45 but the incidence of young adults, teens, and children being diagnosed with the disease has seen an increase in recent years (CDC, 2018). The IDF states that as of 2017, there are 425 million adults living with diabetes and they estimate that number will rise to 629 million people by 2045.

Type 2 diabetes is a chronic metabolic disease that often can be prevented, managed, or delayed with healthy lifestyle changes such as: losing weight if you're overweight, healthy eating, and getting regular physical activity (CDC, 2018). The prevention and management of type 2 diabetes is an important consideration when taking into account that the population of the United States is gradually becoming more overweight and sedentary. The risk of developing diabetes can be reduced by reducing body weight, increasing physical activity and improving nutrition and dietary habits (CDC, 2018).

Smokers are 30 – 40% more likely to develop type 2 diabetes than nonsmokers. Tobacco usage and cigarettes are associated with a higher risk of type 2 diabetes and increase the difficulty of managing the disease (CDC, 2018). While smokers have an increased risk of type 2 diabetes, it remains debatable as to whether there exists a causal relationship between smoking and type 2 diabetes (Akter, Goto, & Mizoue, 2017).

The consumption of alcohol is an associated factor that may have a relationship with the development of type 2 diabetes. Alcohol is assumed to have a negative effect on glucose metabolism due to its high calorie nature and higher calorie meals often consumed in conjunction with alcohol (Teratani et al., 2012). This increased caloric intake may also lead to an increase in bodyweight. It has been found that there exists a reported dose-dependent relationship between the volume of alcohol consumption and the risk of type 2 diabetes (Knott, Britton, & Bell, 2018). Previous population-based cohort studies have shown that low-moderate drinkers of alcohol have a reduced risk of type 2 diabetes in comparison to heavy drinkers and abstainers (Kerr et al., 2018) although there are differences in the likelihood of developing diabetes between the two genders with women who consume excess alcohol being more likely to develop type 2 diabetes. An examination of the association of these associated factors and type 2 diabetes may help identify areas where diabetes-based prevention programs need to direct their focus.

Purpose of the Study

The purpose of this study was to examine prediabetes, type 2 diabetes, and associated factors among adults in the United States using the National Health and Nutrition Examination Survey (NHANES).

Research Question

When controlling for age, gender, race, and socioeconomic status; what is the relationship between type 2 diabetes, prediabetes, and associated factors: physical activity, nutrition, body weight, tobacco use, and alcohol consumption?

Hypothesis

When controlling for age, gender, race and socioeconomic status; low physical activity, low nutrition, increased body weight, tobacco use, and alcohol consumption are positively related to diabetes risk.

Chapter II

LITERATURE REVIEW

Introduction

Diabetes mellitus is a noncommunicable, chronic, metabolic disease that affects an estimated 425 million adults across the world. Type 2 diabetes is characterized by insulin resistance or relative insulin deficiency (IDF, 2018). Insulin resistance is when muscle, fat, and liver cells have a decreased response to insulin and have an impaired ability to take up glucose from the blood (National Institute of Diabetes and Digestive and Kidney Diseases [NIDDK] 2018).

Demographics

Type 2 diabetes most frequently occurs in most adults over the age of 45, but the incidence of young adults, teens, and children being diagnosed with the disease have seen an increase in recent years. Individuals with type 2 diabetes are characterized by insulin resistance and are at risk for complications such as heart disease, vision loss, and kidney disease (CDC, 2018). Risk factors for type 2 diabetes include: prediabetes, being overweight (BMI of 25 or higher), 45 years of age or older, family history (parent, brother, or sister with type 2 diabetes), physically active less than three times a week, having ever had gestational diabetes or given birth to a baby who weighed more than nine pounds, and being an African American, Hispanic/Latino American, American Indian, or Alaska Native (CDC, 2018).

There are an estimated 425 million adults living with all forms of diabetes across the globe (IDF, 2018). Over 200 million adults live with undiagnosed diabetes. The prevalence of diabetes across all income levels has risen significantly from 1980 to 2014 (WHO, 2016) and 79% of adults living with diabetes live in low-income and middle-income countries (IDF, 2018). The prevalence of diabetes is increasing across the globe. According the *Global Report on Diabetes* (World Health Organization [WHO], 2016) the prevalence of diabetes worldwide has increased 4.7% in 1980 to 8.5% in 2014. The number of adults with diabetes has nearly quadrupled since 1980, rising from 108 million adults in 1980 to 422 million adults in 2014 (WHO, 2016). Forty percent of this increase was attributed to population growth, 28% from a rise in age-specific prevalence, and 32% from an interaction between these two variables. It is estimated that by 2045, the number of adults living with diabetes will increase to 629 million people (IDF, 2018) It is estimated that diabetes-related complications caused four million deaths worldwide in 2017.

The prevalence of diabetes from 1980 – 2014 has increased in all regions of the world (WHO, 2016). The following regions all experienced an increase in diabetes prevalence from 1980 to 2014: African Region (3.1% to 7.1%), Region of the Americas (5% to 8.3%), Eastern Mediterranean Region (5.9% to 13.7%), European Region (5.3% to 7.3%), South-East Asia Region (4.1% to 8.6%), the Western Pacific Region (4.4% to 8.4%). The increase in diabetes prevalence mirrors the rise in overweight and obese individuals and is evidenced by the

Eastern Mediterranean Region having the highest prevalence of physical inactivity among adults (WHO, 2016). The WHO reported that more than 1 in 3 adults were overweight and more than 1 in 10 adults were obese (WHO, 2016).

The *National Diabetes Statistics Report* (CDC, 2017) reported that there were 30.3 million people or 9.4% of the population of the United States living with diabetes as of 2015. The report found that diabetes prevalence increased with age, with 4% of the population between ages 18 – 44 years of age having diabetes, 17% of adults ages 45 – 64, and 25.2% for adults age 65 or older. The prevalence of diabetes is similar between both sexes, with 9.2% of women and 9.4% of men having diabetes. The risk for diabetes is great in the United states as well. The NIDDK (2018) reported that more than 84 million adults in the United States have prediabetes. Prediabetes is a condition in which blood glucose levels are higher than normal but not high enough for diabetes to be diagnosed. Diabetes prevalence varies among racial and ethnic groups in the United States. Diabetes prevalence among the racial groups were reported as follows: American Indian/Alaska Native 15.1%, Asian 8%, Black 12.7%, Hispanic 12.1%, and White 7.4% (CDC, 2017).

Socioeconomic Status

Hongjiang, Xiangrui, Wild, Gasevic, and Jackson (2017) define socioeconomic status as a complex concept that describes an individual's position in society. Socioeconomic status consists of many dimensions and various indicators such as income, education, and occupation. A study conducted by Everson, Maty, Lynch, and Kaplan (2002) revealed that low socioeconomic status is associated with increased risk for depression, obesity, and diabetes. This study also revealed that socioeconomic status patterning of disease manifests early in life and continues across one's lifetime. These associations can be seen across cultures and different racial and ethnic groups (Everson et al., 2002).

