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Validity of Waist-to-height Ratio as a Screening Tool for Type 2 Diabetes Risk in Non-Hispanic Whites, Non-Hispanic Blacks, and Mexican American Adult Women

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Abstract

Validity of waist-to-height ratio as a screening tool for type 2 diabetes risk in non-Hispanic Whites, non-Hispanic Blacks, and Mexican American Adult Women, from the ages 20-65 years of age.

Background:

A prominent screening measure for type 2 diabetes is a simple measure of waist circumference. Waist circumference is an aggregate measurement of the actual amount of total and abdominal fat accumulation and is a crucial correlate of the complexities found among obese and overweight patients. However, waist circumference does not take into consideration the frame of an individual. Hence, recent epidemiologic data have suggested the use of height adjusted waist circumference (waist-to-height ratio). The use of waist-to-height ratio in screening for type 2 diabetes is poorly understood.

Aims:

The aim of this study is to determine racial/ethnic differences in the association of the independent variables waist-to-height ratio and waist circumference, with type 2 diabetes in non-Hispanic Whites, non-Hispanic Blacks, and Mexican American adult women, ages 20-65 years old.

Methods:

Data from the NHANES 2007-2008 surveys were used. Race/ethnic specific odds ratios from univariate and multivariate logistic regression models were to estimate the associations of waist-to-height ratio and waist circumference with type 2 diabetes. In the multivariate models, adjustments were made for age and alcohol use.

Results:

In the univariate models, WC was associated with 1.06, 1.07 and 1.04 increased odds of type 2 diabetes in Mexican Americans, non-Hispanic Whites and non-Hispanic Blacks, respectively. The corresponding values waist-to-height ratio were 2.85, 3.20 and 1.88, respectively. On adjusting for confounders, WC was associated with 1.07, 1.05, and 1.05 increased odds of type 2 diabetes in Mexican Americans, non-Hispanic Whites and non-Hispanic Blacks, respectively. WHtR was associated with 2.95, 2.38, and 2.37 increased odds of type 2 diabetes in Mexican Americans, non-Hispanic Whites and non-Hispanic Blacks, respectively.

Conclusion:

This study indicates that WHtR may be a powerful anthropometric predictor of risk for type 2 diabetes for Mexican American, non-Hispanic White and non-Hispanic Black American women ages 20-65.The literature on WHtR as a screening tool for type 2 diabetes in American women is lacking. This study is one of the first to examine the association between WHtR across varying races of American women. Future researchers should explore populations of women and men in the US with more races represented.

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CHAPTER I
INTRODUCTION

1.1 Background

It has been established by the scientific community that obesity increases the risk for developing type 2 diabetes (Perez & Medina-Gomez, 2011). There is further evidence that distribution patterns of fat are directly related to the risk for developing type 2 diabetes. Fat carried around the abdomen, because of the nearness to visceral organs, has a much stronger association with risk for developing type 2 diabetes than fat carried in other areas (Okosun, Liao, Rotimi, Prewitt, & Cooper, 2000). The exact cause of this is not certain but many theories exist, including the release of harmful substances, such as free fatty acids, which hinder the normal metabolic processes of organs (Ferrannini & Camastra, 1998; Haffner, 1997, 1998; Harris et al., 1998; Okosun, Cooper, Prewitt, & Rotimi, 1999; Wilks et al., 1999).

There are several predictors of body fat. Body mass index (BMI) is used as a predictive tool for populations to predict the proportion of individuals in a population that are overweight. BMI does not tell you where the fat is distributed. The more specific measure of waist circumference (WC) is used to predict the amount of fat carried in the abdomen. Waist-to-hip ratio (WHR) predicts fat carried in two locations, the abdomen and the thighs/buttox region. Waist-to- height ratio (WHtR) assesses the fat carried around the abdomen in comparison to the height of the individual.

There exists a body of research examining abdominal adiposity and increased risk for type 2 diabetes. The past trend was to use the anthropometric measure of WC to predict abdominal adiposity. Then arose the question of the precision of using WC to predict abdominal adiposity of an individual. This variable does not factor in the build of the person being measured. It stands to reason that when comparing two individuals that are both physically fit, a person of short stature will have a smaller WC than a much taller person. The variance of WC along the height gradient could cause two problems for a study defining abdominal adiposity using the WC measure. The first problem is that a person of short stature with a significant amount of abdominal adiposity could fall below the WC cut offs for risk. Their measurement could be a healthy one for a person of average height, but in proportion to their stature it could be an indicator of risk for disease. The second problem is that individuals who are much taller and have a much wider breadth to their body could be classified as at risk when in reality they do not have enough abdominal adiposity to be at risk for disease. These arguments also hold true against a measurement of WHR which does not account for the stature of a person.

It is known by the medical community that abdominal adiposity is a major factor in the development of type 2 diabetes, whereas fat distributed elsewhere does not have the same affect on the metabolic processes (Okosun et al., 2000). This would imply that a measurement of WC, WHR, or WHtR would be superior to a simple measure of BMI to predict an outcome of type 2 diabetes. Despite the differences in health outcomes that abdominal adiposity and fat distributed elsewhere cause, the existing body of research does not point to one clear conclusion as to which anthropometric measure is superior in predicting type 2 diabetes. A comprehensive analysis of research on the predictive abilities of BMI, WC, WHR, and WHtR and type 2 diabetes yields varying results. A meta-analysis was conducted of research spanning the years 1966-2004 that examines the anthropometric measures BMI, WC, and WHR and their association with type 2 diabetes. A total of 32 research cases were assessed and results showed that BMI, WC, and WHR all have similar associations with type 2 diabetes (Vazquez, Duval, Jacobs, &

Silventoinen, 2007). Some believe that the similarity between BMI and WC could be due to the fact that they have a strong correlation between them with r~0.8. However, WHR does not have a strong correlation with BMI, having an r~0.4 (Vazquez, et al., 2007).

There is research that points to WC as the better predictor of risk associated with type 2 diabetes. A cross-sectional study conducted of both men and women in the Netherlands found that WC is superior to other anthropometric methods of predicting risk associated with type 2 diabetes (Grievink, Alberts, O'Niel, & Gerstenbluth, 2004).

Further research shows that WHR gives the best results for predicting the risk of type 2 diabetes. One such study is limited to women aged 55-69 years (Kaye, Folsom, Sprafka, Prineas, & Wallace, 1991). A second study showing WHR as the best predictor of risk for type 2 diabetes was limited to adult men in Tehran (Hadaegh et al., 2009).

Perhaps the great variance in results from study to study stems from an inherent problem the anthropometric measures have. WC and WHR do not take into account the overall build of a person’s frame. The answer to the dilemma presented by using WC and WHR to predict risk for type 2 diabetes is to factor in height. Thus a new wave of research has begun where WHtR is replacing WC and WHR along with the prediction that WHtR will be a more accurate tool than WC or WHR as a predictor of disease risk.

