Assessing the Association Between Physical Activity and Prediabetes Using the National Health and Nutrition Examination Survey 2007-2014

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A Thesis Presented

By

MABELINE VELEZ

Submitted to the Graduate School of University of Massachusetts Amherst in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

May 2019

Department of Public Health

ASSESSING THE ASSOCIATION BETWEEN PHYSICAL ACTIVITY AND PREDIABETES USING THE NATIONAL HEALTH AND NUTRITION EXAMINATION SURVEY 2007-2014

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Approved by:

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Nicole VanKim, Chair

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Lisa Chasan-Taber, Member

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Paula Stamps, Graduate Program Director
Division of Biostatistics and Epidemiology

DEDICATION

To God, who has been my strength and refuge at all times and to my mom who moved heaven and earth to make me the woman I am today.

ACKNOWLEDGMENTS

I would like to thank my advisor, Nicole Vankim for her guidance and advice throughout this process. Additionally, I am very grateful to member of my committee, Lisa Chasan-Taber for her guidance and suggestions during the writing process.

I want to thank the National Health and Nutritional and Examination Survey for the use of their database for this project.

Lastly, a very special thanks to Kathleen Szegda, Frank Robinson and Peter Blain from Baystate Health for their continue support and always seeing the potential in me. Also, to all my family and friends who were there for me every step of the way, thank you!

ABSTRACT

ASSESSING THE ASSOCIATION BETWEEN PHYSICAL ACTIVITY AND PREDIABETES USING THE NATIONAL HEALTH AND NUTRITION EXAMINATION SURVEY 2007-2014

MAY 2019

MABELINE VELEZ B.A., WESTERN NEW ENGLAND UNIVERSITY

M.S. UNIVERSITY OF MASSACHUSSETTS AMHERST

Directed by: Professor Nicole VanKim

Prediabetes, a condition in which glucose levels are higher than normal but not high enough to be diagnosed as type 2 diabetes, affects approximately 37% of adults in the United States and is a major public health concern. Extensive research has evaluated the association between physical activity (PA) and type 2 diabetes; however, few studies have examined the association between PA and prediabetes. Therefore, we evaluated the association between PA (including leisure time, occupational and total) and prediabetes status among adults, stratified by gender, using multinomial logistic regression models fit to serial cross-sectional 2007-2014 National Health and Nutrition Examination Survey data. After adjusting for age, race, body mass index, smoking status, family history of hypertension and education, results suggest that the association between leisure time [moderate PA: 0.98 (95% CI: 0.80–1.21); tertile 3: 1.05 (95% CI: 0.75–1.49)] and total PA [tertile 1: 1.15, (95% CI: 0.96–1.38); tertile 2: 1.00, (95% CI: 0.79–1.27); tertile 3: 0.96, (0.77–1.20)] and undiagnosed prediabetes and was not statistically significant among women. However, compared to women who engaged in no occupational PA, engaging in the highest tertile was statistically significantly associated with lower odds of undiagnosed prediabetes [tertile 3: 0.75, (95% CI: 0.58–0.97)].

Compared to men who engaged in no leisure time PA, men engaging in the highest tertile of leisure time PA had a statistically significant lower odds of undiagnosed prediabetes [Tertile 3: 0.79, (0.65–0.98)]. Compared to men who did not engage in any PA, men engaging in any PA did not have a statistically significant decrease in odds of undiagnosed prediabetes [tertile 1: 0.90, (0.71–1.16); Tertile 2: 0.93, (0.74–1.18); Tertile 3: 0.99, (0.80–1.21)]. Overall, our results show that for both men and women, there was a general lack of association between leisure-time, occupational, and total physical activity and prediabetes status in adjusted analyses.

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CHAPTER 1

INTRODUCTION

The incidence of type 2 diabetes has increased in the United States and worldwide, and, because of this, there has also been an increase in prediabetes.[1] Prediabetes is a condition in which glucose levels are above normal, yet not high enough to be diagnosed as type 2 diabetes.[2] The National Diabetes Statistic Report (2017) estimates that in the United States, 33.9% of adults had prediabetes.[3] Despite the high prevalence, only 11.6% of adults with prediabetes were originally diagnosed by a medical provider.[3] The prevalence of prediabetes based on data from 2011–2014 indicates that prediabetes is higher in adult men (36.6%) as compared to adult women (29.3%).[3]

Type 2 diabetes is a condition that affects the quality of life, often decreasing life expectancy.[4] The burden of prediabetes comes with an increased risk of comorbidities associated with diabetes, such as cardiovascular disease, physical disability and death.[5–7] Prediabetes is an important predictor of type 2 diabetes; individuals who have prediabetes are twenty times more likely to be diagnosed with type 2 diabetes within five years.[5]

Evidence suggests that physical activity is important in regulating glucose levels among individuals who have prediabetes.[8–11] Therefore, the American Diabetes Association, the United States Physical Activity Guidelines as well as the World Health Organization recommends that individuals should engage in a total of 150 minutes of weekly moderate to vigorous physical activity.[12,13] The American Diabetes Association recommends physical activity and does not differentiate between occupational physical activity and leisure-time physical activity. Findings from the Centers of Disease Control Prevention Morbidity and Mortality Weekly Report (2011) using data from the 2007 Behavioral Risk Factor Surveillance Survey (BRFSS) suggest that after adding occupational physical activity, the total number of people meeting physical activity guidelines increased from 64.5% to 70.8%.[14] However, men were more likely to follow the physical activity guidelines compared to women. Therefore, it is important to understand if occupational physical activity has the same benefits as leisure-time physical activity.

There are several biological, social and lifestyle predictors associated with an increased risk of developing prediabetes. Biological risk factors include predictors such as sex and family history. Studies suggest that men are more likely to developed diabetes compared to women.[15] Additionally, individuals with a family history of diabetes are at higher risk of developing it. Biological risk factors also include a history of hypertension.[16] Various literature have suggested that social factors such as income, race/ethnicity and education are positively associated with prediabetes.[4,17,18] Other predictors that have been associated with prediabetes includes modifiable-lifestyle risk factors such as being overweight or obese, smoking status and poor diet.[19] In addition, lack of physical activity is a risk factor that had been associated with the development of diabetes.

