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The effect of long work hours on physical activity and obesity in the state of Georgia

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Epidemiology

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2014

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An abstract of

A thesis submitted to the Faculty of the
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Abstract

The effect of long work hours on physical activity and obesity in the state of Georgia

By Miranda Cook

Background: Obesity affects 30.2% of Georgia adults, presenting a large economic and public health burden. Long work hours may be contributing to the rising obesity problem by reducing time for physical activity, particularly for individuals working in sedentary occupations.

Methods: Cross sectional analysis was performed using data from the 2015 Georgia Behavior Risk Factor Surveillance System to estimate the relationship between long work hours, leisure-time physical activity (LTPA), and obesity. Prevalence ratios were estimated across work hour and occupational activity groups and mediation analysis was performed to estimate the proportion of the relationship mediated by changes in LTPA associated with long work hours.

Results: Those working in low activity occupations were more likely to meet aerobic guidelines for LTPA compared to those in intermediate and high activity occupations (χ^2: 19.3; P-value: <0.01), however, ability to meet recommendations did not differ significantly across work hour categories. The impact of long work hours on obesity varied across occupational activity levels, with employees in intermediate activity occupations working long hours at the greatest risk for obesity. The estimated proportion of the relationship between long work hours and obesity mediated by inability to meet physical activity recommendations was 0.39% and the estimate was non-significant (Sobel test statistic:<0.01; P-value: 0.14).

Conclusion: These findings suggest that the effect of long work hours on obesity cannot be explained by the effects of long work hours on ability to meet aerobic guidelines on LTPA, however, stratified analyses suggest that occupational activity may play an important role in this relationship. Future work examining the role of occupational activity is required to better understand the mechanisms through which long work hours impact obesity risks.

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Table of Contents

Chapter I.

Background

Obesity affects over one hundred million US adults, presenting a large economic and public health burden. It increases an individual's risk of heart disease, stroke, type 2 diabetes, and certain types of cancer - some of the leading causes of preventable death.[1] According to 2015 Behavioral Risk Factor Surveillance System (BRFSS) age-adjusted estimates, 35.5% of all U.S. adults are obese.[2] In the state of Georgia, 30.2% of adults are obese according to 2015 BRFSS data, and the state has the 19th highest adult obesity rate in the nation.[2,3] Obesity rates have been steadily increasing both nationally and in Georgia over the past decades.[2,3] Current estimates for healthcare costs associated with obesity range from $147 billion to $210 billion per year.[4,5] In Georgia, these costs are estimated to be $2.1 billion or $250 per Georgian per year.[6] Obesity is a complex, multi-faceted public health problem with many contributing factors.

Factors contributing to obesity

Behavioral, biological, and societal factors contribute to the development of obesity with certain groups more affected than others. Demographic factors affecting obesity include sex, age, race and ethnicity, education, and income.[7,8] Based on 2014 Georgia BRFSS data, females are more likely to be obese than males (32.4% vs. 28.6%). Younger adults are the least likely to be obese of all age groups (17.0%) and middle-aged adults are more likely to be obese than those aged 65 or older (36.2% vs. 29.5%). Non-Hispanic Black adults are the most likely to be obese (37.8%), followed by non-Hispanic White adults (28.9%), Hispanic adults (23.3%), and non-Hispanic Asian adults (4.3%).[7] Adults with higher levels of education have lower prevalence of obesity with those with less than a high school education are the most likely to be obese (37.7%) and those with a college degree or higher are the least likely (25.6%). Additionally, those with

the lowest incomes have higher prevalence of obesity (39.7%) than those with the highest incomes (24.1%).[7] Although certain demographic factors may make one more likely to become obese, certain behavioral and biological processes also impact whether or not an individual becomes obese.

When an individual consumes more calories than expended, surplus energy gets stored in the body as fat, which can eventually lead to the development of obesity.[9] For this reason, both physical activity, which expends calories, and caloric intake, which contributes calories, play an important role in energy balance and determine whether an individual can maintain a healthy body weight, lose excess body weight, or maintain successful weight loss.[9] Physical activity is an important piece of the energy equation, as both consuming fewer calories overall and expending a greater number of calories through exercise can help to maintain a healthy weight. Adequate amounts of physical activity can contribute to the prevention of weight gain and lead to weight loss, especially if sustained for 12 months or longer.[10,11]

Physical activity recommendations and trends

Physical activity helps to maintain a stable weight over time but the amount needed varies person to person and depends on the caloric intake of the individual.[9] However, general guidelines for the population, as outlined in the 2008 Physical Activity Guidelines for Americans, recommend 150 minutes of moderate-intensity aerobic activity, 75 minutes of vigorous-intensity aerobic activity, or an equivalent combination of moderate- and vigorous- intensity aerobic activity.[9] Policies and efforts to increase physical activity include community-wide campaigns, individual health behavior change programs, social support interventions in community settings, urban design strategies and land-use policies, as well as transportation policies and practices.[12]