The current body of research on WHtR as a predictor of type 2 diabetes is not comprehensive. The findings thus far point to WHtR as the better predictor of type 2 diabetes, however the research is not inclusive enough. A study was done of men in Tehran comparing WHtR, BMI, WC, and WHR as predictors of type 2 diabetes. The study was adjusted for age, hypertension, smoking, and family history. Relative risk of developing diabetes was computed for each variable. ROC curves were employed to determine the predictive power of each anthropometric measurement. The area under the ROC curve is the probability that a classifier will rank a randomly chosen positive instance higher than a negative one. Through use of the ROC curve the study determined that WHtR was best for predicting central obesity (Hadaegh, Zabetian, Harati, & Azizi, 2006).

A study was conducted with results that diverged from those seen in the previously mentioned studies. The study was of men and women 35 years of age and older that measured BMI, WHR, WC, and WHtR as predictors for impaired glucose tolerance (IGT is a symptom/predecessor of diabetes) and type 2 diabetes. The study found that WHtR was the best predictor of IGT while WC was the best predictor of type 2 diabetes (Lopatynski, Mardarowicz, & Szczesniak, 2003).

A prospective study was done on a sample of women residents of Tehran, and controlled for age and socioeconomic status. The subjects were non-diabetic at baseline and followed for a median duration of 3.6 years. WC, BMI, WHR, and WHtR were recorded. The study adjusted for age, family history of diabetes, hypertension, HDL-C, and TG. Logistic regression analyses were completed and ROC curves used to compare the predictive power of each anthropometric variable. WHtR had the largest area under the ROC curve indicating the best predictive power of risk for developing type 2 diabetes. WC, WHR, and BMI were found to be equal in power to predict type 2 diabetes. One interesting fact this study found was that when weight was restricted to overweight and obese subjects that only BMI was found to have the superior predictive power (Hadaegh et al., 2009). The results of this study are supported by another study done of Chinese adults. 61,703 adults were followed for a median of 2 years. The ROC curve was employed to differentiate predictive power of BMI, WC, WHR, and WHtR. The study found WHtR to be the most powerful predictor of type 2 diabetes. The results found were similar for both genders (Jia et al., 2011).

Three cross-sectional studies were analyzed in order to investigate which anthropometric measure is the better predictor of type 2 diabetes across varying populations. The populations examined were Mexican-Americans and non-Hispanic Whites living in San Antonio Texas, residents of Mexico City, and residents of Spain. The population was men and women 35-64 years of age. The ROC curve was used to determine the most powerful predictor. WHtR had the largest area under the curve, but there was only statistical significance for Mexican women, Mexican-American women, and Spanish women. The study concluded that WC was likely a good predictor of type 2 diabetes for men, but for women WHtR was the most powerful predictor (Lorenzo et al., 2007). A study conducted in Taiwan, determined similar results as Lorenzo et. al (2007) finding that WHtR was a better indicator for predicting cardiovascular risk factors than WC, WHR, and BMI. The WHtR was found to be a better predictor for women as predicting the risk of hypertension, diabetes, or dyslipidemia (Lin et al., 2002).

Yet another study further supported the establishment of WHtR as the better anthropometric predictor of cardiovascular risk. A cross-sectional, clinical-epidemiological study was performed on 5,377 subjects. The population was men and women, ages 20-79, in Germany. BMI, WC, hip circumference, WHR, and WHtR were all examined as anthropometric measures for the prediction of metabolic syndrome, dyslipidemia, and type 2 diabetes. The results showed a much larger area under the ROC curve for WHtR for all risk conditions in the female population, and for type 2 diabetes and dyslipidemia in men (Schneider et al., 2007).

1.2 Research questions and hypothesis

Upon reviewing the existing body of literature on WHtR as a predictor of type 2 diabetes, there exists an obvious gap in information. There is no study performed in the US that investigates the power of WHtR as a predictor of type 2 diabetes for a population of women. There is also no study that investigates the power of WHtR as a predictor of type 2 diabetes for different races of women. I propose to fill this gap in information by examining the validity of waist-to-height ratio as a screening tool for type 2 diabetes risk in non-Hispanic Whites, non-Hispanic Blacks, and Mexican American women. The hypothesis of this study is that WHtR is better than WC as an anthropometric tool for predicting risk associated with type 2 diabetes in American women, ages 20-65. The study will investigate whether WHtR varies in predicting abilities across the population groups of non-Hispanic Whites, non-Hispanic Blacks, and Mexican American adult women.

CHAPTER II
REVIEW OF THE LITERATURE

2.1 The Burden of Diabetes in the US

The US currently faces a diabetes crisis. The US population is just over 300 million (US Census Bureau, 2011) and over 23 million Americans have diabetes (US Department of Health and Human Services, 2008). 23.5 million or 10.7 % of Americans 20 years and over have diabetes. Of American women 20 years of age and older, 11.5 million, or 10.2% have diabetes (Centers for Disease Control and Prevention, 2008). The US population of those 65 years of age and older suffer from heightened risk for type 2 diabetes and have a 26.9% prevalence within their population. The progression of the diabetes crisis in America is happening at an alarming speed. The CDC reported that from 1980 through 2008 the number of Americans with diabetes more than tripled, increasing from 5.6 to 18.1 million by the year 2008 (CDC, 2011).

If the rate of diabetes continues with it's aggressive climb not only is the quality and duration of life for many Americans threatened, but the pockets of the players in healthcare are going to have a proverbial hole burned into them. The National Institute of Health (NIH) gives a current quote on how much healthcare is spending on diabetes in the US as a whopping $174 billion per year. This includes the direct medical costs estimated at $116 billion, and the indirect costs of $58 billion. Indirect costs include such things as disability pay, work loss, and early death. These statistics come from the NIH's last official report on Diabetes statistics in 2007. Since 2007 it is likely that these numbers have become bigger (NDIC, 2011). These numbers, once adjusted for population age and sex differences, show that without diabetes medical costs would be 2.3 times less what they currently are (American Diabetes Association, 2011).

The focus of this study is on Type 2 diabetes. The reason for the focus is because type 2 diabetes accounts for 90 to 95 percent of diagnosed diabetes cases (NDIC, 2011). Type 2 diabetes is also preventable in most cases, therefore a great target for Public Health interventions.

2.2 Epidemiology of Type 2 Diabetes

Type 2 diabetes, also known as adult-onset diabetes, is a chronic disease consistently ranking in the top ten leading causes of death in the US. Diabetes currently ranks seventh (NDIC, 2011). Diabetes is a disorder in which cells do not utilize insulin properly. Insulin triggers the uptake of glucose from the bloodstream into the cell. If insulin is not utilized properly excessively high levels of glucose build up in the bloodstream. Glucose serves as one of the primary sources of energy for the body, and the primary source of energy for the brain. Most energy in the body is created by first consuming carbohydrates, which are then broken down into several components, one of which is glucose. Through a series of physiological processes glucose is oxidized into ATP, the currency of energy. Glucose not only serves as fuel for the body but is vital in the production of proteins and in the metabolization of lipids. If glucose remains in the bloodstream and is not taken into the cell, it cannot serve as energy.