Studies to date have focused on the association between leisure-time physical activity and prediabetes.[5,8,9,20,21] Findings from cross-sectional studies and randomized control trials suggest that engaging in moderate to vigorous level of leisure-time physical activity has a protective effect compared to individuals who engage in none to very little physical activity.[5,8,9,20,21] However, few studies have evaluated the association between occupational physical activity and diabetes, and these studies have mixed findings.[22–24] For example, a prospective study conducted by Hu et al. found that there was a statistically significant inverse association between occupational physical activity and diabetes.[23] However, two other prospective studies found no association between occupational physical activity and diabetes.[22,24]

Gender is a strong predictor for prediabetes and the onset of diabetes—where men are at greater risk compared to women.[25] Although men have greater skeletal muscle mass compared to women, who have greater adipose mass,[26] the prevalence of prediabetes is higher in men when compared to women.[3] Skeletal muscle has a vital role in glucose uptake, therefore, a greater skeletal muscle mass increases the amount of circulating glucose the body.[13] Additionally, greater muscle mass help to regulate glucose uptake in the body for longer periods of time.[13,27]

Emerging studies suggest that the insulin-regulating pathway, which regulates glucose uptake via insulin stimulating signaling, is protective for women.[26,28] Even though the pathway is not clear as to why, some studies suggest that it is due to hormonal differences. During physical activity, energy expenditure is facilitated by increased fat oxidation in women, which leads to greater glucose uptake as compared to men. Thus, women who are physically active are more likely to uptake greater amount of glucose in higher levels of physical activity compared to men.[26] This leads to women having lower amounts of glucose circulating in the blood, and they are more likely to have normal levels of glucose when compared to men.[26] As a result of this difference in insulin regulation, it is important to examine the differences in the relationship between physical activity and prediabetes stratified by gender. To our knowledge, no previous study has examined the association between occupational physical activity and prediabetes stratified by gender.

This study aims to examine whether occupational physical activity and leisure-time physical activity are independently associated with a reduced risk of prediabetes. We hypothesized that there would be an inverse association between leisure-time physical activity and prevalence of prediabetes. We hypothesized that there would be an inverse association between occupational physical activity and prevalence of prediabetes. We further hypothesized that the effect of physical activity on prediabetes would be stronger in women compared to men.

CHAPTER 2

METHODS

Study Population

We used data from the 2007–2014 National Health and Nutrition Examination Survey (NHANES). NHANES is a complex, multistage probability survey that examines a national representative sample of the US population of all ages.[29] The participants were interviewed at home followed by a clinical examination in the mobile examination center (MEC). A total of 40,617 individuals participated in the NHANES survey from 2007 to 2014. The participants were eligible to participate in the survey if they were part of the selected household and were age two and over. The response rate for the interview sample were 78.4% (2007–2008 cycle), 72.4% (2009–2010 survey cycle), 72.6% (2011–2012 survey cycle) and 71.0% (2013–2014), and the response rate for the examination sample were 75.4% (2007–2008 cycle), 77.3% (2009–2010 survey cycle), 69.5% (2011–2012 survey cycle) and 68.5% (2013–2014).[29]

Prediabetes Assessment

The Diabetes Interview Questionnaire (DIQ)[30] is a detailed assessment of diabetes performed by trained interviewers, who asked questions regarding prediabetes, insulin use and other diabetes-related complications and awareness. It is a self-reported tool that has been validated by various studies.[31,32] The Women Health Initiative conducted a validation study from a cohort of post-menopausal women aged 50 to 79 years. A group of women who self-reported having a diagnosis of diabetes was selected. These self-reported cases were then confirmed using medication inventories or a fasting glucose test that was collected at baseline. The results of the study found that self-reported diabetes is a valid tool to use in epidemiological studies. The final results showed that 72% of self-report diabetes were confirmed cases.[31]

In addition to the self-reported prediabetes status, we used blood biomarker to detect those individuals with undiagnosed prediabetes. For the purpose of our study, we used the hemoglobin A1C laboratory assay to detect undiagnosed prediabetes. Hemoglobin A1C is the most common diagnostic blood test used worldwide to confirm cases of both diabetes and prediabetes.[18] This biomarker has been widely validated and has a high sensitivity of 99% for detecting diabetes.[42] When compared to other diagnostic tests, such as fasting glucose and the 2 hours OGTT test, hemoglobin A1C has the highest sensitivity.[33, 42] Therefore, the American Diabetes Association also strongly recommends hemoglobin A1C as the diagnostic method for the diagnosis of both diabetes and pre-diabetes. In addition to having such a high sensitivity, the test is able to measure average blood glucose for the past 120 days.

NHANES analyzed hemoglobin A1C blood sample through chromatogram, which is an analyzer that does not require pretreatment of the blood samples. The blood samples were sent and run for analysis in Fairview Medical Center Laboratory at the University of Minnesota, Minneapolis Minnesota.[29]

In a combination of self-reported questionnaire and laboratory assay, the participants were categorized into three prediabetes status: no prediabetes, undiagnosed prediabetes and diagnosed prediabetes. Previous studies[9,21] have used this method to create a prediabetes status variable. We used established hemoglobin A1C level guidelines as recommended by the American Diabetes Association to categorize individuals in the correct prediabetes status.[33] Therefore, individuals with "no prediabetes" were defined as those who answered "No", to the question "Have you ever been told you had prediabetes?" and had a hemoglobin A1C level below 5.7%. Undiagnosed prediabetes consisted of a subjects who answered “No” to the above question and had a hemoglobin A1C level between 5.7% and 6.4%. Any subject that answered “Yes” to the question above were considered cases of diagnosed prediabetes regardless of hemoglobin A1C levels. Additionally, if an individual answered “borderline” to the question “Have you ever been told by a doctor or health professional that you have diabetes or sugar diabetes?”, they were considered diagnosed prediabetes, as many often describe prediabetes as borderline diabetes.[31] Subjects who did not answer these questions or had missing hemoglobin A1C data were excluded from the final analysis (n = 1,515).

Physical Activity Assessment

The Global Physical Activity Questionnaire[34] is an assessment tool used to assess the physical activity of an individual. It includes questions that assess daily activities, leisure-time activities and sedentary behaviors. Furthermore, it includes a series of questions that include detailed information about the frequency, duration, level of intensity and type of physical activity. This questionnaire has been validated in several studies.[35–37] Cleland et al. conducted a validation study of the physical activity questionnaire using the Actigraph GT3X.[35] The study had a final sample size of 65 individuals who were asked to continuously wear an activity monitor for seven days. Individuals were also asked to take the physical activity questionnaire twice—one time with a trained interview and one that is self–administered. The results suggest that when trained interviewers administered the questionnaire, a moderate correlation was found between GPAQ the accelerometer data ($r = 0.484$). This analysis was done separately for women and men, and the results showed moderate correlations for both women ($r = 0.434$, $p = 0.010$) and men ($r = 0.496$, $p = 0.005$). Other validity studies across the globe have yielded similar results when compared to those using accelerometer data.[35,36,38]

For the purpose of our study, we analyzed the questions that assess leisure-time physical activity as well as those that analyzed occupational physical activity duration and intensity in order to estimate metabolic equivalent task (MET)-hours for each type of physical activity. We used METs to measure physical activity intensity because MET scores are units that describe energy expenditure of specific activities; therefore, it is the ratio of the rate of energy expended during an activity to the rate of energy expended at rest.[39] Thus, MET-hours provide an estimated physical activity score based on intensity and duration. Occupational physical activity is considered "paid or unpaid work, studying or training, household chores, and yard work"[40], and leisure-time physical activity is defined as any time spent doing recreational physical activities, such as sports and fitness. Total physical activity is the sum of both total occupational physical activity and leisure-time physical activity as well as walking.