Despite the benefits associated with physical activity and national efforts to increase physical activity, only half of adults (50.2%) met the 2008 Physical Activity Guidelines in 2013.[7] Some groups are less likely to meet recommendations than others with younger, non-Hispanic White, male, more highly educated adults with higher household incomes the most likely to meet recommendations, both nationally and in Georgia. Based on 2013 Georgia BRFSS data, Hispanic adults are the least likely to meet guidelines (44.1%), non-Hispanic Black adults are slightly more likely (47.2%), and non-Hispanic White adults are the most likely to meet aerobic recommendations (53.5%). Men are more likely to meet guidelines than women (53.9% vs. 47.9%). Younger adults are more likely to meet guidelines than older adults, with adults 18-24 the most likely to meet recommendations (58.9%) and adults age 35-44 the least likely (47.3%). Adults with less education are less likely to meet recommendations, as those with less than a high school education are the least likely (37.1%) and college graduates the most likely (59.4%) to meet guidelines. Additionally, those with higher household incomes are more likely to meet recommendations than those with lower incomes. Adults in households making less than $15,000 a year are the least likely to meet recommendations (41.4%) and those in households making $75,000 or greater are the most likely to meet recommendations (61.1%).[7]

Americans living in the South are the least likely to be physically active of all regions in the country.[13] Georgia is the 15th most inactive state, with 27.3% of adults failing to meet CDC recommendations according to 2015 BRFSS data.[3] Proposed explanations for low physical activity rates include economic growth, technological advancements, and social changes such as changes in the workforce.[14,15] People are increasingly working longer hours in more sedentary jobs, which has potentially reduced the amount of time available for exercise, leading to weight gain.

Occupation trends and impacts on physical activity

The rise in low-activity occupations coupled with increasing work demands has resulted in long work hours in primarily sedentary roles, potentially reducing total physical activity for many Americans.[15–26] Historically in the United States, the labor market was primarily comprised of agricultural occupations. This shifted with the industrial revolution as manufacturing and goods-producing (ie. 'blue collar') occupations began to dominate the workforce landscape.[27] Industrial restructuring began nationally in the 1980s and 1990s, as advances in computer technology drove a shift away from manufacturing roles and towards more office-setting (ie. 'white collar') and professional roles.[27] The Southeastern United States remained a stronghold for manufacturing jobs into the early 2000s due to cost-competitiveness advantages of the region including inexpensive land costs, lower energy costs, and fewer union restrictions.[27,28] However, growth in trade and services industries in this region still outpaced manufacturing gains during this time. By 2015, the workforce composition in Georgia mirrored national trends more closely, with only 13.8% of employment geared towards goods-production, compared to 70.4% of employment devoted to service-producing occupations in the state.[29] These reductions in goods-producing jobs have given rise to more sedentary jobs in the workforce. Nationally, sedentary jobs have increased 83% since 1950 when 16 million people were employed in low-activity occupations. By 1970 that figure was 33.7 million and by 2000 it was 58.2 million.[27] Physically active jobs now account less than 20% of the workforce.[30] Full-time workers spend more than 8 hours per day at work, on average, with one-third to one-half of that time spent sitting down.[31]

Daily energy expenditure is determined, partially by the amount of physical activity that takes place at an individual's occupation and partially by the amount of physical activity that an individual performs in recreation, household, transportation, and other domains of life. From 1960 to 2008, average occupation-related expenditures from physical activity have declined by more than 100 calories per day for both men and women.[17] Their findings indicated that this

decline in occupation activity (OA) alone could account for a substantial portion of the increases in average BMI in the US over that same period.[17] While the relationship between OA and leisure-time physical activity (LTPA) is not entirely clear, most studies find that greater OA is associated with less LTPA.[32–41] The health benefits of OA are unclear, however the benefits of LTPA are robust.[42] Public health messages promote the importance of physically active lifestyles outside of the workplace to offset sedentary work roles. Many commonly cited barriers to meeting physical activity recommendations include a perceived lack of time due to work demands and responsibilities.[18–22]

Long work hours are increasing for all working Americans.[23–26] In 2014, 50% of all full-time employees in the US reported to work more than 40 hours per week on average and 39% reported to work 50 or more hours per week.[23–26] Prior to the 1980s, workers with the lowest income were more likely to work long hours than those with the highest income.[26] Recently however, the greatest increases in long work hours have largely been concentrated in the high-educated, high-income, older, salaried working population. By 2006, top paid workers were twice as likely to work long hours compared to the lowest paid.[26] These increases were not attributable to increased multiple jobholders, increased prevalence of long work hours among multiple jobholders, nor declines in employment.[26] Despite increased work hours being largely concentrated in higher SES workers, trends show that hours are increasing for all groups. It is possible that those working longer hours at lower levels of SES are affected differently than those of high SES. However, the role of SES has not been studied in-depth in research on work hours.