Insulin is secreted by the pancreas. The secretion of insulin triggers the uptake of glucose into the cell, which is then used for energy. Diabetes is characterized by either the body’s inability to produce enough insulin, or insensitivity of the cell to receiving insulin. When there is a shortage or insensitivity to insulin, glucose builds up in the bloodstream leading to many adverse health effects. Of the many adverse health effects, the main threats are heart disease, blindness, kidney failure, and amputations of the lower limbs.

Whether or not the body is unable to produce insulin, or whether the body is insensitive to insulin defines the variance between types of diabetes. There are two main types of diabetes. Type 1 diabetes only accounts for 5% of diagnosed cases and is characterized by the inability of the body to produce insulin. This is usually diagnosed in the early years of life. There is no known prevention or cure for type 1 diabetes.

Type 2 diabetes accounts for 90-95% of diagnosed cases and is characterized by cells in the body being unreceptive towards insulin and eventually the decreased production of insulin by the pancreas (Hu et al., 1999). There is scientific evidence that type 2 diabetes is preventable and reversible and will be discussed later.

The third type of diabetes is gestational diabetes which only occurs during pregnancy and can lead to severe pregnancy complications. It is diagnosed in 2-10% of pregnancies and lasts the duration of the pregnancy (NDIC, 2011). Because type 2 diabetes accounts for the majority of diagnosed cases, it would seem to make sense from a public health perspective to focus efforts on type 2 diabetes to alleviate the problem the US faces.

2.3 Risk Factors for Diabetes

The risk factors for developing diabetes include obesity, physical inactivity, older age, family history, a history of gestational diabetes, race/ethnicity, and impaired glucose tolerance (IGT). One of the most commonly known risk factors associated with developing type 2 diabetes is overweight/obesity. This risk factor is one that can be screened for at home by doing a simple calculation of BMI. In addition to being an easy screening tool, overweight is also a risk factor that is reversible, making it a prime target for type 2 diabetes intervention measures. 79 percent of adults in the US that have type 2 diabetes have a BMI that is overweight or obese (Stagnitti, 2001). The measurement of BMI is obtained by dividing a person's weight in kilograms by the square of their height in meters. An overweight BMI is considered to be from 25 to 29.9, obese is 30 and above.

There is not one direct path of causation between obesity and diabetes but there exists a strong relationship between obesity and insulin resistance (Ferannini & Camastra, 1998; Haffner, 1997; Harris et al., 1998; Okosun et al., 1999; Wilks et al., 1999). Obesity can hinder the production and use of insulin in the body and thus increase the risk for diabetes. More specifically, fat carried around the abdomen increases the risk for diabetes at a higher proportion than overall fat (Okosun et al., 2000).

Diabetes is grouped into a cluster of metabolic syndromes that is referred to commonly in literature as Multiple Metabolic Syndrome (MMS). A person is characterized as having MMS if they have two or more of the metabolic conditions, including hyperinsulinemia, glucose intolerance, hypertension, hypertriglyceridemia, high levels of low-density lipoprotein (LDL-C) and low levels of high density cholesterol (HDL-C). Overall, MMS affects the ability of the body to regulate all internal functions. MMS has been associated with an increased risk for type 2 diabetes via insulin resistance. Although the relationship between abdominal fat and insulin resistance has been established, the mechanism by which it occurs remains unclear. One proposed mechanism suggests that the abdominal fat releases an excessive amount of free fatty acids into the surrounding body systems. In addition to free fatty acids, the abdominal fat causes elevated levels of free testosterone and reduced sex-hormone-binding-globulin. These factors all contribute to a decreased uptake of insulin into the cell (Okosun, et al., 2000).

From a public health perspective abdominal adiposity is a great screening tool to predict risk for diabetes because it is assessed by measuring waist circumference (WC), waist-to-hip ratio (WHR), or waist-to-height-ratio (WHtR). Although this is not a measure of whether or not an individual has diabetes, it does tell of whether a person carries an excessive amount of fat in their abdomen. This is economical and can be performed by most people at home. The current body of scientific literature recognizes a waist circumference ≥ 102cm for men, and ≥88cm for women as the cutoff for risk of developing a disease associated with MMS (Okosun, et al., 2000).

Although WC has been helpful thus far in medicine research for predicting adverse health effects due to excess fat around the abdomen, it is not a full-proof method of assessing a person's risk. A woman that is six foot tall that shares the same WC as a woman who is five foot three inches is likely to have a completely different body frame, therefore making the WC measure an inaccurate tool. The amount of fat located around the abdomen of the two women with the same WC could be significantly different, enough to invalidate the measure of risk. In theory, a larger framed woman could screen positive for a risk she does not have, because the breadth of her frame is larger than the average population. A smaller framed woman could screen negative because relative to the population she has a small WC, but in proportion to her body, she has excessive abdominal fat. For this reason it is necessary for the scientific community to propose a better tool to measure the risk for adverse health effects associated with abdominal adiposity. It only seems rational to include height as a variable to account for significant differences in body frame. Because of this I am proposing that a measurement of waist-to-height ratio replace the current trend of exclusively measuring the WC or WHR.

Physical activity plays a significant role in the prevention and control of type 2 diabetes. Physical activity has the power to help prevent type 2 diabetes from developing. Once type 2 diabetes has developed, physical activity has the power to help control insulin sensitivity. Physical inactivity substantially increases the risk for developing type 2 diabetes and conversely, physical activity has been shown to protect against and reverse the risk for type 2 diabetes (Hu et al., 1999; Hu et al., 2001; Li, Colditz, Willett, & Manson, 2003). Low physical activity levels have been found to be an indicator of increased risk of mortality in type 2 diabetes patients (Sigal, Kenny, Wasserman, & Castaneda-Sceppa, 2004).

Lifestyle intervention trials amongst a population of individuals with IGT have shown that ~150 minutes of physical activity per week plus attention to diet resulted in a 58% reduced risk in developing type 2 diabetes (Hu et al., 2001; Hu, et al., 1999). Studies have been conducted that stratified physical activity and diet as risk factors for type 2 diabetes, and the results showed that amongst IGT individuals both physical activity and diet were equally effective in reducing risk for type 2 diabetes (Sigal, et al., 2004).

It is never too late to experience the benefits of the power of physical activity to fight type 2 diabetes. As we learned earlier that obesity increases the risk for type 2 diabetes, the obvious deduction is that physical activity will indirectly reduce the risk for type 2 diabetes by preventing overweight or obesity. Most people who are consistently physically active throughout their life will not be significantly overweight, guarding against type 2 diabetes. The effect of physical activity on weight is only a small part of the role it plays in the fight against type 2 diabetes. In individuals who are already diagnosed with type 2 diabetes, physical activity can be a regulator for glycemic control, independent of weight loss. Studies have shown that patients that participated in a structured exercise program experienced glycemic control regardless of whether they lost weight or not (Boule, 2002; Sigal, et al., 2004).