Research by Funakoshi et al. (2017) also concluded that low socioeconomic status is associated with greater risk for type 2 diabetes in young adults. This study also indicated that there also exists an inverse relationship between socioeconomic status and type 2 diabetes. The study conducted by Hongjiang et al. (2017) found that while education was associated with increased diabetes prevalence, there were inconsistent results for association with income and almost no association with occupation. The increase in the incidence of type 2 diabetes leads to both a decline in the quality of life and an increase in medical costs that can increase the burden on society (Hongjiang et al., 2017).

Research by Aekplakorn et al. (2018) has found that there is a higher prevalence of diabetes in Thai adults of both genders with lower educational attainment. The results of their study also revealed that socioeconomic status had a more pronounced relationship with diabetes among women. The results also revealed that there were higher rates for diabetes in rural areas than in urban areas. The study also found that poor glycemic control was high in the middle age groups for both genders and for men with university level education and women with secondary level education.

Associated Factors

Research by Liu, Wang, Maisonet, Wang, and Zheng (2017) has found that associated factors such as smoking, alcohol consumption, physical activity, and diet were associated with type 2 diabetes in adults in the United States. Their study concluded that individuals with diabetes were less likely to consume alcohol and smoke than undiagnosed cases or individuals without diabetes. However, while individuals with diabetes were less likely to participate in those behaviors, they were also less likely to engage in moderate or vigorous physical activity. This study reported 64% of participants having engaged in little to no physical activity. The authors offered the recommendation of strategies being developed with a focus to encourage individuals with diabetes to increase their physical activity levels. Liu et al. (2017) also suggests that health policies should be developed to aim towards promoting healthy living due to the difficulty of changing habitual lifestyles for individuals with diabetes. This study seeks to expand on this study by using a cross-sectional design on the 2015 – 2016 NHANES dataset, and will also include the addition of a variable for body weight and examine the relationship between type 2 diabetes and prediabetes with the use of associated factors.

Glucose Metabolism

Glucose metabolism is a process used by the body to convert glucose into energy that the cells will utilize. Insulin and glucagon are released by the body to regulate glucose metabolism (Aronoff, Berkowitz, Shreiner, & Want, 2004).

Insulin is a pancreatic b-cell hormone that is released in response to increased blood glucose and amino acids levels typically following ingestion of a meal. The role of insulin in the body is to lower blood glucose concentrations. Glucagon is a catabolic hormone that is released by pancreatic a-cells. The role of glucagon in the body is to sustain blood glucose levels during periods of fasting conditions by facilitating processes such as glycogenolysis and gluconeogenesis. Glycogenolysis is the breakdown of glycogen, the body's storage form of glucose. Gluconeogenesis is the production of glucose from sources such as lactate and amino acids when the body is in a state of fasting (Aronoff et al., 2004).

A primary concern for individuals with impaired glucose metabolism is prolonged hyperglycemia. Hyperglycemia is the term for high blood glucose levels (American Diabetes Association, [ADA], 2014). Ketoacidosis is a major concern that stems from prolonged and untreated hyperglycemia. Ketoacidosis occurs as a result of ineffective insulin production. When insulin is impaired, glucose is inefficiently used as fuel and the body breaks down fats as fuel. Ketones are a waste product that is produced when the body breaks down fats as fuel. The blood in the body begins to become acidic as ketones begin to build up. Excess ketones that are normally flushed out the body through urine begin to build up in the blood and result in ketoacidosis. Prolonged ketoacidosis is a serious condition that may lead to a diabetic coma or even death (ADA, 2014).

Postprandial hyperglycemia maintenance and regulation is a major concern for individuals with type 2 diabetes. Postprandial hyperglycemia is an increase in blood glucose after the consumption of a meal (Borror, Zieff, Battaglini, & Stoner, 2018). Research by Cavalot et al. (2011) found that the occurrence of postprandial hyperglycemia in individuals with type 2 diabetes is predictive of cardiovascular events and all-cause mortality in individuals with type 2 diabetes. This 14 – year follow-up study found that fasting blood glucose was not a predictor of cardiovascular events or all-cause mortality. Their study also determined that blood glucose levels two hours after lunch is more representative of postprandial hyperglycemia than breakfast due to the utilization of small breakfasts foods such as a cup of coffee or a small piece of bread (Cavalot et al, 2011).

Physical activity and exercise help and maintain blood glucose levels for individuals with type 2 diabetes and impaired insulin sensitivity. Exercise can reduce postprandial hyperglycemia through muscular contraction mediated blood glucose uptake. Exercise offers an alternative way for blood glucose to exit the bloodstream and enter muscle tissue without insulin (Borror et al., 2018). Research by Short, Pratt, and Teague (2018) showed that a single bout of moderate intensity aerobic exercise increased insulin sensitivity in normal weight, overweight, and obese adolescents. This study found that the increased insulin sensitivity lasts at least 17 hours. A systematic review by Borror et al. (2018) found the most consistent benefits for postprandial exercise were seen in moderate-intensity exercises bouts longer than 45 minutes. The authors conclude that the energy expenditure is the most critical component of postprandial exercise. This conclusion is supported by a study by Nojima et al. (2017). Their study found that improvement in glycemic control is associated with both the initial and the increase in peak VO_2 max. Peak VO_2 max is the gold standard measure of aerobic capacity using the maximum rate of oxygen consumed during incremental exercise. An increase in peak VO_2 max allows for a greater capacity for aerobic exercise. Nojima et al. (2017) concluded that short bouts of exercise along with long-term aerobic exercise training could improve aerobic capacity and glycemic control in individuals with type 2 diabetes.

Physical Activity

Physical inactivity and sedentary lifestyles are one of the major risk factors for type 2 diabetes. Physical inactivity and sedentary lifestyles can be modified through the use of behaviors such as daily physical activity and exercise. Physical activity and exercise are important for improving the overall health status of an individual and for reducing the risk of diseases such as: coronary heart disease, stroke, colon cancer, breast cancer, obesity, type 2 diabetes, and metabolic syndrome**.** A study by Stuji (2018) mentions the positive effects of regular physical activity on blood glucose control in addition to other parameters that are important in type 2 diabetes treatment. Research by Bhargava, Chourdhary, Shukla, and Arjaria (2017) found that exercise significantly reduces the risk of developing diabetes. One major benefit of exercise that the study mentions is improved insulin sensitivity. The CDC (2018) also states that regular physical activity has additional benefits such as: improved cognitive function, reduced risk of depression, improved sleep, strengthened muscles, slow the loss of bone density associated with aging, improved cardiovascular fitness, and improved glucose tolerance.

Cardiorespiratory fitness is a major component of exercise. Cardiorespiratory fitness is the body's ability to supply oxygen to the body during exercise or physical activity. Kawakami et al. (2018) conducted a longitudinal cohort study on Japanese men that found that high cardiorespiratory fitness is associated with a lower risk of type 2 diabetes over an extended period of time. The inverse association between cardiorespiratory fitness was present over short and long follow-up periods, and the magnitudes of their associations were similar as well. Their study found that the association between cardiorespiratory fitness and type 2 diabetes was independent from other potential risk factors.