Studies have shown that working in occupations with high job demands and long hours diminishes opportunities for LTPA.[44–47] One study demonstrated that decreased work hours due to layoffs increased LTPA.[44] Although these increases were not shown to offset reductions in occupational and transportation-related physical activity experienced due to job loss, these findings point to a relationship between time spent at work and opportunities for leisure-time physical activity.[44] Other studies have shown that high job strain leads to reductions in physical

activity. Findings from these studies indicated that those who intended to exercise but did not exercise were more likely to report higher job demands than those who followed through on their intentions to exercise.[45–47]

A study in 2000 of Australian workers examined the role of occupation and work hours on LTPA, finding that physical activity generally decreased as work hours increased for males and noting a difficult to interpret trend for women.[20] In this study sample, females worked fewer hours than men and were more likely to work in part-time roles (defined as less than 35 hours per week). Additionally, blue collar workers were less likely to meet physical activity guidelines than professional and white collar workers. Physical activity reported by professionals and white collar works did not differ significantly.[20] Occupational variations in physical activity were not explained by work hours, pointing to potential effect modification by occupation type. Differences for part-time workers were detected for both genders, with those working fewer hours reporting greater LTPA than those working full-time. No differences in LTPA were detected for male or female full-time workers and were not changed when controlling for age, living situation, smoking status, BMI, and self-reported health. Their initial descriptive results suggested that professionals both worked longer hours and were more likely to meet physical activity recommendations, pointing to a more complex relationship.[20] Considering that salaried individuals with high education levels and incomes are the most likely to work long hours but are also the most likely to meet physical activity recommendations, it is plausible that some of the health risks associated with long work hours are being buffered by benefits that come from higher SES, obscuring effects across SES levels.[26]

Occupational impacts on obesity

Occupation factors such as the rise of sedentary jobs, increasing work hours, and increasing jobs demands are contributing to the high prevalence of obesity among US adults, potentially by diminishing opportunities for physical activity. Like physical activity rates, obesity

prevalence varies by occupational category and status. In general, prevalence of obesity is higher for those in blue collar occupations than for those in white collar or professional roles.[48–50] Although the highest prevalence of obesity remains concentrated disproportionately in blue collar positions, prevalence is increasing in white collar roles. A study examining National Health Interview survey data noted a significant increase in prevalence of obesity for those in white collar occupations between 2004-2007 and 2008-2011 but no change was noted for blue collar occupations.[48] Studies consistently find that workers in health care support, protective services, and transportation and material moving experience the highest prevalence of obesity.[49,51] These occupations are considered relatively highly demanding occupations often requiring employees to work long hours and providing low control over their work environment, characteristics which may increase risk of obesity.[52] Job stress and long work hours may lead to fatigue and reduce engagement in leisure time physical activity, leading to weight gain and obesity.[53] These findings point to a relationship wherein physical activity may mediate the observed relationship between long work hours and obesity.[52,53]

Long work hours have been shown to increase obesity risk.[50,52–60] In a systematic review of studies examining occupational factors related to obesity, 70% of studies reported positive associations between long work hours and weight-related outcomes.[54] Examining previous study estimates, the effect size appears to increase with increasing work hours, although comparability across studies is limited. Effect sizes for the increased risk of obesity associated with long work hours range from 1.08 for those working greater than 40 hours per week to 1.32 for those working greater than 50 hours weekly.[48,55,59] Another study demonstrated that the effect of sedentary work on obesity was modified by work hours for males, indicating that males in sedentary roles were more likely to be obese if they also worked greater than 40 hours per week. However, the same effect was not demonstrated for female workers.[55] Further, both longitudinal and cross-sectional studies have demonstrated an association between working long hours and weight gain. With

adults working long hours at increasingly sedentary jobs, the opportunities for LTPA may be diminished, potentially leading to weight gain and increased prevalence of obesity.

To counter occupation-induced reductions in physical activity, researchers have proposed that employers consider ways to increase physical activity for their employees on the job. Some proposed examples include encouraging employees or providing incentives to take walks during breaks, utilize more physically active forms of transportation such as walking or biking, and redesigning office spaces to include standing work stations or offering stability balls as alternative seating.[15,52,53] Proposed ways for employers to promote physical activity outside of the workplace include arranging challenges involving physical activity with incentives (ie. Incentivizing staff to accomplish physical activity challenges in teams for prizes) in addition to providing employees with educational materials and soliciting their ideas, tailoring the offerings to the employee-identified interests.[61] Further work is needed to better identify actionable, effective worksite obesity prevention strategies for varying occupation types, as many of the proposed strategies may only apply to specific occupation types.

Theoretical gaps

Previous analyses examining the impact of occupation type and long work hours on physical activity and obesity have not examined this effect through multiple domains of physical activity. Examining more than one domain of physical activity, both OA and LTPA, allows us to better understand the impacts of occupation on total physical activity and obesity.[40]

Additionally, by comparing occupations based on OA, we are able to capture variations in ability to meet physical activity recommendations and obesity risk across occupational categories.. Examining the effects of long work hours on physical activity and obesity in the context of OA is imperative as this factor may not only be a confounder but also an effect modifier of this relationship. Employees in white-collar and service industry positions may be

particularly vulnerable to health risks associated with long work hours. Specifically, they may be less likely to meet physical activity recommendations and have increased prevalence of obesity compared to blue-collar workers who may be meeting recommendations due to OA as well as professional and higher-income white-collar workers who are more likely to meet recommendations through LTPA.