When clinical trials are conducted with type 2 diabetes patients to observe the effects of exercise on insulin sensitivity, the average amount of physical activity used is three times per week. The intensity and duration of exercise is directly related to the period of time an individual's insulin sensitivity is regulated. The effects of exercise on insulin sensitivity generally last 24-72 hours after a single aerobic workout session. Because insulin sensitivity is not usually regulated past 72 hours, it is highly recommended that an individual should not go more than two days without physical activity (Wallberg-Henriksson, Rincon, & Zierath, 1998; Boule, 2002). There is evidence that people presenting with IGT can reverse the risk of progression to type 2 diabetes with moderate weight loss through physical activity (Tuomilehtoet al., 2001; Ratner, 2002).

The elderly in the US experience a significantly greater burden of type 2 diabetes than the younger population, having a rate of 27% in those 65 years and older (Abbatecola, Evans, & Paolisso, 2009; NDIC, 2011; Diabetes Basics, 2011). In 2010 the NDIC reported that of the population in the United States 65 years of age and older 26.9% have diabetes. Contrast this to 11.3% of the population that is 20 years of age and older.

Gestational Diabetes Mellitus (GDM) is an intolerance for carbohydrates that mimics type 2 diabetes and affects 7% of all pregnancies. GDM appears first during pregnancy and ends with the termination of the pregnancy. Although GDM ends with pregnancy it increases the risk for development of type 2 diabetes by a factor of at least seven. Women who have had GDM have a reported 35-60% chance of developing type 2 diabetes 10-20 years after the birth of their child and 5-10% are diagnosed as having type 2 diabetes immediately following pregnancy (NDIC, 2011). GDM has a higher incidence in African Americans, Hispanic Americans, and American Indians. Not only does GDM affect the pregnant woman but it affects the child, increasing the child's risk for developing type 2 diabetes later in life (Clausen, Mathiesen, Hansen, Pedersen, Jensen, Lauenborg, & Damm, 2008; Bellamy, Casas, Hingorani, & Williams, 2009; Ben-Haroush, Yogev, & Hod, 2004).

Type 2 diabetes is not an equal opportunist when it comes to striking different ethnicities. Those racial populations that experience a greater risk for diabetes include

African American, Hispanic/Latino Americans, American Indians, and some Asian Americans and Pacific Islanders. A national survey for those diagnosed with diabetes from 2007-2009 reported a prevalence of Whites 7.1%, 8.4% Asian Americans, 12.6% blacks, 11.8% Hispanics (Diabetes Basics, 2011). The American Diabetes Association currently estimates the percent of American Indians and Alaska Natives to have the highest age-adjusted prevalence of diabetes in the US, at an astonishing 17% (In My Community, 2011; Diabetes Basics, 2011).

These facts have been reinforced by many studies on the US population, however the statistics vary when BMI is controlled for. For example, a 20 year prospective study was done on women investigating the variance in risk for developing type 2 diabetes attributable to ethnicity. The study reported risk ratio's (RR's) calculated using Whites as the comparison. The study showed that once BMI is controlled for, the order of increased risk for type 2 diabetes amongst different ethnicities changes. Without controlling for BMI those who experience the greatest risk are Blacks, followed by Hispanics, Asian Americans, and last Whites. Once BMI is controlled for the order changes to those at greatest risk being Asian Americans, followed by Hispanics, Blacks, and last Whites. The study concluded that Asians experience particularly detrimental results from weight gain, more than the other races.

A 20 year prospective study was done on women to study the variance in risk for developing type 2 diabetes attributable to ethnicity. The study was conducted within the years 1980-2000. Dietary and lifestyle factors were controlled for. Age-adjusted relative risks were calculated using Whites as the comparison. The RR's were found to be 1.43% for Asians, 1.76% for Hispanics, and 2.18% for blacks. After these RR's were calculated, BMI was controlled for and these numbers changed to 2.26 for Asians, 1.86 for Hispanics, and 1.34 for blacks. The study concluded that Hispanics, blacks, and Asians all experience significantly higher risk of developing type 2 diabetes, with and without controlling for BMI. After adjusting for BMI, the study concluded, as did the previous study, that Asians experience heavier consequences from weight gain, more than the other races.

A diagnosis of type 2 diabetes is not a death sentence. In fact, unlike many chronic diseases, diabetes is reversible through diet and exercise. Because of this, type 2 diabetes is an excellent target for public health interventions. Literature shows that not only does physical activity and healthy eating prevent diabetes, but it can reverse diabetes at a rate of around 60%. Patients followed prospectively over several years who maintained a more active lifestyle than control groups, and maintained a healthier way of eating experienced a 58 percent lower incidence of type 2 diabetes (Tuomilehto, Lindstrom, Eriksson, Valle, Hamalainen, Ilanne-Parikka,…Uusitupa, 2001; Diabetes Prevention Research Group, 2002).

2.4 Waist-to-height Ratio as a Screening Tool

The purpose of this study was to identify an economical screening tool for type 2 diabetes to be used in a population of women in the US, varying in race. Screening tools are one of the fundamentals of public health because they empower the general population with the knowledge required for them to be proactive in fighting disease. Because type 2 diabetes ranks as the seventh leading cause of death in the US, the public health community must make it a top priority for developing screening tools that are low enough in cost to be used by all SES strata. WHtR is a screening tool for type 2 diabetes that fits this description perfectly. The measurement can be performed at home using only a tape measure and a simple division calculation. Division does not require anything above an elementary school education. If the ratio is calculated to be .59 or higher the individual is at risk for developing type 2 diabetes and should seek out a physician for biological tests to diagnose type 2 diabetes. Even if the diagnosis is not positive for type 2 diabetes the individual can use their WHtR score to alter their diet and exercise to prevent future development of type 2 diabetes. The purpose of this study is to examine the power of WHtR to predict type 2 diabetes specifically within the population of women, and across varying races in the US.

Chapter III
METHODOLOGY

3.1 Data Source

The data for this study was taken from the National Health and Nutrition Examination Survey 2007-2008. This is a survey conducted by The National Center for Health Statistics (NCHS) of the Centers for Disease Control and Prevention (CDC). The survey is a multi-stage survey including interviews, examinations, and laboratory tests. The data from the survey is made available to researchers for analyses on the CDC website. NHANES is meant to be representative of the civilian, non-institutionalized, 2 months of age and older, population of the United States. The first three NHANES surveys were conducted periodically and spanned 6 years per survey. The data from each survey was released as a single, multi-year data set. Since 1999 format was switched from periodic to a continuous, annual survey. The continuous surveys are released as data sets every two years. The survey used for this study was continuous, thus the span of 2007-2008. The downside of the continuous surveys is that they have a smaller sample size than the previous surveys.

The sample design for NHANES 2007-2008 begins with identifying Primary Sampling Units (PSU) within the sampling frame. The sampling frame consisted of all US counties. The PSUs are usually chosen as single counties, or if the population within one county is not adequate in size the PSU may extend beyond one county into another to better represent the population. Within the counties, clusters of homes are selected, each person within the home is screened for demographics and one or more person is chosen from each household. For NHANES 2007-2008, the sample population was 12,943, the interviewed sample was 10,149, and the examined sample was 9,762. Of this sample the female population was 6,426, the interviewed female sample was 5,053, and the examined female population was 4,849. For the purposes of this study the population was restricted to those females between the ages of 20-65, thus the sample of females for this study had a sample size of n=2264. Once this was restricted to race the sample size decreased to n=2170.