Individuals were asked if they performed vigorous and/or moderate leisure-time physical activity for intervals of 10 minutes or more. Additionally, we evaluated vigorous and/or moderate work-related physical activity for intervals of 10 minutes or more. We calculated the average minutes spent per week doing vigorous leisure-time physical activity. The vigorous MET-minutes were calculated by multiplying the average weekly time spent doing a vigorous leisure-time physical activity by the suggested MET score. Vigorous leisure-time physical activity MET score is 8.0.[40] MET-hours were derived by dividing the MET-minutes by 60. Furthermore, we calculated moderate MET minutes by multiplying the average minutes spent per week doing moderate leisure-time physical activity by the suggested MET score. Moderate leisure-time physical activity suggests that the MET score is 4.0. The moderate to vigorous leisure-time physical activity (MVPA) was calculated by summing the average MET-hours spent doing vigorous leisure-time physical activity and average MET-hours spent doing moderate leisure-time physical activity. The same steps above were followed to create a total moderate to vigorous occupational physical activity variable (MVOPA) by summing vigorous and moderate occupational physical activity (the suggested MET score for vigorous work activity was 8.0 and the for moderate work activity was 4.0). Moreover, we created a total physical activity variable, which is the sum of moderate and vigorous leisure-time physical activity and moderate to vigorous occupational physical activity. Lastly, in terms of leisure-time physical activity, occupational physical activity and total physical activity, we divided the participants into tertiles according to the distribution of the total METs hours per week. We also created a category with a reference group that indicated no level of physical activity (0 MET score).

Assessment of Covariates

There were a number of potential covariates that were considered for inclusion in analyses. Based on prior literature that has examined the association between prediabetes and physical activity as well as the known risk factors for prediabetes, we considered biological risk factors from biomarkers such as low density lipoprotein (LDL), high density lipoprotein (HDL) and triglycerides. We also considered demographic covariates such as race/ethnicity (Black, Hispanic, White and others), education (less than high school, high school graduate, some college and college graduate) and income ratio (less or equal to 1.3, 1.3 to 3.5 and greater than 3.5) and age. Risk factors such as smoking status, high blood pressure, diet and family history of diabetes were also considered. We categorized smoking status into three categories: never smoker, past smoker and current smoker. Body mass index (BMI) was categorized based on the Center for Diseases Control and Prevention's BMI guidelines and were categorized into four categories: underweight (<18.5 kg/m^2), normal (18.5 kg/m^2 to <25 kg/m^2), overweight (25 kg/m^2 to <30 kg/m^2) and obese (>30 kg/m^2). Furthermore, we created a hypertension variable. As our dataset includes data collected from 2007 to 2014, we used the old hypertension guidelines as previously recommended by the American College of Cardiology (ACC) and American Heart Association (AHA). Participants were considered hypertensive if systolic blood pressure was above 140 mmHg and diastolic blood pressure was greater than or equal to 90 mmHg or if they indicated receiving hypertension medication. We created a Healthy Eating Index Score, which measures diet quality based on the 24-hour diet recalls.[43] Furthermore; family history of diabetes was assessed via self-report.

Statistical Analysis

The inclusion criteria in our study included individuals with self-reported prediabetes or borderline diabetes as well as individuals without prediabetes that had Hemoglobin A1C and physical activity data available. We excluded individuals with self-reported diabetes (n = 903) and hemoglobin A1C levels above 6.5% (n = 1,972). Additional exclusion criteria included individuals with a history of coronary heart disease (n = 644), heart failure (n = 313), angina pectoris (n = 584) and heart attack (n = 440). Individuals younger than 18 years of age at the time of examination (n = 15,835) were also excluded as the physiology of prediabetes and physical activity is different between children and adults. Other exclusion criteria were individuals with missing information on prediabetes status (n = 1,515).

NHANES is a complex survey; therefore, the data weights were created and applied to the final dataset to properly analyze the data. Weights are a method used to make sure that the data is representative of the U.S. Census civilian non-institutionalized population.[41] We conducted descriptive statistics, and the participants were stratified by gender. Chi-square tests were done to analyze categorical variables, and the t-test was used to analyze continuous variables. Descriptive statistics are shown as frequency and percentage for categorical variables and as means and standard deviation for continuous variables. Two-sided P values < 0.05 were considered statistically significant. Data management was done using SAS 9.4. Additionally, all statistical analyses were done using STATA version 15.0.

Model Building

We performed an unweighted correlation test to eliminate covariates that had collinearity with one another by using the Pearson correlation test. In our study, these covariates were LDL (correlation coefficient = 0.30), HDL (correlation coefficient = -0.40) and triglycerides (correlation coefficient = 0.30), which were correlated to body mass index. We decided to retain body mass index. We used a stepwise selection of variables to build our model, as it allowed us to determine significant covariates in the model and exclude those that were non-significant. We built separate models for leisure-time physical activity, occupational physical activity and total physical activity for men and women. For each model, we used the adjusted Wald test to test for the potential confounder. For each separate model, we included those variables with a P value less than 0.05, as these were considered significant and were included in the final model.

A final, parsimonious model was created that included all the significant covariates from all separate models in order to facilitate presentation and interpretation of results. The results from the final model were compared to the results of each separate model to make sure that there was no difference. The final model included the following covariates: age, race, smoking status, body mass index, high blood pressure and family history of diabetes. High blood pressure and education was significant among men but not among women. However, adding education and hypertension did not change the results for women.

Multinomial logistic regression was used to analyze the association between physical activity (leisure time, occupational, and total) and prediabetes status [no prediabetes (reference group), undiagnosed prediabetes and diagnosed prediabetes] among women and men. Model 1 was our unadjusted model that only looked at the association between prediabetes status and physical activity. Model 2 was our adjusted model that adjusted for age, race, BMI, smoking status, family history of diabetes and hypertension based upon the results of the stepwise selection of variables. Additionally, for leisure time physical activity exposure, we created a third model, Model 3, which adjusted for age, race, BMI, smoking status, family history of diabetes, hypertension as well as occupational physical activity to adjust for those individuals that engaged in both leisure time physical activity and occupational physical activity. We adjusted for occupational physical activity to control for those individuals who might engage in both occupational physical activity as well as leisure time physical activity. A similar Model 3 was used with leisure time physical activity as a covariate when examining occupation physical activity as a primary exposure. We did not include a Model 3 for total physical activity.