Additionally, no analysis has investigated potential mediation by physical activity in the relationship between long work hours and obesity. This analysis proposes to quantify the proportion of effect of occupation on obesity that is mediated by physical activity. Specifically, we seek to quantify the proportion of effect mediated by reductions in physical activity associated with long work hours. Figure 1 illustrates the relationship proposed here.

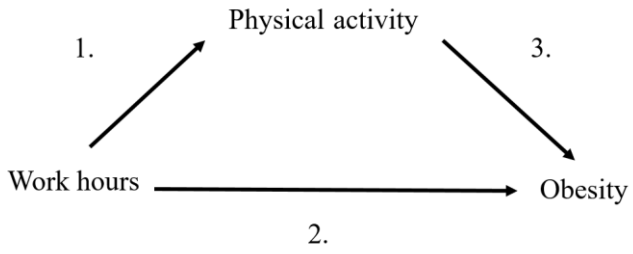

Figure 1. Directed acyclic graph (DAG) illustrating the relationship between work hours, physical activity, and obesity proposed. This study intends to 1) estimate the relationship between work hours and ability to meet aerobic guidelines, 2) estimate the relationship between work hours and obesity risks, and 3) estimate the proportion of the relationship between work hours and obesity that is mediated by reductions in physical activity associated with long work hours.

This study aims to better understand the relationship between long work hours, meeting physical activity recommendations, and obesity among adult men and women in the state of

Georgia. It contains three primary objectives. First, it intends to explore the relationship between long work hours and meeting physical activity recommendations by calculating prevalence ratios stratified by covariates as appropriate and adjusting for potential confounders. Second, it intends to explore the relationship between long work hours and obesity prevalence by calculating prevalence ratios stratified by covariates as appropriate and adjusting for potential confounders. Third, this study intends to estimate the controlled direct effect of long work hours on obesity and identify the proportion of the relationship mediated by changes in physical activity associated with long work hours.

Chapter II.

Manuscript

Abstract

The effect of long work hours on physical activity and obesity in the state of Georgia

By Miranda Cook

Obesity affects 30.2% of Georgia adults, presenting a large economic and public health burden. Long work hours may be contributing to the rising obesity problem by reducing time for physical activity, particularly for individuals working in sedentary occupations. Cross sectional analysis was performed using data from the 2015 Georgia Behavior Risk Factor Surveillance System to estimate the relationship between long work hours, leisure-time physical activity (LTPA), and obesity. Prevalence ratios were estimated across work hour and occupational activity groups and mediation analysis was performed to estimate the proportion of the relationship mediated by changes in LTPA associated with long work hours. Those working in low activity occupations were more likely to meet aerobic guidelines for LTPA compared to those in intermediate and high activity occupations (χ^2: 19.3; P-value: <0.01), however, ability to meet recommendations did not differ significantly across work hour categories. The impact of long work hours varied across occupational activity levels, with employees in intermediate activity occupations working long hours at the greatest risk for obesity. The estimated proportion of the relationship between long work hours and obesity mediated by inability to meet physical activity recommendations was 0.39% and the estimate was non-significant (Sobel test statistic: <0.01; P-value: 0.14). These findings suggest that the effect of long work hours on obesity cannot be explained by the effects of long work hours on ability to meet aerobic guidelines on LTPA, however, stratified analyses suggest that occupational activity may play an important role in this relationship. Future work examining the role of occupational activity is required to better understand the mechanisms through which long work hours impact obesity risks.

Introduction

Obesity affects over one hundred million US adults, presenting a large economic and public health burden. It increases an individual's risk of heart disease, stroke, type 2 diabetes, and certain types of cancer - some of the leading causes of preventable death.[1] Long work hours may be contributing to the rising obesity problem by reducing time for physical activity, particularly for individuals working in sedentary occupations, such as service roles, which have become increasingly common in the state of Georgia.[28]

Previous studies have estimated the impact of long work hours on increased risk of obesity.[50,52–60] In a systematic review of studies examining occupational factors related to obesity, 70% of studies reported positive associations between long work hours and weight-related outcomes.[54] Significant effect sizes for the increased risk of obesity associated with long work hours range from 1.08 for those working greater than 40 hours per week to 1.32 for those working greater than 50 hours weekly.[48,55,59]