NHANES survey has historically over sampled low income individuals, adolescents, elderly, Blacks, and Mexican Americans. This is in order to conduct more accurate analyses of these groups. In 2007 NHANES began oversampling all Hispanic persons, not just Mexican Americans and stopped oversampling adolescents. The NCHS reports that the sampling of non-Mexican American Hispanics from 2005-2008 was not adequate enough to produce accurate results. The NCHS suggests that this population not be used for data analyses between 2005-2008. For this reason, the Hispanic population chosen for this study was limited to Mexican Americans. The NHANES 2007-2008 study population of females in this study consisted of 453, or 20.9% Mexican Americans, 508 or 23.4% non-Hispanic blacks, and 916 or 42.2% non-Hispanic whites.

NHANES is a widely used data source for analyses because of the standards upheld throughout the survey process. The NCHS recognizes that in an effort to minimize error in the sampling process and in the taking of measurements, that strict standards must be enforced. The NHANES program creates in depth protocols that are reviewed by the scientific and public health community before the survey is administered. All of the NHANES staff is trained before data collection, and there is periodical refresher training that occurs throughout the data collection process. NHANES has a rigorous quality control system which ensures all components of data collection are meeting protocol standards.

Despite all of the strict measures taken to create an accurate data set, there is always a certain measure of error in such a survey. NHANES has limitations including, sampling and non-sampling errors, this could include error in measurement. Much of the data collected for NHANES comes from an interview in which the data is based upon self-reporting. Participants may have recall problems, miscomprehension of the survey questions, misreporting, and many other possible deviations from fact. The examination and laboratory features of the NHANES survey are subject to measurement error and error due to difference in technique of staff members. This type of error is minimized through the implementation of strict protocol. Each variable that NHANES collects data for has a specific procedural guideline that all staff are trained to implement. This unfortunately does not exclude all possibility for error.

3.2 Definition of Terms

The variables in this study included age, race, alcohol use, waist circumference, standing height, waist-to-height-ratio, and diabetes. Age was measured in years at the time of screening. Candidates available for this study ranged between 20-65 years of age and 2264 participants qualified. Participants were limited to this age range because type 2 diabetes is manifested more often beyond the adolescent years. If ages 20 and younger were included in the data analysis it would be more likely that the participant would have type 1 diabetes, also called juvenile diabetes, because of the nature of the disease. The age was restricted to people no older than 65 years of age because the elderly experience a greatly increased risk for type 2 diabetes (NDIC, 2011). The reason for excluding this age group from the study was to examine the relationship between anthropometric measures and type 2 diabetes without clouding the results with a high risk population.

Race was categorized into three groups including Mexican American, non-Hispanic black, and non-Hispanic white. Participants were categorized based upon checking a box of the race that they identified themselves as. 2170 participants qualified for this study based upon race. The reason the Hispanic sample was limited to those that were Mexican American was because the sampling of non-Mexican American Hispanics was not adequate enough for the years 2005-2008 in order to achieve accurate results (NCHS). In addition to the non-Mexican American Hispanics, the race category of “other” was excluded. This category would not have been helpful to this study because the goal was to identify association of anthropometric measures and type 2 diabetes according to a specific race.

Alcohol use was self-reported as having had 12 or more drinks within the past year. 2014 of the participants reported their alcohol use, for the remaining participants the alcohol use data was missing. Alcohol was included as a control variable because of the role it may play in association with development of type 2 diabetes (Kim, Chu, Kim, & Moon, 2011; Shanmugam, Mallikarjuna, & Reddy, 2011).

Waist circumference was measured by removing clothing from the waist, crossing the participant's arms and placing hands on opposite shoulders. A horizontal line is drawn just above the uppermost border of the ilium and the examiner places a steel measuring tape around the waist at this point. A second examiner checks the accuracy of positioning of the measuring tape. The waist circumference is measured to the nearest 0.1 cm after the participant has exhaled breath. There was waist circumference data available for 2,106 participants.

Standing height was measured using a stadiometer with a fixed vertical board and a headpiece. The participant stands straight against the backboard with body weight evenly distributed across both feet. Heels are together and toes are apart. The angle between the toes should be approximately 60^{o}. The back of the head, shoulder blades, buttocks, and heels should be against the backboard. Standing height is measured to the nearest 0.1 cm. There were 2,180 participants with data recorded for standing height.

Waist-to-height ratio was determined by taking waist circumference in cm divided by standing height in cm. This was limited to the number of participants with a waist circumference measurement at 2,106 participants. Diabetes was defined as the participant ever having been told by a physician that they had diabetes. 2,235 participants had data for this variable. Cut-off values for WHtR with respect to risk for type 2 diabetes have not been firmly established, but have been researched and published in peer-reviewed journals to be around 0.59 (Mansour & Al-Jazairi, 2007; Can et al., 2010).

3.3 Statistical Methods

SPSS for Windows 2010 was used for all analyses in this study. The data was normalized as shown in Table 1. Frequencies of diagnosis of type 2 diabetes by race are shown in Table 2. A Oneway ANOVA was used to compare mean values of the continuous variables age, WC, height, and WHtR across race/ethnicity (Table 3). The Tukey post hoc test was used to predict which group was different at 0.05 level of probability (Table 3). A Crosstab evaluation was used to determine the percent values for the categorical variables, alcohol use, diabetes, WC groups, and WHtR groups (Table 4). The Chi-square test was used to determine the significance of the categorical percentages at the 0.05 level of probability (Table 4). Multiple univariate binary logistic regression analyses were performed for each racial group with diabetes as the dependent variable and age, WC, WHtR, and alcohol use as the independent variables (Table 5). A multivariate binary logistic regression analysis was run to determine the relationship between WC and risk associated with type 2 diabetes controlling for age, alcohol, and race (Table 6). A second multivariate binary logistic regression analysis was run to examine the association between WHtR and risk for type 2 diabetes controlling for age, alcohol, and race (Table 7). All of the independent variables were continuous variables except for alcohol use which was categorical and coded as 0=less than 12 drinks in the past year, and 1=12 drinks or more in the past year. Diabetes was the dependent variable and was categorical. Diabetes was coded as 0=never been previously diagnosed as having diabetes, and 1=previous diagnosis of diabetes. The statistical measure of association for the binary logistic regression analyses was the Odds Ratio (OR). 95% CI were used to determine statistical significance. A 95% CI that did not cross 1 was considered to be statistically significant.

Chapter IV
RESULTS

4.1 Population Statistics

Descriptive statistics for the overall population are presented in Tables 1 and 2. There were 2,264 women in the data set, of which 1,851 qualified for the race categories used in the study. There were 449 Mexican Americans, 901 non-Hispanic Whites, 501 non-Hispanic Blacks. Looking at the entire population, diabetic women were older, had larger waist circumferences, were shorter in stature, and had a higher WHtR. 43.8% of type 2 diabetic women used alcohol and 57.8% of all non-type 2 diabetic women used alcohol.