CHAPTER 3

RESULTS

As shown in Table 1, our final sample size was an unweighted total of 17,871 participants, including 9,134 women and 8,737 men. After applying survey weights, among all the participants, the majority was White (67.9%), had no family history of diabetes (66.6%) and had an average age of 43 years old. Additionally, most participants were overweight (33.8%), were never smokers (57.2%) and had an income ratio greater than 3.5 (42.7%). After stratifying by sex, women had an average age of 45 years old, were mostly White (68.4%) and had no family history of diabetes (64.6%). Participant characteristics differed significantly between men and women with the exception of history of hypertension. Specifically, among women, the majority had normal weight (36.1%), were never smoker (62.2%) and had an income ratio greater than 3.5 (40.8%). The average age for men in our sample was 42 years, and a majority of men were White (67.3%) and had no family history of diabetes (66.6%). Most men were overweight (39.2%), never smoker (51.7%) and had an income ratio greater than 3.5 (44.6%).

Table 2 shows the bivariate association between covariates and prediabetes status in women. After applying weights to our dataset, among women, 68.9% had no prediabetes, 24.5% had undiagnosed prediabetes and 6.9% had diagnosed prediabetes. Women without prediabetes were on an average 41 years old, had normal weight (41.1%) and had an income ratio greater than 3.5 (44.3%). Women with undiagnosed cases of prediabetes tended to be older, with an average age of 56 years, were obese (43.5%) and had an income ratio between 1.3 and 3.5 (29.7%). Women with diagnosed cases of prediabetes were on an average 52 years old, were obese (52.8%), had an income ratio greater than 3.5 (40.6%) and were mostly White (69.05%).

Table 2 also shows the bivariate associations between covariates and prediabetes diabetes status in men. Men without prediabetes were younger, with an average age of 39 years old, were overweight (39.3%) and had an income ratio greater than 3.5 (44.8%). Men that had undiagnosed prediabetes tended to be older with an average age of 51 years old, were obese (42.2%) and had an income ratio greater than 3.5 (42.2%). Men who were diagnosed prediabetes had an average age of 54 years, were also obese (40.9%) and had an income ratio greater than 3.5 (52.0%).

Physical Activity and Undiagnosed Prediabetes

As seen in Table 3, we evaluated the association between type of physical activity and undiagnosed prediabetes among women. Unadjusted results (Model 1) show that compared to women who engaged in no MVPA, engaging in MVPA was statistically significantly associated with a lower odds of undiagnosed prediabetes [tertile 1: 0.84, (95% CI: 0.73–0.97); tertile 2: 0.58, (0.48–0.69); tertile 3: 0.45, (95% CI: 0.34–0.58)]. In Model 2, compared to women who engaged in no MVPA, engaging in low levels of MVPA was statistically significantly associated with an increased odds of undiagnosed prediabetes [tertile 1: 1.25, (95% CI: 1.05–1.50)]. Compared to women who engaged in no MVPA, engaging in moderate and high levels of physical activity was no longer significant [tertile 2: 0.98, (0.80–1.21); tertile 3: 1.05, (95% CI: 0.75–1.49)]. In Model 3, we additionally adjusted for occupational physical activity, and the results were similar to those in Model 2; compared to women who engaged in no MVPA, engaging in low MVPA was statistically significantly associated with an increase in the odds of undiagnosed prediabetes [tertile 1: 1.26, (95% CI: 1.05–1.50)].

The unadjusted model (Model 1) suggests that compared to women who engaged in no MVOPA, engaging in low MVOPA was not statistically associated with the decrease in the odds of undiagnosed prediabetes [tertile 1: 0.87, (95% CI: 0.72–1.07)]. Compared to women who engaged in no MVOPA, engaging in moderate and high levels of MVOPA was statistically significantly associated with a lower odds of undiagnosed prediabetes than no prediabetes [tertile 2: 0.74, (95% CI: 0.61–0.89); tertile 3: 0.65, (95% CI: 0.51–0.82)]. After adjusting for covariates, as shown in Model 2, the results suggest that compared to women who engaged in no MVOPA, engaging in high level of MVOPA was statistically significantly associated with a lower odds of undiagnosed prediabetes [tertile 1: 1.01, (95% CI: 0.80–1.28); Tertile 2: 0.98, (95% CI: 0.77–1.24); tertile 3: 0.75, (95% CI: 0.58–0.97)]. Additionally, we also adjusted for leisure-time physical activity in Model 3, and the results remained significant; compared to women who engaged in no MVOPA, engaging in high level of MVOPA reminded statistically significantly associated with lower odds of undiagnosed prediabetes [tertile 3: 0.75 (95% CI: 0.58–0.98)].

The unadjusted model (Model 1) suggests that compared to women who engaged in no total physical activity, engaging in total physical activity was statistically significantly associated with lower odds of undiagnosed prediabetes [tertile 1: 0.74, (95% CI: 0.63–0.87); Tertile 2: 0.53, (95% CI: 0.44–0.65); tertile 3: 0.48, (95% CI: 0.39–0.59)]. However, after adjustment to the model compared to women who engaged in no total physical activity, engaging in total physical activity was not statistically significantly associated with lower odds of undiagnosed prediabetes [tertile 1: 1.15, (95% CI: 0.96–1.38); tertile 2: 1.00, (95% CI: 0.79–1.27); tertile 3: 0.96, (95% CI: 0.77–1.20)].

For men, we also examined the association between the type of physical activity and undiagnosed prediabetes (Table 4). As per the unadjusted model (Model 1), compared to men who engaged in no MVPA, engaging in MVPA was statistically significantly associated with a lower odds of undiagnosed prediabetes [tertile 1: 0.64, (95% CI: 0.52–0.79); tertile 2: 0.56, (95% CI: 0.44–0.69); tertile 3: 0.41, (95% CI: 0.34–0.50)]. When adjusted for covariates, Model 2 suggests that compared to men who engaged in no MVPA, engaging in high MVPA was statistically significantly associated with lower odd0s of undiagnosed prediabetes [tertile 1: 0.86, (95% CI: 0.67–1.10); tertile 2: 0.69, (95% CI: 0.69–1.08); tertile 3: 0.79, (95% CI: 0.65–0.98)]. Additionally, in Model 3, we adjusted for occupational physical activity; compared to men engaged in no MVPA, engaging in high MVPA was statistically significantly associated with lower odds of undiagnosed prediabetes [tertile 1: 0.85, (95% CI: 0.67–1.09); tertile 2: 0.85, (0.68–1.07); tertile 3: 0.78, (95% CI: 0.64–0.96)].

The association between occupational physical activity and undiagnosed prediabetes was evaluated in Table 4. The unadjusted model (Model 1) suggests that compared to men who engaged in no MVOPA, engaging in MVOPA was statically significantly associated with increase in the odds of undiagnosed prediabetes [tertile 1: 1.02, (95% CI: 0.82–1.28); tertile 2: 0.98, (95% CI: 0.82–1.18); tertile 3: 1.00, (95% CI: 0.85–1.19)]. Model 2, our adjusted model, suggests that compared to men that engaged in no MVPA, engaging in high MVPA was statistically significantly associated with increased odds of undiagnosed prediabetes [tertile 1: 1.15, (95% CI: 0.90–1.48); tertile 2: 1.11, (95% CI: 0.90–1.36); tertile 3: 1.21, (95% CI: 1.00–1.46)]. After adjustment for leisure-time physical activity (Model 3), the results remained significant, showing an increase in odds for men who engaged in high levels of occupational physical activity [tertile 1: 1.18, (95% CI: 0.93–1.50); tertile 2: 1.12, (95% CI: 0.91–1.38); tertile 3: 1.22, (95% CI: 1.01–1.42)].