Research by Stuji (2018) found that Dutch health care professionals experience difficulties with physical activity in type 2 diabetes care. The study further elaborates that due to the complex nature of physical activity, two areas of tension were identified: understanding of patient behavior, and professional views on the responsibility of who is responsible for the process of behavior change. There is a discrepancy between health professionals who believe it is the patient's responsibility for increasing physical activity and those who believe it is the professional's responsibility to introduce and encourage physical activity.

The results of a systematic review and meta-analysis by Boyer et al. (2018) found that physical activity provides significant protection from type 2 diabetes for all racial groups except for non-Hispanic blacks. The study suggested that meeting the physical activity recommendations (>150 minutes of physical activity per week) may not be enough to reduce diabetes risk for non-Hispanic blacks without additional weight loss and dietary interventions. This meta-analysis emphasizes the need for further research on how race may impact physical activity and suggests a revision of the CDC's physical activity guide to reflect the amount of physical activity for each racial group.

Exercise is a type of physical activity and typically defined as structured and planned physical activity with a specific goal or purpose in mind. Cai, Li, Zhang, Xu, and Chen (2017) conducted a systematic review that examined the effects of exercise on the quality of life on patients with type 2 diabetes. The systematic review examined four modalities of exercise: aerobic exercise, resistance training, a combination of aerobic exercise and resistance training, and yoga. The results of this systematic review found that aerobic activity produced a significant effect on the quality of life of type 2 diabetes patients between the groups. The resistance training and combined exercise groups displayed mixed results. Some of the resistance training and combined exercise groups did not provide supervised exercise or determined if the participants had completed the training programs. The yoga group displayed positive intervention effects on quality of life, but only one study assessed the effects of yoga. Further research is needed to examine the effects of resistance training, yoga, and similar exercise modalities.

Body Weight

The CDC (2018) measures classify adults as "overweight" or "obese" according to their body mass index (BMI). BMI is an individual's weight in kilograms divided by the square of their height in meters. An overweight BMI is classified as being 25.00kg/m^2 through 29.99kg/m^2 and an obese BMI is classified as 30.00kg/m^2 or greater. Obesity is further subdivided into the following categories: obesity class 1 (BMI of 30.00kg/m^2 – 35.99kg/m^2), obesity class 2 (BMI of 35.00kg/m^2 – 39.99kg/m^2), and obesity class 3 (≥ 40kg/m^2). According to the CDC (2018), 39.8% or 93.3 million adults in the United States are obese. One of the risk factors for type 2 diabetes is being classified as overweight or obese. The NIDDK (2018) lists the following factors that may contribute to obesity: family history and genes, race or ethnicity, age, sex, dietary patterns, physical activity, community, culture, sleep, medical conditions, medication, and stress. The NIDDK (2018) also lists the following as potential health risks due to obesity: type 2 diabetes, high blood pressure, heart disease, stroke, sleep apnea, metabolic syndrome, fatty liver diseases, osteoarthritis, gallbladder diseases, some cancers, kidney diseases, and complications with pregnancy.

A meta-analysis by Zaccardi et al. (2017) aimed to assess the association between the association between BMI with all-cause and cardiovascular mortality in individuals diagnosed with type 2 diabetes. The meta-analysis found that BMI is nonlinearly associated with all-cause mortality and the lowest risk was found in the overweight group. The meta-analysis also found increased risk for all-cause mortality in lower BMI values than in high ones. The lowest risk was found in individuals with a BMI of around 33kg/m^2. The authors note that this may be attributed to cardiorespiratory fitness being a potential modifier in the association between BMI and mortality. Zaccardi et al. (2017) suggested that “fit and fat” phenomenon exists where higher cardiorespiratory fitness reduces the increased mortality risk from BMI. This is supported by a study by Neeland et al. (2015) which found that while visceral adipose tissue, fat tissue located deep within the abdomen and internal organs, was related to increased risk to all-cause mortality, BMI was not. This study noted that increasing muscle mass and physical activity counteracts the negative effects of visceral adipose tissue through fatty acid catabolism and the prevention of insulin resistance. The CDC (2018) noted that due to the fact BMI is a measure of only weight and height, it is common for athletes and individuals with a large of amount of lean muscle mass to fall into the overweight or obese BMI categories. The meta-analysis by Zaccardi et al. (2017) also suggested that other possible confounding variables of the association between BMI and all-cause mortality are glucose lowering drug treatments and smoking which are both negatively correlated with BMI and positively with all-cause mortality.

Diet and Nutrition

Type 2 diabetes is typically characterized as impaired or ineffective use of insulin. Insulin is released by the body in response to glucose to regulate blood sugar levels. The body will usually release more insulin as a response to control glucose levels (CDC, 2018). Type 2 diabetes if left unregulated, may lead to a loss of control and regulation of blood glucose levels, hypoglycemia or hyperglycemia (CDC, 2018). Research by Larkin (2001) had 3234 overweight participants aged 25–85 years old that participated in a lifestyle intervention group with a focus in improving diet, exercise, and behavior modification reduced diabetes risk by 58% and the participants lost 5 – 7% of their bodyweight as well. A longitudinal study by Liu et al. (2017) that found American adults consuming a poor diet were more likely to report having type 2 diabetes than those reporting having an excellent diet. The study suggests dietary improvements such as mainly consuming foods with low energy density and high diet quality is essential in diabetes treatment. This is supported by a study by Aekplakorn et al. (2018) that found the prevalence of diabetes has increased from 7% in 2004 to almost 10% in 2014 in Thailand. The author posits that the increased prevalence may be attributed to multiple factors including unhealthy dietary patterns. The average Thai diet typically consists of a high intake of carbohydrates, sweets, and fat. White rice and sticky rice are staples in the Thai diet and are characterized by a high glycemic index. Aekplakorn et al. (2018) mentions that white rice and its high glycemic index is associated with increased diabetes risk. The authors noted the similarities between the Thai diet and the American diet in the Southeastern United States may have attributed to the increase in diabetes prevalence.

Tobacco Use

There is an increase of 30 – 40% in the likelihood of developing type 2 diabetes in smokers than in nonsmokers. Cigarette and tobacco usage are associated with a higher risk of type 2 diabetes and increases the difficulty of managing the disease (CDC, 2018). In a systematic review and meta-analysis by Akter et al. (2017) it was found that there is an increased risk of type 2 diabetes in smokers in comparison to nonsmokers. Their study estimated that 11.7% of diabetes cases among men and over 2% of diabetes cases among women can be attributed to active smoking due to the casual relationship smoking has with diabetes. There was also a dose-dependent relationship discovered among smokers as well, with diabetes risk increasing by 16% for each increment of 10 cigarettes smoked per day. The meta-analysis also found that there was a 38% greater risk of type 2 diabetes for Japanese men than nonsmoking Japanese men. This is further supported by a study by Teratani et al. (2012) that also found a positive dose-dependent relationship between tobacco consumption and type 2 diabetes risk and this relationship is more pronounced with increased tobacco consumption.