The means of the population were compared with the population split by race/ethnicity (Table 3). Upon comparison of the means, White and black women were older ($p<.01$), and taller than Mexican American women ($p<.001$). Black women had larger WC's than white and Mexican American women ($p<.001$). Black and Mexican American women had higher WHtR's than white women ($p<.001$) (Table 3). A Crosstabs evaluation was used to determine frequencies within the population, split by race/ethnicity (Table 4). There were more white women that were alcohol users, next were Mexican Americans, and following shortly were black women. White women had the lowest percentage of diabetes, next were Mexican American women, and lastly black women had almost three times the percentage of diabetes as did white women (Table 4).

4.2 Univariate and Multivariate Analyses

A univariate analysis was conducted using the binary logistic regression model (Table 5). This was done in an effort to predict the relationship between each independent variable and the dependent variable, diabetes, according to race. Age was found to be independently associated with an increased risk for diabetes across all three races. For every increase of one year in age the risk for diabetes increased by 10, 3, and 8 percent for Mexican, white, and black American women. WC was found to be independently associated with an increased risk for diabetes across all three races. For every .1 increase in WC the risk for diabetes increased by 6, 7, and 4 percent for Mexican, white, and black American women. WHtR was found to be independently associated with an increased risk for diabetes across all three races. For every .1 increase in ratio the risk for diabetes increased by 185, 142, and 88 percent for Mexican, white, and black American women. Alcohol was only found to be statistically significant in association with risk for diabetes in white women. White American women experience a protective effect from alcohol use with a decrease in risk for diabetes by 69 percent.

A multivariate analysis was conducted using the binary logistic regression model to determine whether WC was associated with a risk for type 2 diabetes, controlling for age, alcohol use, and stratified by race (Table 6). WC was found to be independently associated with an increased risk for diabetes across all three races. Mexican Americans experienced the greatest association between WC and diabetes. For every .1 cm increase in ratio, there was an increase in risk associated with type 2 diabetes by 7 percent. Non-Hispanic Whites had the second highest association between WC and diabetes. For every .1 cm increase in ratio, the risk associated with type 2 diabetes increased by 5.2 percent.

Non-Hispanic Blacks had an association very close to non-Hispanic Blacks, with an increase in risk associated with type 2 diabetes by 5.1 percent for every .1cm increase in WC. These three associations for WC and risk for diabetes are similar across all three races. Age was also found to be associated with increased risk for diabetes across all races. For each one year increase of age, there was a 7 percent increase in risk associated with type 2 diabetes for all races. Alcohol use was not significantly associated with risk for diabetes. Race was only found to be significantly associated with diabetes for non-Hispanic Blacks and non-Hispanic Whites. The non-Hispanic Black population had the greatest association between race and diabetes with an increase of risk for type 2 diabetes by 63 percent compared to the other two races in the study. Non-Hispanic Whites experienced a protective affect of race for risk associated with diabetes of 47 percent when compared to the other two races in the study.

A multivariate analysis was conducted using the binary logistic regression model to determine whether WHtR was associated with a risk for type 2 diabetes, controlling for age, alcohol use, and stratified by race (Table 7). WHtR was found to be independently associated with an increased risk for type 2 diabetes across all three races. Mexican Americans experienced the greatest association between WHtR and diabetes. For every .1cm increase in ratio, there was a 195 percent increase in risk associated with type 2 diabetes. Non-Hispanic Whites had the second highest association between WHtR and diabetes. For every .1cm increase in ratio, the risk associated with type 2 diabetes in non-Hispanic Whites increased by 138 percent. Non-Hispanic Blacks had an association very close to non-Hispanic Whites, with an increase in risk associated with type 2 diabetes of 137 percent for every .1cm increase in WHtR. Age was also found to be associated with increased risk for diabetes across all races. For each one year increase of age, there was a one-fold increased risk for diabetes for all races. Alcohol use was not significantly associated with risk for diabetes. Race was only found to be significantly associated with risk for type 2 diabetes for non-Hispanic Blacks and non-Hispanic Whites. The non-Hispanic Black population had the greatest association between race and diabetes with an 80 percent increase in risk associated with type 2 diabetes compared to the other two races in the study. Non-Hispanic Whites experienced a protective affect for risk associated with type 2 diabetes by 39 percent when compared to the other two races in the study.

Chapter V
DISCUSSION AND CONCLUSION

5.1 Aim

The main purpose of this investigation was to provide evidence that WHtR is a powerful predictor of type 2 diabetes for a population of American women. One area of focus was the comparison of WHtR with WC in predictive powers for risk of diabetes. A second area of focus was the investigation of whether there exists a difference in the association between WHtR and risk for developing type 2 diabetes across races. The races examined were non-Hispanic Black, non-Hispanic White, and Mexican American.

5.2 A Comparison of WC and WHtR in Predictive Power

Upon examination of the analyses, it was evident that the predictive abilities of WHtR and WC were not the same. The two anthropometric measures produced OR’s, associated with risk for developing type 2 diabetes, that were different from one another. This would imply that WC and WHtR are not interchangeable in predictive abilities of risk associated with type 2 diabetes. This aligned with the theoretical framework behind the study, being that the measures of WC and WHtR are not interchangeable in assessing risk for type 2 diabetes. The body of literature that exists, comparing WHtR against other anthropometric measures such as WC supports the finding that WHtR and WC differ in predictive powers for type 2 diabetes. Most of the literature confirms that WHtR is the more powerful predictor of type 2 diabetes when compared to WC (Hadaegh, Shafiee, & Azizi, 2009; Hadaegh, et al., 2006; Jia, et al., 2011; Lin, et al., 2002; Lorenzo, et al., 2007; Schneider, et al., 2007). Only one conflicting study was found, and it was not entirely conflicting. The study was conducted on men and women 35 years of age and older and found that WHtR was the best anthropometric measure for predicting IGT and WC was the best anthropometric measure for predicting type 2 diabetes (Lopatynski, et al., 2003). The reason for this discrepancy is unclear especially because WHtR was found to be the best predictor of risk for IGT. Type 2 diabetes is characterized by an intolerance for glucose and IGT could be described as a minor form of type 2 diabetes. In other words, WHtR is the most powerful anthropometric measure to predict one of the main symptoms of type 2 diabetes. There is no known rationale that explains why WC was found to be a better predictor of diagnosed type 2 diabetes.

The univariate analyses demonstrated the greater predictive value of WHtR when compared to WC as a screening tool for risk of developing diabetes. This held true for all three races of women. Mexican American women had the highest prediction for risk by WHtR at 185 percent vs. the 6 percent increase in risk predicted by WC. Next were White women at 142 percent vs. 7 percent increase in risk predicted by WC. Last were Black women at 88 percent vs. 4 percent increase in risk predicted by WC. These greater percentages in prediction of risk for type 2 diabetes associated with WHtR confirm the hypothesis that WHtR is indeed a better predictor of risk than WC. These numbers however, are not adjusted for confounding factors and therefore the results of the multivariate analysis must be analyzed in order to gain a more accurate assessment of predictive powers of the two anthropometric measures.