Lastly, we looked at the association between total physical activity and undiagnosed prediabetes in men. The unadjusted model (Model 1) suggests that compared to men who engaged in no total physical activity, engaging in total physical activity was statistically significantly associated with lower odds of undiagnosed prediabetes [tertile 1: 0.67, (95% CI: 0.54–0.82); tertile

2: 0.55, (95% CI: 0.44–0.68); tertile 3: 0.55, (95% CI: 0.46–0.65)]. However, after adjusting for covariates as shown in Model 2, compared to men who did not engage in total physical activity, engaging in total physical activity did not become statistically significant of undiagnosed prediabetes [tertile 1: 0 .90, (95% CI: 0.71–1.16); tertile 2: 0.93, (0.74–1.18); tertile 3: 0.99, (95% CI: 0.80–1.21)]

Physical Activity and Diagnosed Prediabetes

The association between the type of physical activity and diagnosed prediabetes was evaluated for both men and women (Table 3 and Table 4). As seen with the unadjusted model (Model 1), compared to women that engaged in no MVPA, engaging in moderate and high level of MVPA was statistically significantly associated with lower odds of diagnosed prediabetes [tertile 1: 1.00, (95% CI: 0.77–1.28); tertile 2: 0.63, (95% CI: 0.46–0.86); tertile 3: 0.42, (95% CI: 0.42–0.87)]. Model 2, our adjusted model, suggests that compared to women who engaged in no MVPA, engaging in low level of MVPA was statistically significantly associated with higher odds of diagnosed prediabetes [tertile 1: 1.32, (95% CI: 1.03–1.70); tertile 2: 1.32, (95% CI: 0.73–1.44); tertile 3: 1.27, (95% CI: 0.86–1.88)]. In Model 3, which additionally adjusted for occupational physical activity, compared to women who engaged in no MVPA, engaging in low MVPA was statistically significantly associated with increase in the odds of diagnosed prediabetes [tertile 1: 1.30, (95% CI: 1.01–1.67); tertile 2: 1.00, (95% CI: 0.71–1.40); tertile 3: 1.25, (95% CI: 0.85–1.85)].

Table 3 shows the association between occupational physical activity and diagnosed prediabetes among women. Model 1 suggests that compared to women who engaged in no MVOPA, engaging in low MVOPA was statistically significantly associated with higher odds of diagnosed prediabetes [tertile 1: 1.28, (95% CI: 1.00–1.65); tertile 2: 1.10, (95% CI: 0.85–1.44);

tertile 3: 0.94, (95% CI: 0.62–1.41)]. Model 2 suggests that compared to women who engaged in no MVOPA, engaging in low MVOPA was statistically significantly associated with an increase in the odds of diagnosed prediabetes [tertile 1: 1.46, (95% CI: 1.11–1.92); tertile 2: 1.32, (95% CI: 0.96–1.82); tertile 3: 1.17, (95% CI: 0.75–1.81)]. Additionally, in Model 3, we adjusted for leisure-time physical activity; compared to women who engaged in no MVPA, engaging in low MVPA was statistically significantly associated with an increase in the odds of diagnosed prediabetes [tertile 1: 1.44, (95% CI: 1.09–1.92); tertile 2: 1.32, (95% CI: 0.96–1.81); tertile 3: 1.16, (95% CI: 0.75–1.78)].

The results for the association between total physical activity and diagnosed prediabetes are shown in Table 3. Model 1 suggests that compared to women engaged in no total physical activity, engaging in total physical activity was statistically significantly associated with lower odds of diagnosed prediabetes [tertile 1: 0.81, (95% CI: 0.62–1.04); tertile 2: 0.63, (95% CI: 0.46–0.85); tertile 3: 0.70, (95% CI: 0.53–0.92)]. However, after adjustment for age, race, body mass index, smoking status, family history of diabetes, hypertension and education results became non-significant [tertile 1: 1.10, (95% CI: 0.83–1.46); tertile 2: 1.04, (95% CI: 0.77–1.44); tertile 3: 1.33, (95% CI: 0.96–1.86)).

The association between leisure-time physical activity and diagnosed prediabetes among men are shown in Table 4. When compared to men who engaged in no MVPA, engaging in MVPA was statistically significantly associated with lower odds of diagnosed prediabetes [tertile 1: 1.01, (95% CI: 0.71–1.45); tertile 2: 0.80, (95% CI: 0.56–1.13); tertile 3: 0.48, (95% CI: 0.36–0.65)]. However, after adjustment to the model, as shown in Model 2, compared to men who engaged in no MVPA, engaging in MVPA was no longer statistically associated with lower odds of diagnosed prediabetes [tertile 1: 1.05, (95% CI: 0.73–1.50); tertile 2: 1.05, (95% CI: 0.71–1.55); tertile 3:

0.94, (95% CI: 0.65–1.38)]. In Model 3, we also adjusted for occupational physical activity, and the results reminded non-significant [tertile 1: 1.05, (95% CI: 0.74–1.51); tertile 2: 1.07, (95% CI: 0.74–1.54); tertile 3: 0.96, (95% CI: 0.67–1.38)].

Model 1 suggests that compared to men who engaged in no MVOPA, engaging in high MVOPA was statistically significantly associated with lower odds of diagnosed prediabetes [tertile 1: 1.21, (95% CI: 0.79–1.85); tertile 2: 0.87, (95% CI: 0.58–1.30); tertile 3: 0.65, (95% CI: 0.46–0.91)]. After adjustment to the model, the results became non-significant [tertile 1: 1.27, (95% CI: 0.81–1.99); Tertile 2: 0.93, (95% CI: 0.60–1.44); tertile 3: 0.90, (95% CI: 0.62–1.31)]. Furthermore, we adjusted for leisure-time physical activity and found that compared to men who engaged in no MVOPA, engaging in MVOPA was not statistically significantly associated with lower odds of diagnosed prediabetes than no prediabetes [tertile 1: 1.26, (95% CI: 0.81–1.96); tertile 2: 0.93, (95% CI: 0.60–1.43); tertile 3: 0.90, (95% CI: 0.62–1.31)].

The crude results between total physical and diagnosed diabetes in men showed a decrease in odds for men who engaged in moderate to high levels of total physical activity [tertile 1: 0.76, (95% CI: 0.51–1.13); Tertile 2: 0.71, (95% CI: 0.49–1.02); tertile 3: 0.40, (95% CI: 0.30–1.53)]. After adjustment to the model, the results became non-significant [tertile 1: 0.87, (95% CI: 0.58–1.32); tertile 2: 1.05, (95% CI: 0.71–1.56); tertile 3: 0.77, (95% CI: 0.56–1.06)].