Fewer studies have been conducted examining the mechanisms by which long work hours influence obesity risk. One explanation may be that those working long hours have reduced opportunities for physical activity. Many commonly cited barriers to meeting recommendations include a perceived lack of time due to work demands and responsibilities.[18–22] Of the few studies conducted examining this relationship, results point to diminished opportunities for leisure-time physical activity (LTPA) for those working in occupations with high job demands.[45–47] One study found examining the role of long work hours on LTPA reported that as work hours increased, LTPA generally decreased for the men in the study. However, the authors reported that the trend for women was difficult to interpret.[20] Findings also indicated that those in professional-type occupations were more likely to work long hours and meet LTPA recommendations, pointing to potential effect modification by occupation type. Those employed in higher status positions, and of higher SES, engage in more sedentary behavior

at work whereas those working in lower status positions are reporting more OA, oftentimes resulting in higher levels of total physical activity for those in lower status occupations.[40,41]

This study intends to investigate the impact of long work hours on physical activity and obesity across levels of OA, in order to identify potentially vulnerable groups. Further, this study will estimate the proportion of effect of long work hours on obesity that is mediated by LTPA to better understand the mechanism through which work hours impact obesity.

Methods

Study Design

This analysis was performed using data from the 2015 Georgia Behavioral Risk Factor Surveillance System (BRFSS). The BRFSS is a yearly state-based cross-sectional surveillance system of health-related telephone surveys that asks adult Georgians about health-related risk behaviors, chronic health conditions, and use of preventive services.[62] It has been collected by the Georgia Department of Public Health in collaboration with the CDC since 1984.[62]

Study Population

Of the 4,678 adults who participated in the 2015 Georgia state BRFSS, 3,139 were excluded due to missing work hours information, 618 due to missing physical activity information, 380 due to missing BMI information, 31 due to current pregnancy, and 3 based on being employed in the armed forces. The majority of exclusions were related to lack of current employment or employment within the last year. Of the 2,082 that were eligible to be asked occupation-related modules, 1,539 provided valid responses. After accounting for other study exclusions, a total of 1,425 were included in this study. Those included in the study had higher incomes but did not vary significantly on other study outcomes, exposures, or potential covariates compared to those excluded from the study.

Study Measures

Exposure: Work Hours

Data regarding work hours came from Georgia BRFSS Module 20: Social Context. Work hours were divided into categories of less than 40, 40-44, 45-49, 50-54, & greater than 55 hours per week based on Kirk and Rhodes' review which suggests that greater granularity

in work hours categorization may more clearly identify the threshold of work hours correlated with decreases in physical activity.[40]

Outcome: Obesity

Body mass index (BMI [kg/m^2]) was calculated based on respondent's self-reported height and weight. A BMI of less than 18.5 was considered underweight, a BMI greater than 18.5 and less than 25.0 was considered normal weight, a BMI greater than or equal to 25.0 and less than 30.0 was considered overweight, and a BMI greater than or equal to 30 was considered obese. BMI calculated from self-reported height and weight is highly correlated with BMI derived from measured height and weight, with r values approximating 0.90.[63] However, self-report measures tend to underestimate BMI. This bias is especially prominent for females, non-Hispanic whites, older adults, and those with higher BMIs.[64–67]

Mediator: Physical Activity

Data on vigorous LTPA were obtained as BRFSS calculated variables. Those that engaged in 150 or more minutes a week of moderate-intensity or 75 or more minutes a week of vigorous-intensity physical activity, or an equivalent combination of moderate- and vigorous-intensity activity were considered to meet aerobic physical activity recommendations, corresponding with the 2008 physical activity guidelines for Americans.[9]

Covariates

Certain demographic variables may be related to obesity, long work hours, and physical activity. To accurately estimate the relationship between long work hours and obesity as well as the relationship between long work hours and physical activity, several factors were considered as potential covariates. These included age, race and ethnicity, gender, education, healthcare

coverage, smoking status, poverty status, and occupational activity. Age was reported in the following ranges: 18-24, 25-34, 35-44, 45-54, 55-64, and 65 or older based on respondent's response to the question, "What is your age?". Race and ethnicity was reported by the respondent and categorized as follows based on most common races and ethnicities, including: Non-Hispanic White, Non-Hispanic Black, Hispanic, and Other. Gender of respondent was recorded as either male or female. Education level was categorized based on respondents answer to the question, "What is the highest grade or year of school you completed?" and recorded into the following three categories: Less than grade twelve, high school or some college, and college degree or higher. Health care coverage was recorded as either 'Yes' or 'No' based on respondent report which included any kind of health care coverage such as health insurance, prepaid plans such as HMOs, government plans such as Medicare, or Indian Health Services. Respondents were determined to be current smokers if they reported to smoke every day or some days and non-smokers if they were former smokers or never smoked.

Poverty status was derived from respondents' reported income and household size, based on Hawaii Health Data Warehouse Methodology.[68] Income was reported by respondent as annual household income from all sources and was categorized as follows: <$35,000, $35,000-$74,999, and $75,000 or more. Household size was reported as a continuous measure based on adults and children living in the household. For this analysis, each income range was collapsed into the midpoint value then divided by 2015 census poverty thresholds based on household sizes to obtain percentage poverty level. A dichotomous measure of poverty was created with participants at or below 100% of the poverty threshold considered to be in poverty, and those above this threshold considered to not be in poverty.