The multivariate analysis revealed that once confounders were adjusted for, WC was significantly associated with an increase in risk for type 2 diabetes by 7, 5, and 5 percent for Mexican Americans, Whites, and Blacks respectively. For every .1 increase in WC Mexican American adult women experience an increase in risk associated with type 2 diabetes by 7 percent. For every .1 cm increase in WC White and Black American adult women experience an increase in risk associated with type 2 diabetes by 5 percent. WHtR was significantly associated with an increase in risk for type 2 diabetes by 195, 138, and 137 percent in Mexican Americans, Whites, and Blacks respectively. For every .1 cm increase in WHtR, Mexican American women experience a 195 percent increase in risk associated with type 2 diabetes. For every .1 cm increase in WHtR White American adult women experience a 138 percent increase in risk associated with type 2 diabetes. For every .1 cm increase in WHtR Black American adult women experience a 137 percent increase in risk associated with type 2 diabetes. The OR's for WHtR and association with risk for type 2 diabetes are much greater than for WC across Mexican, White, and Black American adult women. This indicates that WHtR is a better predictor of risk associated with type 2 diabetes. This supports the hypothesis that WHtR will be a better predictor of risk associated with type 2 diabetes when compared to WC.

5.3 WHtR Across Race

There is not a great body of literature available to confirm that the power of WHtR to predict risk for type 2 diabetes varies across race. There is one study, however, that confirms a variance of predictive abilities across different races but disagrees with how WHtR varies (Lorenzo, et al., 2007). The study specifically contradicts the results of the multivariate analysis of WHtR. Non-Hispanic White women were found to not have any significant prediction of risk for type 2 diabetes by WHtR. The study does however support the finding that Mexican American women experience a significant prediction of risk for type 2 diabetes by WHtR.

Lorenzo et al. (2007) conducted a three-part cross sectional study that used populations in San Antonio, Texas, Mexico City, Mexico, and Spain. Within the San Antonio population only Mexican American and non-Hispanic White women were included. The participants in Mexico City and Spain were not categorized by race.

The study found that WHtR was the better anthropometric measure, when compared to WC, of risk for type 2 diabetes only for Mexican, Mexican American, and Spanish women. The study conducted by Lorenzo et al. (2007) has several apparent flaws in selection of populations for comparison. The restriction of American women to only Mexican Americans and non-Hispanic Whites living in San Antonio Texas would seem to not be a fair representation of the overall population of women in the US. Because of this I believe the results for the American women studied cannot be compared to this study. More specifically, conclusions for the non-Hispanic White American population of women should not be drawn from the study by Lorenzo et al. (2007) and applied to the overall population of women in the US. The population used for this study was sampled using strict statistical measures to ensure an accurate representation of the US population.

This study found that the predictive abilities of WHtR for risk associated with type 2 diabetes are almost the same for White and Black American adult women. Mexican American adult women had slightly higher risk predicted by WHtR for risk associated with type 2 diabetes. In other words, Mexican American women experience a greater amount of risk associated with type 2 diabetes as their WHtR increases, when compared to White and Black American adult women. There is no literature on similar populations with which to compare these findings to.

This study is the first to examine WHtR as an anthropometric measure of risk for type 2 diabetes across non-Hispanic Black, non-Hispanic White, and Mexican American women. Because of this there is no reference literature with which to compare the results specific to race within a population of American women. There are however studies that support the finding that WHtR is indeed a better predictor of type 2 diabetes than WC within populations of women worldwide including Tehran, China, Spain, Taiwan, and Germany (Hadaegh, Shafiee, et al., 2009; Jia, et al., 2011; Lin, et al., 2002; Schneider, et al., 2007).

5.4 Implications for Public Health

The results of this study have great implications for improvements in public health. WHtR is a screening tool that is affordable to all SES strata. The only equipment needed is a simple tape measure, which is a staple in most American homes, and can be bought for a small cost. There is no need for a visit to a physician, the tool can be used to assess risk for type 2 diabetes from the comfort of home. This eliminates any issues a person may have with poor access to healthcare. The mathematical calculation is a simple division problem, a skill that is learned in elementary school.

The job of public health professionals is to educate the American population on how to perform the proper measurements of waist circumference and height, provide the equation for obtaining the ratio, and to provide the appropriate cutoffs for risk. This is something that could be incorporated into health class in school, broadcasted as television and radio commercials, implemented into physicians' practices as part of the standard physical. It is not a lofty goal to attempt to disseminate the use of WHtR as a screening tool for type 2 diabetes across the nation.

With the knowledge of the WHtR screening tool for type 2 diabetes, the hope that this study projects is that the American population can pay closer attention to what amount of abdominal fat is safe, and what amount can possibly kill you. Knowledge is power and if Americans were to take this knowledge and alter diet and physical activity to stay below risk for type 2 diabetes then maybe diabetes would drop from it's leading position as the 7th highest cause of death in the US. The payoff of the tool could help alleviate the financial burden diabetes places on the US government. The measure of WHtR is economically sound, with virtually no cost for the screening tool, and a modest budget for education purposes. If there were to be a great reduction in type 2 diabetes because of the WHtR screening tool the 174 billion dollar annual expense for diabetes in the US could potentially be reduced.

5.5 Strengths and Limitations

The strengths of this study are founded on the credibility of the NHANES III data set. The NHANES III is a survey conducted by the CDC, employing rigid protocol throughout data collection. The sampling is representative of the national population US women.

Limitations of this study include non-response to the survey. Previous research has shown that NHANES III does not have a significant amount of bias due to non-response (Landis, Lepkowski, Eklund, & Stehouwer, 1982). One of the greatest obstacles encountered during this study was missing values for variables that were desired. For example, family history of diabetes could not be used as a control variable because the value was missing for all diabetic participants. This is likely due to survey design. Other variables that are known risk factors for diabetes were also excluded, including BMI, triglycerides, HDL, LDL, hypertension, smoking, and physical activity. It is possible that these variables have an effect on the association between WHtR and diabetes across varying races of women. Although alcohol use was included as a control variable, the definition of having 12 or more drinks within the last 12 months does not give great detail on the actual drinking patterns of the participants and therefore may not adequately reflect risk associated with diabetes.

5.6 Recommendations

There is still a great lack of literature on WHtR as a screening tool for type 2 diabetes. Future researchers should explore populations of women and men in the US with more races represented. Currently, much of the research has been conducted outside of the US and therefore cannot be accurately applied to the US population.

5.7 Conclusion

In conclusion, the measure of WHtR was significantly associated with risk for type 2 diabetes in Mexican, non-Hispanic Black, and non-Hispanic White American women (ages 20-65). For every .1 increase in WHtR Mexican, non-Hispanic Black, and non-Hispanic White American adult women experience increases in risk associated with type 2 diabetes of 195, 138, and 137 percent respectively. As WHtR increases Mexican American adult women experience a disproportionate increase in risk associated with type 2 diabetes. White and Black American adult women experience similar increases in risk associated with type 2 diabetes as WHtR increasese. When comparing the anthropometric measures of WC and WHtR, it is evident through this study that WHtR is overall a stronger indicator of risk for type 2 diabetes.