CHAPTER 5

DISCUSSION

In summary, in this cross-sectional study, we found that among women and men, an higher levels of leisure-time physical activity were associated with decreased odds of undiagnosed prediabetes. However, after adjustments to the model, the association was no longer statistically significant for both women and men. Similarly, we did not find evidence of the association between leisure-time physical activity and diagnosed prediabetes for either women or men. Two prior studies have looked at the association between leisure-time physical activity and prediabetes.[8,9] Similar to our findings, one prior study among young adults from rural South Africa found no association (beta = 1.016; 95% CI 0.35-2.78) between total physical activity and prediabetes.[8] In contrast, a study conducted by Wang et. al. found a statistically significant association of leisure-time physical activity with a decrease in odds of undiagnosed prediabetes [Tertile 1: 0.72, (95% CI: 0.58, 0.90), Tertile 3: 0.78, (95% CI: 0.66, 0.94)] .[9] The differences in our study and that by Wang et. al. may be due to several reasons. First, our study was stratified by gender where Wang et al.'s study looked at the association among adults. As prior literature suggests, gender is a strong predictor for prediabetes; therefore, the results could have been influenced by not being stratified by gender. Second, our study adjusted for important confounders such as family history of prediabetes. Family history of prediabetes is a strong predictor of prediabetes; therefore, not adjusting for this confounder might have overestimated the true odds ratio. Lastly, Wang et al. stratified by age, unlike our study which only adjusted for it. [9] Lack of age stratification could explain why our crude results were significant for the crude model, yet they became non-significant after adjusting for important covariates.

With respect to men and women, our results suggest that engaging in occupational physical activity was not associated with undiagnosed prediabetes. Additionally, we did not find an association between occupational physical activity and diagnosed prediabetes for either women or men. These findings are similar to that of Matshipi et al. who also did not find an association (beta = 0.016, 95% CI: 0.36-2.83) between occupational physical activity and prediabetes among adults in South Africa.[8] This finding is important especially among men who, by adding occupational physical activity, are more likely to meet physical activity guidelines. Even though more research needs to be done, the evidence suggests that engaging in occupational physical activity is not as beneficial as leisure-time physical activity.

Last, there is evidence in our results that an increase in total physical activity was associated with a lower odd of undiagnosed prediabetes for both women and men. However, after adjustment to the model, the effect was no longer statistically significant. Similarly, these findings were found when we looked at the association between total physical activity and diagnosed prediabetes for both men and women. Difference in crude and adjusted models maybe due to mixing of effects or confounding. By adjusting for age, race, BMI, education, family history of diabetes, and hypertension we controlled for those variables that have an influence on both physical activity and prediabetes status. Therefore, even though the unadjusted results suggest that there might be an association, the adjusted model is a better indicator of the true association between type of physical activity and prediabetes status.

There are several strengths to our study. First, we used a national sample for our analysis and applied weights for our analysis, which made it representative for the US population. Additionally, we looked at each type of physical activity separately to assess the different effects on prediabetes status. The strength of our study is that we used measurements and questionnaires that have been validated by previous validation studies.

There are several limitations to our study. First, our study is a cross-sectional study; therefore, temporality is a concern. Although unlikely, it is possible that prediabetes led to a lack of physical activity; however this is unlikely as prediabetes is asymptotic. A second limitation of our study may have been due to non-differential misclassification of the exposure. Physical activity measures time and intensity, and it is possible that some participants over reported their levels and intensity of physical activity. Although this is unlikely, as we used a validated questionnaire, there is a possibility that our odds ratio might be biased toward the null.

Our results may be generalizable to men and women who are at risk for prediabetes. Our proposed physiological mechanism is that physical activity helps control glucose levels circulating in the body, which decreases the likelihood of developing prediabetes. There is no evidence that suggests that such mechanisms would differ among people living outside the United States.

CHAPTER 6

CONCLUSION

In conclusion, our results show that for both men and women, there is a general lack of association between leisure-time physical activity, occupational physical activity and total physical activity and prediabetes status. These findings contribute to a better understanding of the importance in identifying which type of physical activity should be recommended for diabetes prevention and prediabetes management. Additionally, our study had sufficient power due to our large sample size, but this association should be reanalyzed with prospective cohort to address issues of temporality. Also in a prospective cohort we would be able to identify individuals who have been continuously physically activity and those who are not consistently physically active and also assess incident onset of disease diagnosis, thus addressing issues related to temporality as well as with dose-response of physical activity exposure.

Table 1. Descriptive Characteristics by sex in NHANES, 2007-2014, (N=17,871)

Characteristics	Overall (n= 17,871)	Female (n= 9,134)	Male (n=8,737)	*p value*
Age	43.48 (16.68)	44.81(16.90)	42.06(16.00)	*< 0.000*
HEI‡ Score	55.13 (13.36)	56.19 (13.18)	54.01 (13.19)	
MVPA Occupationa	160.64 (136.44)	130.36 (111.82)	173.50 (133.82)	*<0.000*
MVPA	47.17 (39.54)	40.72 (28.55)	52.36 (41.29)	*<0.000*
Total PA	79.64 (104.91)	55.64 (73.92)	102.35 (120.30)	
Race				
White	7,781 (67.89)	4,012(68.44)	3,769 (67.29)	*<0.000*
Black	3,659 (10.83)	1,854 (11.39)	1,805 (10.23)	
Hispanic	4,553(14.25)	2,344 (13.3)	2,209 (15.27)	
Other	1,878(7.03)	924 (6.87)	954 (7.21)	
Body Mass Index*				*<0.000*
Underweight	386(1.98)	243 (2.56)	143 (1.36)	
Normal	5,486(32.94)	2,906 (36.11)	2,580 (29.54)	
Overweight	5,582 (33.76)	2,476 (28.66)	3,106 (39.22)	
Obese	5,439(31.32)	3,075 (32.67)	2,364 (29.88)	
Education				*<0.000*
Less than High Schoo	4,395(16.83)	2,129 (15.91)	2,266 (17.81)	
High School Graduate	4,178(22.53)	2,009 (21.17)	2,169 (23.98)	
Some College	5,216 (16.83)	2,892 (33.41)	2,324 (28.91)	
College Graduate or H	4,037 (31.24)	2,085 (29.52)	1,952 (29.30)	
Income Ratio				*0.011*
Less or equal 1.3	5,515(23.01)	2,957 (24.3)	2,558 (21.63)	
1.3-3.5	5,764 (34.34)	2,932 (34.84)	2,832 (33.81)	
Greater 3.5	4, 998(42.65)	2,449 (40.86)	2,549 (44.56)	
Smoking Status				*<0.000*
Never	9,755 (57.15)	5,688 (62.22)	4,067 (51.68)	
Past	3,558 (21.81)	1,477 (19.35)	2,081 (24.47)	
Current	3,700(21.04)	1,568 (18.43)	2, 132 (23.85)	
Family History				*<0.000*
Yes	4,470 (27.02)	3,198 (35.36)	2,625 (31.26)	
No	12, 076 (72.98)	5,208 (64.64)	5,346 (68.74)	
Hypertension †				*0.1873*
Yes	4, 470 (24.03)	2,433 (26.1)	2, 210(24.86)	
No	12.076 (75.97)	5,856 (73.9)	5,598 (75.14)	

Numbers may not sum to 17,871 due to missing data

Percent are weighted and counts are actual number of observations

MVPA abbreviation for moderate to vigrouse leisure time physical activity

MVPAO abbreviation for moderate to occupational physical activity

*BMI less than 18.5 is underweight, BMI between 18.8 to <25 is normal, 25 to <30 overweight. and >30 obese.

