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RESEARCH ARTICLE

Physical Activity and Abnormal Blood Glucose Among Healthy Weight Adults

Arch G. Mainous III, PhD,[1,2] Rebecca J. Tanner, MA,[1] Stephen D. Anton, PhD,[3] Ara Jo, MS,[1] Maya C. Luetke, MSPH[1]

Introduction: Physical activity has been linked to prevention and treatment of prediabetes and diabetes in overweight and obese adults. This study examines the relationship between low physical activity levels and risk of abnormal blood glucose (prediabetes or undiagnosed diabetes) in healthy weight adults.

Methods: Data from the 2014 Health Survey for England were analyzed in July 2016, focusing on adults with a BMI $\geq$18.5 and $<$25 who had never been diagnosed with diabetes (N=1,153). Abnormal blood glucose was defined as hemoglobin A1c $\geq$5.7. Physical activity was measured through the International Physical Activity Questionnaire. Bivariate analyses and Poisson models were conducted on the effect of physical activity on abnormal blood glucose, controlling for age, sex, waist to hip ratio, sitting time, age X physical activity interaction, sex X physical activity, and race.

Results: Abnormal blood glucose was detected in 23.7% of individuals with low activity levels, 14.8% of those with medium activity levels, and 12.2% of those with high activity levels ($p<0.003$). Similarly, 25.4% of inactive individuals (physically active for $<$30 minutes per week) were more likely to have abnormal blood glucose levels than active individuals (13.4%, $p<0.0001$). Higher physical activity was associated with a lower likelihood of abnormal blood glucose in an adjusted Poisson regression.

Conclusions: Among healthy weight adults, low physical activity levels are significantly associated with abnormal blood glucose (prediabetes and undiagnosed diabetes). These findings suggest that healthy weight individuals may benefit from physical exercise.

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INTRODUCTION

Diabetes has reached epidemic proportions. Worldwide, the number of people with diabetes has risen from 108 million in 1980 to 422 million in 2014.[1] Diabetes is a major cause of kidney failure, heart attacks, stroke, and lower limb amputations.[2] In addition to the morbidity and mortality associated with diabetes, the cost of diabetes care is substantial.[3]

Early detection and screening for undiagnosed Type 2 diabetes is needed because of the utility of treatment to prevent Type 2 diabetes complications.[4] Second, there is an equal or more important need to detect prediabetes, a state of abnormal blood glucose that indicates high risk for the development of Type 2 diabetes.[5] Strategies for detection of abnormal glucose tend to focus on individuals who are overweight or obese.[4,6] Recent data have indicated, however, that a substantial proportion of individuals at a "healthy weight" (BMI between 18.5 and 24.9) have prediabetes.[7] In fact, among healthy weight individuals aged 45 years and older in the U.S.,

From the [1]Department of Health Services Research, Management and Policy, University of Florida, Gainesville, Florida; [2]Department of Community Health and Family Medicine, University of Florida, Gainesville, Florida; and [3]Department of Aging and Geriatric Research, University of Florida, Gainesville, Florida

Address correspondence to: Arch G. Mainous III, PhD, Department of Health Services Research, Management, and Policy, University of Florida, Health Sciences Center, PO Box 100195, Gainesville FL 32610. E-mail: arch.mainous@phhp.ufl.edu.

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the prevalence of prediabetes was 33.1% in 2012.[7] One theory for this substantial proportion of healthy weight, prediabetic adults in the U.S. is that sedentary lifestyle may contribute to unhealthy changes in body composition, even among individuals who are not overweight. Some individuals at healthy weights have what has been referred to as "normal-weight obesity," a condition characterized by high body fat and lower lean muscle mass while still falling within the BMI parameters of "healthy" weight.[8]

This study is innovative in examining abnormal blood glucose in healthy weight adults, a population previously believed to be at low risk of glucose abnormalities. Because typical strategies to prevent prediabetes or Type 2 diabetes (e.g., calorie restriction and weight reduction) are inappropriate for individuals who are not overweight, it is unclear whether physical activity moderates the presence of abnormal glucose in this healthy weight population. The purpose of this study was to examine the relationship of physical activity with abnormal blood glucose among adults at a healthy weight who previously had not been diagnosed with diabetes.