Keith et al. (2016) conducted a contemporary multi-ethnic cohort study that found no independent association between tobacco use and insulin resistance or type 2 diabetes incidence. There was no found association between tobacco use and insulin resistance or type 2 diabetes incidence regardless if the participants were sustained smokers or sustained quitters. It should be noted that that this study measured only tobacco usage but not the amount of tobacco used. The dose-dependent relationship between tobacco usage and type 2 diabetes risk is evidenced in studies such as the one by Teratani et al. (2012) that found a positive dose-dependent relationship between tobacco usage and type 2 diabetes risk. Their study noted this may be due to the impact of tobacco usage on individuals with prediabetes or diabetes where tobacco use increased insulin resistance or glucose dysregulation. The study by Keith et al. (2016) explains the discrepancy in their study and others may be due to adjusting for many potential confounders such as: age, gender, ethnicity, BMI, income, blood pressure, anti-hypertensive medication, high-density lipoprotein and low-density lipoprotein levels, lipid lowering medication, and alcohol use.

Tobacco cessation may come with new challenges such as post-cessation weight gain, new onset obesity, and diabetes. A study by Bush, Lovejoy, Deprey, and Carpenter (2016) mentioned that the weight gain associated with tobacco cessation is largely a product of increased energy intake and reduced energy expenditure. This is attributed to nicotine's effect on the body's central nervous system. Akter et al. (2017) found that passive smoking is associated with a 21 – 28% greater risk of type 2 diabetes. The study found that the risk of type 2 diabetes remained high among those who quit during the initial five years, but the risk decreases steadily during cessation with risk levels compared to nonsmokers after 10 years of tobacco cessation. Bush et al. (2016) concluded that 80 – 90% of smokers gained weight after quitting smoking without a weight management intervention and 10 – 20% of those smokers gained over 10kg of bodyweight.

Alcohol Consumption

Bhargava et al. (2017) stated that chronic heavy consumption or binge drinking of alcohol negatively affects glucose tolerance and insulin resistance. Heavy alcohol consumption may reduce the body's insulin sensitivity and can also increases the chance of becoming overweight. These factors can put one at an increased risk of developing type 2 diabetes. Chronic pancreatitis is typically caused by heavy alcohol consumption and diabetes is a common side effect of this disease. The authors (Bhargava et al., 2017, p. 66) define binge drinking as "a pattern of drinking that brings a person's blood alcohol concentration (BAC) to 0.08 grams percent or above. This typically happens when men consume five or more drinks, and when women consume four or more drinks, in about two hours."

Bhargava et al. (2017) also found that high levels of binge drinking are a risk factor for diabetes. Kerr et al. (2018) stated that there is a significant relationship between alcohol consumption and diabetes risk and there is a reduced risk of diabetes among low and moderate drinkers compared to abstainers or heavy drinkers. Research by Teratani et al. (2012) found a significant negative dose-dependent relationship between alcohol consumption and diabetes risk. The study mentions this relationship may be explained by an improvement in insulin sensitivity. The improvement in insulin sensitivity may be mediated by inhibiting gluconeogenesis, decreasing inflammation, increasing the production of products such as adiponectin which may improve insulin sensitivity, or an increase in the production of insulin by the pancreas.

A meta-analysis by Knott, Bell, and Britton (2015) found reductions in diabetes risk among moderate alcohol drinkers may be limited to only women and non-Asian populations. This meta-analysis found no reduction in diabetes risk in men at any level of alcohol consumption. This is further supported by a study by Kerr et al. (2018) that found increased diabetes risk for women that are either lifetime abstainers and heavy drinkers. The findings of this study also concluded that low to moderate alcohol consumption reduced diabetes risk for overweight white women and that low alcohol consumption reduced risk for overweight white men. Findings in a study by Knott et al. (2018) found that prolonged exposure to high volumes of alcohol consumption may not be related to diabetes risk. This study showed that individuals with diabetes of both sexes consumed alcohol at a lower rate than those who were not diagnosed. The study claimed these disparities in consumption can be explained by a variety of factors such as lifestyle and sociodemographic factors.

A study by Lim, Lee, and Cho (2018) found that higher average alcohol consumption is associated with increased risk of impaired fasting glucose and diabetes in men and impaired fasting glucose in women. This study also found drinkers that consumed 60 or more grams or 2.1 ounces of alcohol daily for men and 40 or more grams or 1.4 ounces for women had a greater risk for impaired fasting blood glucose and men who were high risk drinkers had greater odds for developing diabetes. The CDC’s guidelines for standard drinks of alcohol is equal to 14.0 grams (0.6 ounces) of pure alcohol. This amount of pure alcohol is found in 12 ounces of beer (5% alcohol content). 8 ounces of malt liquor (7% alcohol content). 5 ounces of wine (12% alcohol content). 1.5 ounces or a “shot” of 80 -proof (40% alcohol content) distilled spirits or liquor (e.g., gin, rum, vodka, whiskey) (CDC, 2018). In both men and women, non-high-risk drinkers did not have higher odds of impaired fasting glucose and diabetes compared to high-risk drinkers (Lim et al., 2018). The study found that acute liver damage that is caused by alcohol may cause defects in glucose control. Short-term excessive alcohol consumption can increase appetite and inhibit gluconeogenesis. Long-term excessive alcohol consumption may contribute to fasting blood glucose increasing and lead to an increase in insulin resistance.

Conclusion

Diabetes is a growing epidemic in the United States and across the world. The prevalence of diabetes may differ depending on your: age, race, gender, and socioeconomic status. The use of the following associated factors may have an impact on type 2 diabetes and prediabetes: physical activity, nutrition, body weight, tobacco usage, and alcohol consumption. This literature review analyzed the effects of these associated factors and their relationship with type 2 diabetes. Using the information gained from the literature review, the purpose of this study was to examine prediabetes, type 2 diabetes, and associated factors among adults in the United States using the NHANES.

Chapter III

METHODOLOGY

Introduction

The purpose of this study was to examine prediabetes, type 2 diabetes, and associated factors among adults in the United States using the National Health and Nutrition Examination Survey (NHANES). This chapter provides information on participants and sample collection, instrument and measures, data entry, and data analysis.

Participants

This study used the two-year-round National Health and Nutrition Examination Survey (NHANES 2015–2016) dataset which was drawn from national surveys conducted by the United States National Center for Health Statistics (NCHS). The NHANES datasets are a series of de-identified public use datasets that received National Center for Health Statistics Research Ethics Review Board approval prior to data collection, see Appendix A for details. The NHANES is a series of studies designed to assess the health and nutritional status of adults and young children. The target population for the NHANES studies is the noninstitutionalized civilian resident population of the United States.