Information about respondents' current industry and occupation was collected in narrative form in the Georgia BRFSS Module 19: Industry and Occupation (I&O). These data were assigned four-digit census I&O codes and were then grouped into 20 industry groups, and

22 occupation groups according to Census 2002 Industry and Occupation Codes.[69] These categories were then subdivided into groups based on OA according to standardized accelerometer-derived categorizations which ranked occupations based on tertiles of activity (Table 1 of the appendix).[70]

Analysis

Data were analyzed by procedures in SAS 9.3 and SAS-callable SUDAAN 11.0.1, accounting for complex sample survey design. To represent the Georgia civilian, noninstitutionalized population over the age of 18 years, estimates were weighted using Georgia BRFSS individual sample adult record weights. Statistical methods included the use of descriptive parameters, Pearson's χ^2 test, and prevalence ratios. Confidence intervals were calculated using conditional marginal methods.

Demographic characteristics were examined for both the unweighted and weighted study population. Prevalence of meeting aerobic guidelines and obesity were examined across demographic and other study characteristics. Mean work hours were examined across levels of demographic and other study characteristics. Pearson's χ^2 test was used to test for statistically significance of differences between groups. Both unweighted and weighted sample proportions were examined for each work hour category, then prevalence of underweight, normal weight, overweight, and obesity were examined across work hour categories. Prevalence ratios were calculated for both prevalence of obesity and prevalence of meeting aerobic physical activity guidelines using the conditional method logistic regression stratified by work hour categories and OA categories. The reference value was set as the prevalence for those working 40-44 hours weekly. Other models were tested with covariates including age, sex, race and ethnicity, education, health care coverage, smoking status, marital status, poverty status, financial security,

and food security, however, model selection found no significant confounding variables nor interaction terms, therefore, only unadjusted estimates are presented.

Mediation analysis was performed according to the Baron and Kenny approach, adapted by MacKinnon and Dwyer for use with dichotomous variables.[71–73] Long work hours were defined as working greater than 44 hours weekly, based on results of bivariate analyses. The total effect of long work hours on obesity was estimated by running the conditional method logistic model regressing prevalence of obesity on work hours. The direct effect of long work hours on obesity was estimated by running a model regressing long work hours on obesity controlling for physical activity. The total effect of long work hours on ability to meet physical activity recommendations was estimated by running a model regressing physical activity on work hours. Coefficients were made comparable across equations by multiplying each coefficient by the standard deviation (SD) of the predictor variable then dividing the SD of the outcome variable. Variances were obtained from equations derived from Mackinnon and Dwyer's method.[72,73] Comparable standard errors were calculated by dividing SD of the predictor variable by SD of the outcome variable. Percent mediated was calculated by dividing the estimated indirect effect by the estimated total effect according to Baron and Kenny methodology.[71,73] The Sobel test was used to test for significance.[74] No exposure-mediator or exposure-outcome confounders were detected in the data when examining potential covariates, therefore unadjusted estimates are presented.

Results

Data were available for 1,425 working adults in the state of Georgia, representing 2,709,568 people. Over half of the weighted population was non-Hispanic white, male, and those aged 35-54 (Table 1). Less than half of the sample met aerobic guidelines for LTPA and 68.2% of the population was overweight or obese (Table 1). Ability to meet aerobic guidelines for LTPA did not vary significantly across categories of sex, age, household income, poverty status, health care coverage, or smoking status (Table 2). Ability to meet aerobic guidelines varied significantly across categories of race/ethnicity, education, and occupational activity with non-Hispanic whites, college graduates, and employees is low activity occupations the most likely to meet guidelines (Table 2). Obesity prevalence did not vary across categories of race/ethnicity, sex, age, education, household income, smoking status, or occupational activity (Table 2). However, employees below the poverty level were significantly more likely to be obese than those above the poverty level (Table 2). Work hours did not significantly vary by race/ethnicity, education, or smoking status (Table 3). Work hours significantly varied across sex, age, income, health care coverage, and occupational activity categories with males, those aged 35-44, those with the highest incomes, those with health care coverage, and those working in low activity occupations reporting the longest work hours (Table 3).

The impact of long work hours on meeting aerobic guidelines

Nearly half (47.8%) of the weighted sample met aerobic physical activity recommendations (Table 1). No significant differences in meeting aerobic guidelines were found between males and females (χ^2: 5.7; P-value: 0.06) nor age groups (χ^2: 16.5; P-value: 0.07; Table 2). However, there were significant differences across race and ethnicity groups (χ^2: 21.4; P-value: <0.05) as well as across education groups (χ^2: 23.8; P-value: <0.01) and occupational activity groups (χ^2: 19.3; P-value: <0.01; Table 2). Work hours varied significantly across occupational activity groups with those in low activity occupations reporting the longest weekly

work hours on average (χ^2: 38.4; P-value: <0.01; Table 3). Employees working 40-44 hours a week made up 36.3% of the population and those working 45+ hours weekly made up 41.9% (Table 4). In general, employees working longer hours were more likely to meet aerobic guidelines. Workers reporting to work 45-49 hours weekly were the most likely to meet guidelines.