† Hypertension mean systolic blood pressure greater or equal to 140 mmHg, or mean diastolic greater or equal to 90mmHg, being under treatment for hypertension

‡ HEI abbriviation for Healthy Eating Index Score.

Table 2. Bivariate association between prediabetes status and covariates in NHANES, 2007-2014, (N=17,871)

Characteristics	**Female**				**Male**			
	Normal(N=6,283)	**Undiagnosed (N=2,241)**	**Diagnosed (N=637)**	*p value*	**Normal (N=6,204)**	**Undiagnosed (N=2,086)**	**Diagnosed (N=447)**	*p value*
	Mean (SD)	**Mean (SD)**	**Mean (SD)**		**Mean (SD)**	**Mean (SD)**	**Mean (SD)**	
Age	40.77 (15.26)	56.38(16.73)	51.57(57.31)	*<0.005*	38.93 (14.57)	50.99 (17.19)	53.69 (13.21)	*<0.005*
HEI‡ Score	56.07(12.82)	56.50 (14.19)	56.41 (13.68)		53.93 (12.89)	53.73 (14.17)	56.09 (12.62)	
MVPA¥ Occupational	29.81 (21.70)	28.31 (21.74)	27.44 (21.16)	*0.527*	37.41 (22.42)	37.82 (27.36)	32.77 (21.69)	*0.791*
MVPA§	11.65 (5.73)	12.25 (8.31)	11.12 (5.42)	*0.45*	16.55 (9.16)	16.86 (12.42)	13.83 (7.49)	*0.705*
Total Physical Activity	52.73 (73.55)	48.57 (74.04)	52.73 (72.41)		103.52 (116.2)	104.78 (141.50)	75.04 (93.92)	
	N(%)	**N(%)**	**N(%)**		**N(%)**	**N(%)**	**N(%)**	
Race				*0.0001*				*<0.005*
White	2,853 (69.59)	874 (64.32)	285 (69.05)		2,854(69.65)	695 (56.41)	220 (74.0)	
Black	1,1618 (10.14)	556 (15.71)	138 (11.24)		1,106(8.52)	614 (17.41)	85 (7.97)	
Hispanic	1,618(13.51)	578 (13.13)	148 (11.56)		1,556 (15.01)	555(17.34)	98(11.25)	
Other	652 (6.75)	206 (6.84)	66 (8.15)		688 (6.81)	222(8.85)	44 (6.78)	
Body Mass Index*				*<0.005*				*<0.005*
Underweight	203 (3.03)	32 (1.46)	8 (1.07)		118 (1.52)	22 (0.95)	3(0.39)	
Normal	2,316 (41.13)	475 (24.43)	115 (19.83)		2,082 (33.22)	420(18.73)	78(16.57)	
Overweight	1,665 (28.32)	655(30.64)	156 (26.22)		2,139 (39.3)	796 (38.11)	171 (42.2)	
Obese	1,733 (27.52)	1,000 (43.47)	342 (52.88)		1,397(25.95)	800 (42.21)	167(40.85)	
Education				*<0.005*				*<0.005*
Less than High School	1,183(13.59)	633(20.91)	139(15.84)		1,339 (14.42)	648 (21.05)	142(15.77)	
High School Graduate	1,194(19.22)	510(25.72)	129(20.27)		1,353 (19.87)	521 (25.81)	135(20.55)	
Some College	1,909(33.85)	620(29.71)	214(36.86)		2,035(34.13)	635(29.72)	222(37.14)	
College Graduate or Higher	1,602(33.34)	405(23.66)	137(27.03)		1,543 (31.58)	405 (23.24)	137 (26.54)	
Income Ratio				*0.0013*				*0.0422*
Less or equal 1.3	1,830(22.85)	656(24.07)	194(21.75)		1,850 (21.7)	599 (22.98)	109 (15.7)	
1.3-3.5	1,858(32.9)	764(40.62)	210(37.65)		1,977 (33.54)	704 (35.28)	151 (32.3)	
Greater 3.5	1,775(44.25)	528 (35.31)	175(40.61)		1,829 (44.76)	566 (41.73)	154 (52.00)	
Smoking Status				*0.016*				*<0.005*
Never	3,928 (63.35)	1,372 (59.39)	388 (59.58)		3,004 (54.13)	884 (44.66)	179 (43.82)	
Past	916(17.93)	427 (21.90)	134 (25.88)		1,282 (22.55)	608 (27.27)	191(40.50)	
Current	1,082 (18.72)	381 (18.74)	105 (14.54)		1,503 (23.31)	552(28.07)	77(15.68)	
Family History				*<0.005*				*<0.005*
Yes	1,982 (32.36)	889 (40.66)	327(49.2)		1,674 (28.46)	721(35.92)	230(51.78)	
No	3,680 (67.64)	1,244 (59.34)	284(50.8)		3,863 (71.54)	1,275(64.08)	208(48.22)	
Hypertension †				*<0.005*				*<0.005*
Yes	1,165(19.32)	977(42.83)	291(47.21)		1,198(19.99)	801(38.17)	211(46.13)	
No	4,458(80.68)	1,104(57.17)	294(52.79)		4,229(80.01)	1,1165(53.87)	204 (53.87)	

Numbers may not sum to 17,871 due to missing data

Percent are weighted and counts are actual number of observations

*BMI less than 18.5 is underweight, BMI between 18.8 to <25 is normal, 25 to <30 overweight. and >30 obese.

† Hypertension mean systolic blood pressure greater or equal to 140 mmHg, or mean diastolic greater or equal to 90mmHg, being under treatment for hypertension

‡ HEI abbriviation for Healthy Eating Index Score.