There were 15,327 individuals selected from 30 different survey locations for the 2015 – 2016 dataset. Of these selected individuals, 9,971 completed the interview process of whom 9,544 individuals were examined. The study used guidelines established by a study by Liu et al. (2017) that examined data for individuals ≥ 20 years of age. This resulted in a total of 9,426 individuals that fit this criterion. Of this group of individuals selected, 5,719 completed the interview process and 5,474 individuals were examined. The information collected included demographic characteristics such as age, gender, and race.

The 2015 – 2016 NHANES dataset used a complex, multistage probability design to sample the civilian, noninstitutionalized population residing in the 50 states in the United States and The District of Columbia (CDC & National Health Center for Health Statistics [NCHS], 2018). The NHANES dataset followed these steps for their sample selection:

1. Selection of primary sampling units (PSUs), which are counties or small groups of contiguous counties.
2. Selection of segments within PSUs that constitute a block or group of blocks containing a cluster of households.
3. Selection of specific households within segments.
4. Selection of individuals within a household.

The NHANES dataset for 2015 – 2016 also oversampled the following subgroups: Hispanic persons, Non-Hispanic black persons, Non-Hispanic Asian persons, Non-Hispanic white and other persons at or below 185 percent of the Department of Health and Human Services (HHS) poverty guidelines, and Non-Hispanic white and other persons aged 80 years and older. These subgroups are oversampled due to a change in 2011 where the NHANES implemented a sampling design change to oversample non-Hispanic Asians, and the already oversampled Hispanics, non-Hispanic Blacks, older adults, and low income

White/Other subgroups and to provide reliable statistics (CDC & NCHS, 2018).

Instruments

The NHANES is a series of surveys designed to assess the health and nutritional status of adults and children across the United States. The study uses a combination of interviews and physical examinations. The study participants answered questions about their physical activity, nutrition, body weight, tobacco use, socioeconomic status, and alcohol consumption (CDC & NCHS, 2018). NHANES data was processed and collected using an advanced computer system with high-end servers.

Selected Measures

This study used type 2 diabetes and prediabetes as it's independent variables. Analysis was conducted for both variables. The control variables are: age, gender, race, and socioeconomic status. The independent variables are: physical activity, nutrition, body weight, tobacco usage, and alcohol consumption.

Demographics

Demographic variables for this study included: age, gender, and ethnicity/race. Participants were divided into the following racial/ethnic groups: Mexican Americans, Other Hispanic, Asian, Black or African American, White, or Other race. This study divided the age groups into the same categories as the study conducted by Liu et al. (2017). Participants in this study were also divided into age groups of: 20 – 39, 40 – 59, and ≥ 60 years of age (CDC, 2017). In addition, participants were also grouped by gender as either male or female.

Type 2 Diabetes

Participants in the 2015-2016 NHANES were asked "Other than during pregnancy, have you ever been told by a doctor that you had diabetes or sugar diabetes?" Participants were given three categories to identify their diabetes status: yes, no, and borderline. Participants that responded "yes" or "borderline" were grouped together. Due to the 2015 – 2016 NHANES not differentiating between type 1 and type 2 diabetes, the study excluded participants younger than 20 years of age. This exclusion was made due to type 1 diabetes usually being developed and diagnosed in children, teens, and young adults (CDC, 2018). Participants that answered no were also asked if they have been diagnosed with prediabetes. The study also ran an analysis on the question "Have you ever been told by a doctor or other 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?" Participants responded as either having or not having prediabetes.

Socioeconomic Status

In this study, socioeconomic status was measured using the ratio of family income to poverty and education attainment level. The ratio of family income to poverty ratio is a threshold measure that factors both total income and the number of individuals in a family. Ratio of family income to poverty had values ranging from 0.00 through less than 5.00 and greater than or equal to 5.00. Ratio of family income was divided into the following groups: poor (less than 1.00), near poor (1.00 through less than 3.00), and not poor (greater than or equal to 5.00) (Liu et al., 2017). Education level was grouped in four categories: less than 12 years of education (includes 12th grade no diploma), 12 years of education (high school graduate or GED or equivalent), some college or associate degree, and college graduate and above (includes bachelor's degree, master's degree, professional school degree, and doctoral degrees).

Physical Activity and Body Weight

In this study, physical activity was measured using amount of physical activity per week in moderate and vigorous intensities. A variable for moderate physical activity was created using measures from the minutes of daily moderate physical activity during work multiplied by the number of days of moderate physical activity during work for a typical week. Another variable for moderate physical activity was created using measures from the minutes of daily moderate physical activity during leisure multiplied by the number of days of moderate physical activity during leisure for a typical week. Participants were grouped into whether they had met the CDC's (2018) physical activity recommendations of 150 minutes of weekly moderate physical activity. Participants were categorized as either yes or no for meeting this threshold in both work or leisure physical activity. A variable for vigorous physical activity was created using measures from the minutes of daily vigorous physical activity during work multiplied by the number of days of vigorous physical activity during work for a typical week. Another variable for vigorous physical activity was created using measures from the minutes of daily vigorous physical activity during leisure multiplied by the number of days of vigorous physical activity during leisure for a typical week. Participants were grouped into whether they had met the CDC's (2018) physical activity recommendations of 75 minutes of weekly vigorous physical activity. Participants were categorized as either yes or no for meeting this threshold in both work or leisure physical activity.

Body weight was measured using the participant's BMI. BMI is calculated using the participant's weight in kilograms divided by the square of their height in meters (CDC, 2018). Participants were grouped into the following categories according to BMI: underweight (BMI below 18.5kg/m^2), normal weight (18.50kg/m^2 – 24.99kg/m^2), overweight (25.00kg/m^2 – 29.99kg/m^2), obese class 1 (30.00kg/m^2 – 34.99kg/m^2), obese class 2 (35.00kg/m^2 – 39.99kg/m^2), and obese class 3 (≥ 40kg/m^2).

Diet and Nutrition

The nutrition and diet for the participants were self-evaluated. The diet and nutrition of the participants was measured the participant's first and second day total nutrient intake from the dietary interview. Nutrition was measured using total sugar intake. The United States Department of Health and Human Services & United States Department of Agriculture (USDA) (2015) recommends individuals limit sugar intake to ≥ 10% of daily caloric intake. The study used a 2,000 calorie diet to measure if the participants in the study met the recommendation of ≤ 50g of sugar consumed. Participants were grouped into whether they had met this recommendation or not.

Tobacco Usage

In the questionnaire participants were asked if they currently smoke cigarettes. Participants that answered either “every day” or “some days” were grouped as smokers and participants that answered no were grouped as nonsmokers. Tobacco usage for the study’s participants were measured using the number of cigarettes smoked per day during the past thirty days. Participants were regrouped into the following categories: 1 – 10, 11 – 20, and ≥ 21 cigarettes per day. The recoding is supported by a meta-analysis by Akter et al. (2017) that found a dose-dependent relationship discovered among smokers, with diabetes risk increasing by 16% for each increment of 10 cigarettes smoked per day.