Prevalence ratio estimates for meeting aerobic guidelines across OA groups indicate that overall, those working in low activity occupations are more likely to meet aerobic guidelines than those working higher activity jobs (χ^2: 12.6; P-value: <0.05) (Table 5). Workers reporting to work 45-49 hours a week in high activity occupations were twice as likely to meet aerobic guidelines than those working 40-44 hours weekly (95% CI: 1.02, 4.27; Table 5). Although effects were mostly not significant across work hour categories for those in intermediate and low activity occupations, the general trend found that workers reporting over 44 hours weekly in low activity occupations were more likely to meet aerobic guidelines compared to those working 40-44 hours weekly. Employees working 50 hours or more weekly in intermediate activity occupations were less likely to meet physical activity recommendations than those working 40-44 hours weekly, although this effect was also not significant.

The impact of long work hours on obesity

The overall prevalence of obesity was 30.8% (Table 1). Obesity prevalence did not significantly differ by sex (χ^2: 2.5; P-value: 0.23), race and ethnicity (χ^2: 13.7; P-value: 0.09), education (χ^2: 7.3; P-value: 0.19), age (χ^2: 14.1; P-value: 0.14; Table 2), household income (χ^2: 4.3; P-value: 0.28), healthcare coverage status (χ^2: 0.2; P-value: 0.80), smoking status (χ^2: 0.8; P-value: 0.52), nor occupational activity (χ^2: 0.8; P-value: 0.80; Table 2). Employees below the poverty level were significantly more likely to be obese than those above the poverty level (χ^2: 8.9; P-value: <0.05; Table 2).

Employees working 45-49 hours weekly had the highest prevalence of obesity of all work hours categories (46.1%). Those working less than 40 hours weekly had the lowest prevalence of obesity (25.4%; Table 6). Obesity prevalence ratios across occupation activity groups reveal differences between workers in intermediate activity occupations and low activity occupations. Employees in low activity occupations working more than 55 hours weekly were approximately half as likely to be obese than those working 40-44 hours weekly (95% CI: 0.32, 0.76; Table 7). Employees working less than 40 hours weekly in low activity occupations were approximately 40% less likely to be obese than those working 40-44 hours weekly (95% CI: 0.04, 0.95). Workers in intermediate activity occupations working 50-54 hours weekly were almost twice as likely to be obese than those working 40-44 hours weekly (95% CI: 1.18, 3.28). No significant differences or trends were found across work hour categories for workers in high activity occupations (Table 7).

Mediation of the relationship between long work hours and obesity

On average, working greater than 44 hours weekly was not significantly associated with greater risk of obesity (PR for the total effect: 1.17; 95% CI: 0.95, 1.43). Controlling for physical activity, the direct effect of working more than 44 hours weekly was not significantly associated with increased risk in obesity (PR for the direct effect: 1.19; 95% CI: 0.97, 1.46). Working greater than 44 hours weekly was significantly associated with a 13% decreased risk of not meeting aerobic recommendations (PR: 0.87; 95% CI: 0.76, 1.00). The estimated proportion of the relationship between long work hours and obesity mediated by inability to meet physical activity recommendations was 0.39%, although the estimate was non-significant (Sobel test statistic: <0.01; P-value: 0.14).

Discussion

Our hypothesis that reduced ability to meet leisure-time aerobic guidelines may explain the relationship between long work hours and obesity was not supported by this analysis. This analysis found no association between work hours and LTPA and no global effect of long work hours on obesity, however significant effects were found in across OA categories, suggesting effect modification by physical activity level at work.

Long work hours did not significantly affect ability to meet aerobic guidelines for LTPA, however the general trend suggested that employees in intermediate activity occupations may be less likely to meet recommendations than employees in high or low activity occupations. These findings are surprising, as some of the most commonly cited barriers to participating in physical activity include a perceived lack of time due to work demands and responsibilities.[18–22] However, these findings correspond with previous study results suggesting incongruences between perceived and actual barriers, with lack of time and work demands presenting a "convenient excuse" to avoid demanding activity.[20]

Long work hours impacted obesity risks differently for employees in intermediate and low activity occupations but had no significant effect for employees in high activity occupations. Employees in intermediate activity occupations such as healthcare support, sales, and transportation and material moving, were more likely to be obese when working long hours compared to those working 40-44 hours weekly. However, employees in low activity occupations such as office and administrative support, management, and education, were less likely to be obese when working long hours compared to those working 40-44 hours a week. Research on occupational trends in Georgia indicate that many workers formerly employed in manufacturing and goods-producing roles may now be employed in service roles.[28] Perhaps these workers are experiencing increased obesity risk due to reductions in occupational activity.[17] The results from this analysis found no significant differences in prevalence of meeting aerobic

guidelines between those in high and low activity occupations (p=0.7390), supporting the notion that these workers may have similar leisure time lifestyles. It is plausible that a worker previously employed in a high activity occupation, now working in an intermediate activity occupation may not compensate for the reductions in occupation physical activity in his or her leisure time, leading to weight gain and increased risk of obesity. Previous studies have found global associations between long work hours and obesity but our findings suggest that occupational activity may modify the relationship, affecting employees differently across occupations.[50,57,75]