This information should be utilized by the Public Health community to disseminate the anthropometric tool of WHtR across the nation as a powerful indicator of risk for type 2 diabetes. Mexican American adult women need to be educated on the disproportional risk they experience from a high WHtR in comparison with White and Black American adult women. Until further research sheds light on the association between WHtR and type 2 diabetes across varying races, all races of women should use the tool. Women should calculate their WHtR and alter their diet and exercise to target abdominal adiposity as it is a known risk factor for type 2 diabetes.

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Appendix 1

Table 1. Descriptive statistics for the NHANES 2007-2008 population of women (ages 20-65) split by diagnosis of type 2 diabetes.

Variable	Type 2 Diabetic $\bar{x}$ ± (SD)	Non-type 2 Diabetic $\bar{x}$ ± (SD)
Age(years)	53.22 ± (10.263)	41.8 ± (13.088)
Waist Circumference(cm)	110.86 ± (16.58)	94.88 ± (16.07)
Height(cm)	159.62 ± (7.53)	161.65 ± (7.18)
Waist-to-height ratio	.6931 ± (.09)	.5876 ± (.09)

Data with ± Standard Deviation values are mean values.

Table 2. Racial characteristics of the NHANES 2007-2008 population of women (ages 20-65) split by diagnosis of type 2 diabetes.

Variable	Type 2 Diabetic (%*)	Non-type 2 Diabetic (%**)
Mexican American	21.3	21.0
Non-Hispanic White	28.0	43.6
Non-Hispanic Black	37.0	21.9
All races/ethnicities	13.7	13.6
Total sample size n=2,143		

*Percentage is defined as the percent of the total population of those diagnosed with type 2 diabetes, n=211. **Percentage is defined as the percent of the total population of those not previously diagnosed with type 2 diabetes, n=1932

Table 3. Oneway ANOVA comparison of the means of the NHANES 2007-2008 population of women (ages 20-65) split by race.

Variable	All races $\bar{x}$ ± (SD)	Mexican American $\bar{x}$ ± (SD)	White $\bar{x}$ ± (SD)	Black $\bar{x}$ ± (SD)	P-values
Age (years)	43.07 ± 13.3	41.4 ± 13.3[b]	43.6 ± 12.8[a]	43.6 ± 13.6[a]	.007
Waist circumference (cm)	97.1 ± 17	97.4 ± 14.7[a]	95.0 ± 17.0[a]	100.6 ± 18.4[b]	< .001
Standing height (cm)	162.1 ± 7.2	156.5 ± 6.3[b]	163.9 ± 6.5[a]	163.7 ± 6.5[a]	< .001
Waist-to-height ratio	.59 ± .1	.62 ± .1[a]	.58 ± .1[b]	.61 ± .1[a]	< .001

The means of continuous variables were compared using Oneway ANOVA. The continuous values with superscript differ from each other according to Tukey at the 0.05 level of probability.

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Table 4. Evaluation of eligible population ofNHANES 2007-2008women (ages 20-65) stratified by race.

Variable	All races	Mexican American	White	Black	P-values
Alcohol use	64.7	59.7	71.3	57.2	< .001
Diabetes	9.8	10.0	6.5	15.6	< .001
Waist circumference groups					< .001
<77 cm	10.8	6.7	14.6	7.6	
78-87 cm	20.3	18.7	21.6	19.4	
88-97 cm	22.7	26.7	22.8	19.2	
>98 cm	46.2	47.9	40.9	53.8	
Waist-to-height ratio groups					< .001
<0.50	20.4	9.9	27.5	17.0	
0.51-0.55	15.2	12.3	17.6	3.5	
0.56-0.61	20.7	24.8	19.2	19.8	
>0.62	43.8	53.1	35.7	49.8	

The percent values for the categorical variables were determined using a Crosstab evaluation. The Chi-square test was used to determine the significance of the categorical percentages at the 0.05 level of probability.

Table 5. Univariate odds ratio associated with type 2 diabetes in the White, Black, and Mexican American NHANES 2007-2008 population of women (ages 20-65).

Variable	Mexican American			White			Black		
		95% CI for OR			95% CI for OR			95% CI for OR	
	OR	Lower	Upper	OR	Lower	Upper	OR	Lower	Upper
Age	1.10	1.07	1.14	1.06	1.03	1.08	1.08	1.08	1.11
Waist circumference	1.06	1.04	1.09	1.07	1.05	1.09	1.04	1.02	1.05
Waist-to-height ratio	2.85	1.98	4.10	3.20	2.42	4.24	1.88	1.49	2.38
Alcohol use	.64	.33	1.24	.54	.31	.95	.64	.38	1.05

OR signifies odds ratio from the univariate analysis using the binary logistic regression model. Diabetes was defined as previously diagnosed by a physician. WC was defined as the measure of the individual’s natural waist in cm. WHtR was defined as a person’s waist in cm divided by their height in cm. Alcohol use was defined as having had 12 or more drinks in the past year.

Table 6. Multivariate odds ratio associated with WC and type 2 diabetes in the White, Black, and Mexican American NHANES 2007-2008 population of women (ages 20-65).

	Mexican American			**White**			**Black**		
Variable	OR	SE	Significance	OR	SE	Significance	OR	SE	Significance
Alcohol	.80	.22	.294	.83	.17	.282	.79	.17	.173
Age	1.07	.01	< .001	1.07	.01	< .001	1.07	.01	< .001
WC	1.07	.01	< .001	1.05	.01	< .001	1.05	.01	< .001
Race*	1.55	.23	.053	.53	.18	.001	1.63	.18	.007

*Race values are for the race specified in the column compared against the other two races in the study. OR = odds ratio from the binary logistic regression model. The OR's were computed with a 95% confidence interval. Diabetes was defined as having been diagnosed with diabetes by a physician. Alcohol use was defined as having had 12 or more drinks within the past 12 months. WC defined as a person's waist.

Table 7. Multivariate odds ratio associated with WHtR and type 2 diabetes in the White, Black, and Mexican American NHANES 2007-2008 population of women (ages 20-65).

	Mexican American			White			Black		
Variable	OR	SE	Significance	OR	SE	Significance	OR	SE	Significance
Alcohol	.83	.22	.376	.85	.17	.328	.82	.17	.254
Age	1.06	.01	< .001	1.07	.01	< .001	1.07	.01	< .001
WHtR	2.95	.11	< .001	2.38	.08	< .001	2.37	.08	< .001
Race*	1.19	.23	.457	.61	.18	.008	1.80	.18	.001

*Race values are for the race specified in the column compared against the other two races in the study. OR = odds ratio from the binary logistic regression model. The OR's were computed with a 95% confidence interval. Diabetes was defined as having been diagnosed with diabetes by a physician. Alcohol use was defined as having had 12 or more drinks within the past 12 months. WHtR defined as a person's waist in cm divided by their height in cm.