Alcohol Consumption

Alcohol consumption for the study’s participants was assessed using if the participant answered either “yes” or “no” when asked if they had consumed at least 12 drinks of alcohol during last 12 months. Participants that responded as having consumed at least 12 drinks of alcohol during the last 12 months were also measured using the average number of alcoholic drinks per day in the past 12 months. Drink is defined in this data as a 12oz. beer, a 5oz. glass of wine, or one and a half ounces of liquor. Participants were grouped as either moderate (1 – 3 drinks) or high risk (≥ 4 drinks) (United States Department of Health and USDA, 2015).

Data Analysis

Using IBM's SPSS Ver. 23 analysis module, the 2015-2016 National Health and Nutrition Examination Survey (NHANES) data was utilized for the current study. The selected dependent variable was whether the participant has ever been diagnosed with non-pregnancy related diabetes. The control variables were age, gender, and race. The selected independent variables were weekly physical activity, daily physical inactivity, diet, socioeconomic status, tobacco usage, alcohol consumption, and body weight. Prevalence estimates were calculated using complex sample crosstabulations. Complex sample logistic regression was used to model the relationship between diabetes, type 2 prediabetes and associated factors: physical inactivity, physical activity, diet, tobacco usage, alcohol consumption, and bodyweight when controlling for age, gender, and race.

CHAPTER IV

RESULTS

Descriptive Statistics

A complex sample crosstabulation analysis was conducted using data from 5,719 adults ≥ 20 years of age who completed questionnaires related to self-reported lifestyle choices and diabetes in the 2015-2016 NHANES questionnaire. The mean age of the study participants was 47.94 (*SD* = 17.76) years of age. The weighted prevalence of type 2 diabetes was 8.3% of adults. Among study participants who reported having type 2 diabetes, 55.1% were male.

Table 1 represents demographic characteristics of participants with type 2 diabetes and prediabetes. This table represents the population percentage of each subgroup in each demographic variable. In addition, diabetes and prediabetes prevalence is also shown for each subgroup in the table. The prevalence of type 2 diabetes increased with age, with type 2 diabetes prevalence being 22.2% (*SE* = 1.70%) for adults aged ≥ 60 years. The prevalence of prediabetes increased with age, with prediabetes prevalence being 14.7% (*SE* = 1.70%) for adults aged ≥ 60 years.

Table 1

Participant Characteristics of Type 2 Diabetes and Prediabetes within Groups of Demographic Variables among Adults in the United States (n = 5,719)

Demographics	**Population** % (*SE*)	**Type 2 Diabetes** % (*SE*)	**Prediabetes** % (*SE*)
Age (years)			
20 - 39	36.20 (1.30)	2.8 (0.4)	4.6 (0.7)
40 - 59	35.9 (1.2)	10.6 (1.1)	13 (0.9)
≥ 60	28 (1.4)	22.2 (1.7)	14.7 (1.7)
Gender			
Male	48.1 (0.6)	12.6 (0.9)	8.6 (0.7)
Female	51.9 (0.6)	9.5 (0.9)	11.4 (0.7)
Race			
Mexican American	8.8 (2.1)	14.7 (2.2)	8.1 (0.8)
Other Hispanic	6.4 (1.3)	11.1 (1.4)	9.3 (1.3)
White	63.9 (3.9)	9.8 (0.7)	10.2 (0.6)
Black	11.3 (2.2)	14.6 (1.3)	9.3 (1)
Asian	5.8 (1.2)	10.7 (1.3)	10.5 (1.3)
Other	3.7 (0.4)	12.9 (2.8)	16.4 (4)
Education			
No high school degree or GED	14.5 (1.7)	16.8 (1.1)	7.7 (1)
High school diploma or GED	20.8 (1.1)	11.2 (1.1)	8.3 (1)
Some college or Associate’s	32.6 (1.4)	11.4 (1.2)	11.1 (1.1)
College Graduate or above	32.2 (2.9)	7.9 (0.9)	11.2 (1.5)
Income Poverty Ratio			
Poor	14.3 (1.4)	14.3 (1.5)	10.6 (2)
Near-poor	37.3 (1.7)	11.6 (1)	8.3 (1)
Non-poor	48.4 (2.7)	9.1 (0.9)	11.9 (0.9)

Associated Factors

Table 2 represents results from the logistic regression analysis that modeled the relationship between type 2 diabetes, prediabetes and associated factors when controlling for age, gender, race, and socioeconomic status. The study found no significant statistical difference between participants with type 2 diabetes and those without type 2 diabetes for the following associated factors: moderate work moderate or vigorous physical activity, underweight BMI, smoke status, smoke 21 or more cigarettes for smokers, and high-risk drinking. When compared to those who were normal weight (4.20%), those who were overweight or obese were more likely to report having type 2 diabetes: overweight (9.60%) *OR* = 2.14 [*95% CI* =1.18, 3.87], obese class 1 (15.70%) *OR* = 4.18 [*95% CI* = 2.46, 7.10], obese class 2 (16.90%) *OR* = 5.02 [95% *CI* = 2.68, 9.40], and obese class 3 (20.8%) *OR* = 7.53 [95% *CI* = 3.67, 15.44].

Additionally, those who smoked 11-20 cigarettes daily (11.40%) were 1.78 [95% *CI* = 1.05, 3.04] times as likely to have type 2 diabetes than those who smoke 1-10 cigarettes daily (7.40%). Those who consumed 51 or more grams of sugar daily (10.20%) were 0.69 [95% *CI* = 0.54, 0.89] times as likely to have type 2 diabetes than those who consume 50 or less grams of sugar daily (14.80%). Those who consumed alcohol (10.30%) were 0.73 [95% *CI* = 0.55, 0.96] times as likely to have type 2 diabetes than those who did not consume alcohol (15.10%).

The study found no significant statistical difference between participants with prediabetes and those without prediabetes for the following associated factors: moderate leisure or vigorous work physical activity, sugar consumption, normal weight BMI, smoking status, number of cigarettes smoked, alcohol consumption, or high-risk drinking status. When compared to those who were normal weight (5.30%), those who were overweight or obese were more likely to report having prediabetes: overweight (9.90%) *OR* = 2.02 [*95% CI* = 1.20, 3.38], obese class 1 (12.60%) *OR* = 2.63 [*95% CI* = 1.49, 4.63], obese class 2 (16.10%) *OR* = 3.59 [95% *CI* = 2.34, 5.51], and obese class 3 (20.00%) *OR* = 4.92 [95% *CI* = 2.57, 9.41]. Those who met the weekly recommendations for moderate intensity work physical activity (8.20%) were 0.655 [95% CI = 0.46, 0.93] times as likely to have prediabetes than those who did not meet the weekly recommendations (13.60%). Those who met the weekly recommendations for vigorous intensity leisure-time physical activity (6.60%) were 0.49 [95% CI = 0.28, 0.88] times as likely to have prediabetes than those who did not meet the weekly recommendations (10.70%).