METHODS

Data from the 2014 Health Survey for England (HSE) were analyzed. The HSE is an annual survey that monitors trends in the health of England's residents. The HSE uses a stratified random probability sample of households. Information on the sampling methodology of the HSE is available from the United Kingdom Data Service.[9] The HSE includes both a computer-assisted personal interview and a nurse visit. For the 2014 HSE, of those respondents with full interviews, 5,941 adults aged ≥16 years and 1,249 children aged 0–15 years had a visit with a nurse.[9] During the nurse visit, a nurse obtained blood, saliva, and urine samples, along with physical measurements of the participant.

To obtain accurate estimates, the HSE is weighted by the Joint Health Surveys Unit of NatCen Social Research and University College London to account for sampling design, non-response, and the type of data used.[10,11] Using the weighting variable allows researchers to make estimates for the entire population in England and reduce possible biases.[9]

The current project focused on adults aged ≥20 years, who had a nurse-measured BMI ≥18.5 and <25, who reported never being diagnosed with diabetes, and who had data available on glycated hemoglobin (HbA1c). Based on these criteria, there were a total of 1,153 respondents (weighted sample size, 1,219). The weighted sample size is the sample size when the weighting variable is applied to the sample. Data were analyzed in July 2016. The study used publicly available de-identified data and was exempted by the University of Florida IRB.

Measures

Individuals were considered to have diagnosed diabetes if they reported that they had been diagnosed with diabetes (other than gestational) by a healthcare provider.

Participants with abnormal blood glucose were identified using HbA1c. Abnormal blood glucose was defined as HbA1c ≥5.7%.[6] Owing to their increased risk of all-cause mortality, individuals with HbA1c <4.0 were removed from the analysis.[12] On August 4, 2016, HSE 2014 users were notified of the need to correct a calibration problem with the HbA1c values in the HSE for 2014 (K Dennison, UK Data Service, personal/written communication, 2016). The HbA1c levels used for this paper have been corrected as recommended by NatCen Social Research, the organization that jointly conducts the HSE on behalf of the Health and Social Care Information Centre. For HbA1c values between 3.5 and 6.62, 0.1 was added to the given HbA1c level. For HbA1c values between 6.3 and 8.9, 0.2 was added to the given HbA1c level. For HbA1c values >8.9, 0.3 was added to the given HbA1c level. There were 953 individuals of normal BMI who did not have diabetes and were aged >20 years and did not have HbA1c results. Although this has the potential to introduce bias, the weighting variable took into account respondents who refused or were unable to give a blood sample to partially mitigate the effect of missing data.

Physical activity was defined in two ways. First, the HSE includes a derived variable of tertiles of moderate or vigorous intensive minutes of activity per week based on the International Physical Activity Questionnaire questions in the HSE.[13] The tertiles are sex specific, and exclude walking.[14] Activity level is characterized as low, medium, and high. For men, low physical activity was 0–120 minutes of moderate- to vigorous-intensity physical activity (MVPA) per week; medium MVPA was 121–840 minutes per week; and high MVPA was ≥841 minutes of MVPA per week. For women, low MVPA was defined as 0 minutes of MVPA per week, medium MVPA was defined as between 10 and 496 minutes of MVPA, and high MVPA was defined as ≥496 minutes MVPA per week.[15] The HSE MVPA measures included some values that were extremely high. Out of concern that these extremely high and unrealistic values would bias the analysis, respondents reporting >5,000 minutes of MVPA per week were excluded from the analysis. In doing so, 26 respondents were recoded as missing. Additionally, of individuals aged ≥20 years with available HbA1c measures and a normal BMI, a total of 156 were missing data on physical activity.

The second way physical activity was operationalized was whether a person was active ≥30 minutes per week, according to their responses on the International Physical Activity Questionnaire. Individuals were considered either active (≥30 minutes of MVPA per week) or inactive (<30 minutes MVPA per week).

Sitting time was analyzed. The HSE asks respondents how many minutes they usually spend sitting on a weekday.

Waist to hip ratio (WHR) was assessed because of its utility as a measure of abdominal obesity, which has been associated with metabolic problems.[14,16,17] The HSE includes a derived variable, mean WHR. Waist circumference was measured midway between the iliac crest and the costal margin twice.[9] The hip circumference was measured at the widest circumference over the buttocks and below the iliac crest twice.[9] The means of each number were used to create a mean WHR.[9] A WHR >0.85 in women or >0.90 in men was considered unhealthy.[18]

For this analysis, respondents were split into two age groups, those aged 20–44 years and those aged ≥45 years. The American Diabetes Association recommends screening for abnormal blood glucose for all adults aged >45 years, as the risk of developing diabetes increases with age.[4] Race/ethnicity was categorized as white, Asian, and other. Sex was defined as male and female.