Table 3. Odds ratios of females diagnosed and undiagnosed prediabetes according to total leisure physical activity, occupational physical activity and total physical activity comapred to females with regulated glucose level, NHANES 2007-2014

		Undiagnosed Prediabetes									Diagnosed Prediabetes								
		Model 1			Model 2			Model 3			Model 1			Model 2			Model 3		
	Sample Size	OR	95% Confidence Interval	*p value*	OR	95% Confidence Interval	*p value*	OR	95% Confidence Interval	*p value*	OR	95% Confidence Interval	*p value*	OR	95% Confidence Interval	*p value*	OR	95% Confidence Interval	*p value*
MVPA MET Hours per week																			
None	4,818	**1.00**			**1.00**			**1.00**			**1.00**			**1.00**			**1.00**		
Tertile 1 (0.66-11.99)	1,636	0.84	0.73 0.97	0.016	1.25	1.05 1.49	0.01	1.26	1.05 1.50	0.01	1.00	0.77 1.28	0.984	1.32	1.03 1.70	0.028	1.30	1.01 1.67	0.04
Tertile 2 (12.00-31.66)	1,679	0.58	0.48 0.69	0.000	0.97	0.79 1.19	0.781	0.98	0.80 1.21	0.864	0.63	0.46 0.86	0.005	1.03	0.73 1.44	0.876	1.00	0.71 1.40	0.992
Tertile 3 (32-252)	998	0.45	0.34 0.58	0.000	1.04	0.74 1.46	0.826	1.05	0.75 1.49	0.76	0.61	0.42 0.87	0.007	1.27	0.86 1.88	0.218	1.25	0.85 1.85	0.246
P-trend				0.000			0.66			0.713			0.001			0.503			0.59
MVOPA MET Hours per week																			
None	10,585	**1.00**			**1.00**			**1.00**			**1.00**			**1.00**			**1.00**		
Tertile 1 (0.66-19.99)	6,068	0.87	0.72 1.07	0.186	1.01	0.80 1.28	0.908	1.00	0.79 1.27	0.957	1.28	1.00 1.65	0.05	1.46	1.11 1.92	0.007	1.44	1.09 1.92	0.01
Tertile 2(20-80)	1,062	0.74	0.61 0.89	0.002	0.98	0.77 1.24	0.847	0.98	0.77 1.24	0.848	1.10	0.85 1.44	0.457	1.32	0.96 1.82	0.084	1.32	0.96 1.81	0.063
Tertile 3 (84-672)	831	0.65	0.51 0.82	0.000	0.75	0.58 0.97	0.032	0.75	0.58 0.98	0.036	0.94	0.62 1.41	0.744	1.17	0.75 1.81	0.479	1.16	0.75 1.78	0.494
P-trend				0.000			0.154			0.175			0.789			0.059			0.056
Total physical activity MET Hours per week																			
None	2,605	**1.00**			**1.00**						**1.00**			**1.00**					
Tertile 1 (0.66-19.99)	2,591	0.74	0.63 0.87	0.000	1.15	0.96 1.38	0.117				0.81	0.62 1.04	0.097	1.10	0.83 1.46	0.491			
Tertile 2 (20-64)	2,290	0.53	0.44 0.65	0.000	1.00	0.79 1.27	0.999				0.63	0.46 0.85	0.003	1.04	0.77 1.44	0.76			
Tertile 3 (64.3-700)	1,638	0.48	0.39 0.59	0.000	0.96	0.77 1.20	0.713				0.70	0.53 0.92	0.011	1.33	0.96 1.86	0.089			
P-trend				0.000			0.417						0.003			0.16			

Abbreviations: MET, Metabolic Equivelent; OR, Odds Ratio; Tertile 1, Tertile 2, Tertile 3

*Model 1: Crude

†Model 2: Adjusted for age, race, body mass index, smoking status, family history, hypertension

‡Model 3: Adjusted for age, race, body mass index, smoking status, family, history and occupational physical activity

Table 4. Odds ratios of male diagnosed and undiagnosed prediabetes according to total leisure physical activity, occupational physical activity and total physical activity, NHANES 2007-2014

		Undiagnosed Prediabetes									Diagnosed Prediabetes								
		Model 1			Model 2			Model 3		Model 1			Model 2			Model 3		
	Sample Size	OR	95% Confidence Interval	*p value*	OR	95% Confidence Interval	*p value*	OR	95% Confidence Interval	OR	95% Confidence Interval	*p value*	OR	95% Confidence Interval	*p value*	OR	95% Confidence Interval	*p value*
MVPA MET Hours per week																		
None	3,920	**1.00**			**1.00**			**1.00**		**1.00**			**1.00**			**1.00**		
Tertile 1 (0.66-11.99)	1,272	0.64	0.52 0.79	0.000	0.86	0.67 1.10	0.228	0.85	0.67 1.09	1.01	0.71 1.45	0.95	1.05	0.73 1.50	0.808	1.05	0.74 1.51	0.765
Tertile 2 (12.00-31.99)	1,672	0.56	0.44 0.69	0.000	0.86	0.69 1.08	0.199	0.85	0.68 1.07	0.80	0.56 1.13	0.194	1.05	0.71 1.55	0.796	1.07	0.74 1.54	0.726
Tertile 3 (32-924)	1,861	0.41	0.34 0.50	0.000	0.79	0.65 0.98	0.029	0.78	0.64 0.96	0.48	0.36 0.65	0.000	0.94	0.65 1.38	0.762	0.96	0.67 1.38	0.821
P-trend				0.000			0.001					0.000			0.699			0.718
MVOPA MET Hours per week																		
None	4,517	**1.00**			**1.00**			**1.00**		**1.00**			**1.00**			**1.00**		
Tertile 1 (0.66-19.99)	969	1.02	0.82 1.28	0.824	1.15	0.90 1.48	0.233	1.18	0.93 1.50	1.21	0.79 1.85	0.374	1.27	0.81 1.99	0.284	1.26	0.81 1.96	0.291
Tertile 2(20-80)	1,333	0.98	0.82 1.18	0.859	1.11	0.90 1.36	0.334	1.12	0.91 1.38	0.87	0.58 1.30	0.841	0.93	0.60 1.44	0.755	0.93	0.60 1.43	0.726
Tertile 3 (82-924)	1,895	1.00	0.85 1.19	0.981	1.21	1.00 1.46	0.05	1.22	1.01 1.42	0.65	0.46 0.91	0.013	0.90	0.62 1.31	0.583	0.90	0.62 1.31	0.575
P-trend				0.964			0.006					0.018			0.609			0.584
Total physical activity MET Hours per week																		
None	1,540	**1.00**			**1.00**					**1.00**			**1.00**					
Tertile 1 (0.66-19.99)	1,679	0.67	0.54 0.82	0.000	0.90	0.71 1.16	0.439			0.76	0.51 1.13	0.18	0.87	0.58 1.32	0.515			
Tertile 2 (20-64)	2,269	0.55	0.44 0.68	0.000	0.93	0.74 1.18	0.545			0.71	0.49 1.02	0.06	1.05	0.71 1.56	0.785			
Tertile 3 (64.3-984)	3,228	0.55	0.46 0.65	0.000	0.99	0.80 1.21	0.907			0.40	0.30 0.53	0.00	0.77	0.56 1.06	0.111			
P-trend				0.000			0.791					0.00			0.258			

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