Table 2

Odds Ratio in Associated Factors for Type 2 Diabetes and Prediabetes

Associated Lifestyle Factors	Type 2 Diabetes *OR (95% CI)*	Prediabetes *OR (95% CI)*
Physical Activity		
Moderate work physical activity		
Type 2 diabetes	0.87 (0.52 – 1.46)	0.66 (0.46 – 0.93)
Non-diabetes	1.00	
Moderate leisure physical activity		
Type 2 diabetes	1.25 (0.69 – 2.28)	0.74 (0.42 – 1.26)
Non-diabetes	1.00	
Vigorous work physical activity		
Type 2 diabetes	0.70 (0.30 – 1.65)	0.80 (0.24 – 2.68)
Non-diabetes	1.00	
Vigorous leisure physical activity		
Type 2 diabetes	0.94 (0.42 – 2.13)	0.49 (0.28 – 0.88)
Non-diabetes	1.00	
Nutrition		
≥ 51g Sugar		
Type 2 diabetes	0.69 (0.54 – 0.89)	0.76 (0.47 – 1.22)
Non-diabetes	1	
Body Weight		
Underweight		
Type 2 diabetes	0.84 (0.17 – 4.24)	0.20 (0.02 – 1.72)
Non-diabetes	1	
Overweight		
Type 2 diabetes	2.14 (1.18 – 3.87)	2.01 (1.20 – 3.38)
Non-diabetes	1	
Obesity Class 1		
Type 2 diabetes	4.18 (2.46 – 7.10)	2.63 (1.49 – 4.63)
Non-diabetes	1	
Obesity Class 2		
Type 2 diabetes	5.02 (2.68 – 9.40)	3.59 (2.34 – 5.51)
Non-diabetes	1	
Obesity Class 3		
Type 2 diabetes	7.53 (3.67 – 15.44)	4.92 (2.57 – 9.40)
Non-diabetes	1	
Smoking		
Smoker		
Type 2 diabetes	0.67 (0.45 – 1.00)	0.72 (0.39 – 1.33)
Non-diabetes	1	
11-20 Cigarettes		
Type 2 diabetes	1.78 (1.05 – 3.04)	0.78 (0.32 – 1.88)
Non-diabetes	1	
21 or more Cigarettes		
Type 2 diabetes	0.51 (0.14 – 1.79)	1.57 (0.40 – 6.19)
Non-diabetes	1	
Alcohol Consumption		
Drinker		
Type 2 diabetes	0.73 (0.55 – 0.96)	1.07 (0.75 – 1.53)
Non-diabetes	1	
High Risk		
Type 2 diabetes	1.06 (0.67 – 1.66)	0.68 (0.41 – 1.13)
Non-diabetes	1	

Note: *OR* = Odds Ratio; *95% CI* = 95% confidence interval

Chapter V

DISCUSSION

This study examined the following research question: When controlling for age, gender, race, and socioeconomic status, what is the relationship between type 2 diabetes, prediabetes, and associated factors: physical activity, nutrition, body weight, tobacco use, and alcohol consumption? This chapter discusses each of these associated factors as well as limitations, future recommendations for research, and a conclusion.

Demographics

The results of the study found that the prevalence of type 2 diabetes increased with age, with type 2 diabetes prevalence being the highest for adults aged ≥ 60 years. This is consistent with data from the *National Diabetes Statistics Report* (CDC, 2017) that found diabetes prevalence increased with age, with 4% of the population between ages 18 – 44 years of age having diabetes, 17% of adults ages 45 – 64, and 25.2% for adults age 65 or older. Males had a higher prevalence of type 2 diabetes than females. Mexican Americans and Blacks had the highest prevalence of type 2 diabetes. This is also consistent with data from the *National Diabetes Statistics Report* (CDC, 2017) which found type 2 diabetes was most prevalent in American Indian/Alaskan Natives, Hispanics, and Blacks. Type 2 diabetes prevalence decreased with educational attainment with college graduates and above having the lowest prevalence. Diabetes prevalence was highest in individuals classed as “poor” and prevalence decreased in individuals considered “near-poor” and “non-poor”.

The results of the study also found that the prevalence of prediabetes increased with age, with prediabetes prevalence being the highest for adults aged ≥ 60 years. Females had a higher prevalence of prediabetes than males. Other races and ethnic groups had the highest prevalence of prediabetes followed by Asians and Whites. Prediabetes prevalence increased with education attainment with prediabetes prevalence being the highest for college graduates and above. Prediabetes prevalence was the highest for “non-poor” participants.

Physical Activity

This study measured if participants met the weekly physical activity recommendations for moderate and vigorous physical established by the CDC (2018). Physical activity for both intensities was measured in either work-related physical activity or leisure-time physical activity. The study found that participants who met the recommended amounts of physical activity for moderate leisure-time physical activity or vigorous work-related physical activity were less likely to report having prediabetes. However, no difference was found between participants with prediabetes and participants without if they met the recommendations for moderate work-related physical activity and vigorous leisure-time physical activity. In addition, the study found no difference between participants with type 2 diabetes and those without type 2 diabetes and whether they met the physical activity recommendations for moderate and vigorous physical activity in either modality.

These findings may be supported by a meta-analysis by Boyer et al. (2018) that concluded that due to the differences found in the protective effects of physical activity on type 2 diabetes risk between different racial and ethnic groups, the CDC's recommendations for physical activity revised to include specific recommendations for different racial and ethnic groups. The physical activity recommendations established by the CDC may not be suitable for all populations and establishing multiple guidelines for different subgroups may result in more effective use of physical activity as a means of type 2 diabetes and prediabetes prevention. In addition, these findings may be supported by research by Bhargava, Chourdhary, Shukla, and Arjaria (2017) found that exercise significantly reduced the risk of developing diabetes and improved insulin sensitivity. The current study found that those who met the recommendations for moderate work-related physical activity and vigorous leisure-time physical activity for less likely to have the risk factor of prediabetes than those who have not met the recommendations.

Nutrition

Participants who exceeded the United States Department of Health and Human Services & USDA's (2015) recommendation of ≤ 50g of sugar consumed daily based on a 2,000 calorie diet were less likely to report having type 2 diabetes than those who consumed ≤ 50g of sugar daily. There was no significant difference in exceeding the daily sugar consumption recommendation for either participants with prediabetes or those without prediabetes. The findings differ from a longitudinal study by Liu et al. (2017) that found American adults consuming a poor diet were more likely to report having type 2 diabetes than those reporting having an excellent diet. It is important to note that their study measured diet using the participant's self-assessment of their diet. The difference in these findings may be attributed to the latter's use of a longitudinal study and the current study being of a cross-sectional nature. The current study is only able to determine association and at the time of the study, individuals with type 2 diabetes may be trying to control their sugar consumption. Due to the longitudinal nature of the study by Liu et al. (2017) they are able to infer more causality due to following participants over a prolonged period of time and being able to notice yearly trends.

Body Weight

This study assessed if BMI is associated with participants having either type 2 diabetes or prediabetes. The study found that when compared to normal weight individuals, those who were overweight or obese class 1 through 3 were more likely to report having type 2 diabetes or prediabetes. No difference was found between participants with prediabetes and those without for participants with an underweight BMI.

