Introduction

Prevalence of prediabetes and Type 2 diabetes is rapidly increasing in the United States, and has reached epidemic levels. Currently, 30.3 million adults, or 1/10 of the population, in the U.S. are classified as diabetic, and it has been estimated that this incidence will increase to 1/5 of U.S. adults by 2025 [1]. Currently, 86 million adults in the United States are classified as prediabetic, and approximately 90% of those adults are unaware of their condition [1,2]. Since complications due to diabetes are a top cause of death in the United States, reducing the risk of developing either of these conditions is prudent. The overall relationship between obesity and increased risk for developing prediabetes and Type 2 diabetes has been well established. Risk factors related to overweight and obesity include having a BMI ≥ 25 kg/m² (overweight) or ≥ 30 kg/m² (obese) or possessing excess central body fat deposition. It is well established that elevated waist circumference increases the risk of Type 2 diabetes by greater than two-fold [3]. Other risk factors for diabetes include physical inactivity, immediate relatives with Type 2 diabetes, being of African American, Alaska native, American Indian, Asian American, Hispanic/Latino, or Pacific Island American ethnicities, previous diagnosis of gestational diabetes, high blood pressure, HDL cholesterol levels below 35 mg/dL, triglyceride levels above 250 mg/dL, diagnosis of Polycystic Ovarian Syndrome or cardiovascular disease [4].

Abstract

It is well known that overall obesity and excess central adiposity is associated with an increased risk of developing prediabetes and Type 2 diabetes. Because diabetes is found in epidemic proportions and complications related to it are a leading cause of death in the United States, it is important to develop a full understanding of the risk factors and their reduction with lifestyle education. BMI is a common indicator used for risk factor assessment with those being overweight or obese having the highest risk. Similarly, those possessing an elevated waist circumference increase risk. Recent data from the National Diabetes Statistics Report suggest that approximately 12.5% of those diagnosed with diabetes are of a normal body mass index (BMI<25 kg/m²). Little is known if normal or slightly overweight individuals classified by BMI have a waist circumference that can predict insulin resistance, prediabetes, or risk of developing Type 2 diabetes. Therefore the purpose of this study was to examine if there is a relationship between waist and hip measurements and the risk for developing Type 2 diabetes in non-obese persons.

Keywords: Type 2 Diabetes; Body mass index; Overweight; Obese; Waist circumference; Fasting plasma glucose

Abbreviations: BMI: Body Mass Index; WC: Waist Circumference; HC: Hip Circumference; W:HR: Waist-to-Hip Ratio; FBG: Fasting Blood Glucose; WHO: World Health Organization
Utilization of Waist Circumference to Determine Type 2 Diabetes Risk among Normal and Overweight Populations

diabetes in normal weight persons are not abundant. The purpose of this study was to determine if there is a relationship between waist and hip measurements and the risk for developing Type 2 diabetes in non-obese persons.

Materials and Methods

Subjects

All subjects were between the ages of 18 and 50 years, not diagnosed with chronic disease, free of unresolved medical conditions, and weight stable in the past 3 months (+/- 3 kg). Individuals that were underweight (BMI < 18.5 kg/m\(^2\)), obese (BMI > 30 kg/m\(^2\)), pregnant, or have recently lactated (past 6 months) were excluded. Written Consent was obtained from all subjects prior to participation. This study was approved by the University Institutional Review Board.

Anthropometric assessment

Participants wore lightweight clothing, and no shoes. Height was measured using a stadiometer to the nearest 0.1 cm. Weight was measured using an in body scale to the nearest 0.01 kg. Waist circumference (WC) and hip circumference (HC) were measured using a steel measuring tape following WHO guidelines [7]. Waist circumference was measured just above the uppermost lateral border of the right ilium, and hip circumference was measured at the maximum protuberance of the buttocks. BMI was calculated as weight (kg) divided by height squared (m\(^2\)), and waist to hip ratio (W: HR) was calculated as waist circumference (cm) divided by hip circumference (cm).

Laboratory assessment

Fasting blood glucose (FBG) was measured following an overnight (8-12 hour) fast. The blood sample was expressed using Acti-Lance® Lite sterile lancet, following cleaning of the fingertip using an alcohol wipe. Blood glucose was measured with Bayer Contour-Next Blood Glucose meter and test strips. Blood glucose meter was calibrated per manufacturer instructions prior to each measurement.

Statistical analysis

Statistical Analysis was performed using Prism (version 7.0d). Linear regression models were used to determine regression coefficients of WC, BMI, and W: HR for the prediction of FBG. Pearson’s correlation was used to assess the relationship between fasting blood glucose and each WC, BMI, and W: HR. P values less than 0.05 indicate statistical significance [8].

Results

A total of 31 adults participated in the study. Of the 31 adults, 8 were male, and 23 were female. Similarly, 8 participants were overweight (25 kg/m\(^2\) ≤ BMI < 30 kg/m\(^2\)) and 23 were normal weight (18.5 kg/m\(^2\) ≤ BMI <25 kg/m\(^2\)). No subjects were obese. Because of the lack of difference between the normal weight and overweight individuals, data are presented as one study population group (BMI of 18.5-29.9 kg/m\(^2\)). The mean and standard deviations of age, weight, height, BMI, WC, HC, W: HR, and FBG are presented in Table 1. Statistical analysis showed that measures of WC, BMI, and W: HR was not significantly correlated with FBG in the population sampled. Pearson’s correlation coefficients of FBG with WC, BMI, and W: HR is shown in Table 2.

Discussion

There are a few limitations within this study that could cause the lack of statistical significance. First of all, this pilot
Investigation included a small sample size. In the future larger sample sizes should be used to allow the separate analyses of men versus women, different age groups, and normal weight and overweight. Second, a majority of the participants were at least moderately active according to the classification in the Federal Physical Activity Guidelines [9]. Since physical activity is an intervention known to improve FPG, future studies in this population should include an analysis of those who are sedentary.

**Conclusion**

Overall, we conclude that neither WC, nor W: HR, are suitable risk determinants for Type 2 diabetes in the physically active, healthy, young adult population. Individuals with other risk factors for developing prediabetes or Type 2 diabetes should receive the education necessary to induce lifestyle changes aimed at reducing their risk. In the future, larger sample sizes, or physically inactive participants, should be examined to determine waist circumference and Type 2 diabetes risk in the normal weight population.

**Acknowledgement**

This material is supported by the National Institutes of Health program, Nevada INBRE. A special thank you to Jessica Knurick for the encouragement to pursue this endeavor, as well as her guidance. Thank you to Grace MacDonald and the UNLV exercise physiology lab for providing a space to perform data collection, as well as Meagan Levitt and Anna Gingrich for data collection assistance.

**Conflict of Interest**

No conflict of interest exists.

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