The current study differs from a study by Neeland et al. (2015) which found that while visceral adipose tissue, fat tissue located deep within the abdomen and internal organs, was related to increased risk to all-cause mortality, BMI was not. Their study found that increased muscle mass and physical activity counteracts the negative effects of visceral adipose tissue through fatty acid catabolism and the prevention of insulin resistance. Because BMI is only a measure of the ratio between weight and height and not body composition, it is common for athletes and individuals with a large of amount of lean muscle mass to fall into the overweight or obese BMI categories (CDC, 2018). The current study found that BMI is linearly associated with type 2 diabetes and prediabetes with individuals with a BMI classification of obese class 3 having the highest odds of reporting having type 2 diabetes or prediabetes in comparison to normal weight individuals.

Tobacco Usage

The study assessed if smoking and the number of cigarettes smoked are associated with type 2 diabetes and prediabetes. Participants who smoked 11 – 20 cigarettes daily were more likely to report having type 2 diabetes than those who smoked 1 – 10 cigarettes daily. No difference was found for participants with type 2 diabetes and those without type 2 diabetes if they were smokers or not and if they smoked 21 or more cigarettes. No difference was found in participants with prediabetes and those without prediabetes if they were smokers or in the number of cigarettes smoked.

The results for cigarette usage in participants with type 2 diabetes are supported by findings by Akter et al. (2017) that found a dose-dependent relationship with cigarette usage. No significant difference for participants reporting smoking 21 or more cigarettes may be to a smaller sample size (N = 61) compared to 11 – 20 (N = 294) or the 1 – 10 reference group (N = 752). The findings of the current study are also supported by a study by Teratani et al. (2012) which found the relationship between type 2 diabetes is more pronounced with increased tobacco consumption. Their study mentioned this may be due to the impact of tobacco usage on individuals with prediabetes or diabetes where tobacco use increased insulin resistance or glucose dysregulation.

Alcohol Consumption

The study assessed if the consumption of alcohol and high-risk versus moderate risk drinking are associated with type 2 diabetes and prediabetes.

Participants who drank alcohol were less likely to report having type 2 diabetes than those who did not consume alcohol. No difference was found in risk drinking for participants with type 2 diabetes and those without type 2 diabetes. No difference was found in the consumption of alcohol and risk drinking between participants with prediabetes and those without prediabetes.

These findings are supported by a study by Lim et al. (2018) that found in both men and women, non-high-risk drinkers did not have higher odds of impaired fasting glucose and diabetes compared to high-risk drinkers. Kerr et al. (2018) found a reduced risk of diabetes among low and moderate drinkers compared to abstainers or heavy drinkers. The current study found those who reported drinking were less likely to have type 2 diabetes than those who abstained or did not drink alcohol. Findings by Lim et al. (2018) found that long-term excessive alcohol consumption may contribute to fasting blood glucose increasing and lead to an increase in insulin resistance. The authors also found that short-term excessive alcohol consumption can increase appetite and inhibit gluconeogenesis. Due to cross-sectional nature of the current study, it is difficult to assess the effects of long-term high risk drinking and its effects on type 2 diabetes and prediabetes.

Limitations

The study has a number of limitations. Due to the nature of a cross-sectional study, only correlational relationships were assessed and not causal relationships. The NHANES dataset used for the study is limited due to the assumption that the questionnaires were answered honestly and correctly. Due to the self-report nature of the questionnaire, there may be subjective reporting with bias from the interviewer or interviewee. The participants may have relied on memory recall to answer questions rather than using a direct observation (Liu et al., 2017).

Recommendations for Future Studies

Future studies should consider measuring the amount used or consumed for physical activity and sugar consumption in addition to categorizing physical activity by the CDC's (2018) recommendations, and sugar consumption by the dietary guidelines established by the United States Department of Health and USDA, (2015). This will allow future studies to see if any differences exist between meeting the recommendations and the extent to which each associated factor is used. In addition, future studies should also differentiate between prediabetes, type 1, and type 2 diabetes. This will allow future studies to compare prediabetes, type 1 diabetes, type 2 diabetes, and those without diabetes more easily. Future studies should analyze additional variables from the NHANES such as: total caloric intake, carbohydrate consumption, and dietary fiber intake. The addition of these variables will allow researchers to analyze other components of an individual's diet and their association with type 2 diabetes, and prediabetes.

Conclusion

The present study aimed to assess the association between type 2 diabetes, prediabetes, and associated factors. The study found that participants who had a BMI classification of overweight, and obesity classes 1 through 3 were more likely to report having type 2 diabetes or prediabetes than normal weight individuals. Participants who smoked 11 – 20 cigarettes daily were more likely to have type 2 diabetes than those who smoked 1 – 10 cigarettes daily. Participants who reported consuming alcohol were less likely to have type 2 diabetes than those who reported not consuming alcohol. Participants who met the weekly recommendations for moderate work-related or vigorous leisure-time physical activity were less likely to have prediabetes than those who have not met the weekly recommendations. Participants who consumed ≥ 51g of sugar daily were less likely to have type 2 diabetes than those who consumed ≤ 50g sugar daily.

Significance of the Study

This study made significant contributions towards researching the relationship type 2 diabetes and prediabetes, and their relationship with associated factors such as: physical activity, diet, body weight, tobacco usage, and alcohol consumption. The study helped further specify the areas diabetes-based prevention programs should focus on. Diabetes-based prevention programs should increase focus on developing and maintaining healthy weight loss methods and lifestyles for diabetics. Due to the alarmingly fast increase in diabetes across the United states, it is important to target the individuals at risk for type 2 diabetes with diabetes prevention education.

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APPENDICES

APPENDIX A
ETHICS REVIEW BOARD APPROVAL LETTER

Centers for Disease Control and Prevention
CDC 24/7: Saving Lives, Protecting People™

National Health and Nutrition Examination Survey

NCHS Research Ethics Review Board (ERB) Approval*

Survey Name/Date	NCHS IRB/ERB Protocol Number or Description
NHANES 2017-2018	Protocol #2018-01 (Effective beginning October 26, 2017)
	Continuation of Protocol #2011-17 (Effective through October 26, 2017)
NHANES 2015-2016	Continuation of Protocol #2011-17
NHANES 2013-2014	Continuation of Protocol #2011-17
NHANES 2011-2012	Protocol #2011-17
NHANES 2009-2010	Continuation of Protocol #2005-06
NHANES 2007-2008	Continuation of Protocol #2005-06
NHANES 2005-2006	Protocol #2005-06
NHANES 1999-2004	Protocol #98-12
NHANES III	Institutional Review Board (IRB) approval and documented consent was obtained from participants
NHANES II	Underwent internal human subjects review, but IRB approval using current standards was not obtained.
NHANES I	Underwent internal human subjects review, but IRB approval using current standards was not obtained.
NHES	Underwent internal human subjects review, but IRB approval using current standards was not obtained.

* In 2003, the NHANES Institutional Review Board (IRB) changed its name to the NCHS Research Ethics Review Board (ERB).

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