Results of mediation analysis indicate that, globally, long work hours do not significantly impact obesity risks, however, working greater than 44 hours weekly was associated with increased likelihood to meet aerobic recommendations. These findings are surprising, as the majority of previous studies examining this relationship found significant global associations.[50,57,75] Ability to meet physical activity recommendations for LTPA did not significantly mediate a proportion of the relationship between long work hours and obesity. This finding is not surprising, as no significant relationship between long work hours and obesity was detected, and corresponds to previous study findings suggesting that working long hours does not impact ability to meet physical activity recommendations.[20]

Strengths of this study included the inclusion of OA categories in the analysis, greater granularity of work hour categories than previous studies, and the addition of a mediation analysis. BRFSS only reports on leisure time physical activity, however, leaving occupational activity less clear at the individual level. Occupation groups were used as a proxy for occupation activity based on previous accelerometer data research but further work is needed to better understand the role occupational activity plays in the relationship between long work hours and obesity.[70] Previous literature reviews have suggested both that physical activity performed on the job may present as a confounder or effect modifier and that greater granularity of work hour

categories was needed to better identify thresholds of risk for employees so this analysis sought to take these factors into account. Further, no previous studies found have investigated mediation by physical activity in the relationship between work hours and obesity. Although this study found no evidence of mediation, it is an important factor to consider in future mechanistic inquiries into this relationship.

This study may have been constrained by at least two key limitations. First, BRFSS uses self-report data with may have resulted in an underestimation in overall prevalence of obesity. However, BMI calculated from self-reported height and weight is highly correlated with BMI derived from measured height and weight, with r values approximating 0.90.[63] Second, only workers employed or self-employed within the previous year were included in this analysis, based on BRFSS sampling procedures, excluding a large number of those sampled for the survey. However, analysis of key variables did not find significant differences for those excluded, with a few exceptions. Those included in the sample had higher income and education and were younger, on average, than those who were excluded. It is possible that sampling bias may have occurred in such a way that those available to take the survey differed from the rest of the population. Perhaps busier employees with higher work demands were less likely to take the survey, potentially underestimating the effect of long work hours on physical activity and obesity.

Results of this study indicate that the effects of long work hours vary across OA levels, with those in intermediate occupations at the greatest risk for obesity when working long hours. These employees may be particularly vulnerable, presenting as good targets for future intervention work. Further, this study found no evidence that long work hours impact obesity risk through pathways involving LTPA, implying that commonly cited barriers to exercise such as high work demands and fatigue after work may be less impactful than previously thought. Future work is needed to identify other potential mechanistic routes through which long work hours impact obesity risks.

Tables

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Table 1. Demographic characteristics of study population, 2015 Georgia BRFSS

Demographic Characteristics	Unweighted sample size	Unweighted (*n* = 1,425) (%)	Weighted (*n* = 2,709,568) (%)
Race/Ethnicity			
Non-Hispanic White	943	66.7	58.1
Non-Hispanic Black	353	25.0	29.1
Hispanic	55	3.9	8.2
Other	63	4.5	4.6
Sex			
Male	680	47.7	54.8
Female	745	52.3	45.2
Age			
18 - 24	57	4.0	8.9
25 - 34	169	11.9	19.2
35 - 44	276	19.4	25.9
45 - 54	380	26.7	25.1
55 - 64	358	25.1	15.1
65+	185	13.0	5.8
Education			
Did not graduate high school	74	5.2	10.7
Graduated high school or attended some college	693	48.7	58.6
Graduated from college or technical school	656	46.1	30.7
Household Income			
< $35,000	338	26.3	31.4
$35,000 - $74,999	421	32.7	33.6
≥ $75,000	527	41.0	35.0
Poverty Status			
Above poverty level	716	93.5	91.0
Below poverty level[1]	50	6.5	9.0
Healthcare Coverage			
Has coverage	1277	89.9	84.2
Does not have coverage	144	10.1	15.8
Smoking Status			
Not current smoker	1,200	84.7	81.3
Current smoker	217	15.3	18.7
Aerobic Guidelines			
Did not meet aerobic guidelines	715	50.2	52.2
Met aerobic guidelines[2]	710	49.8	47.8
Obesity Status			
Underweight	12	0.8	0.9
Normal weight	440	30.9	30.3
Overweight	535	37.5	38.0
Obese	438	30.7	30.8

1. Defined as at or below 100% of the poverty line

2. Defined as receiving 150 or more minutes of moderate physical activity per day or vigorous equivalent

Table 2. Prevalence of meeting aerobic guidelines and obesity by potential covariates, 2015 Georgia BRFSS

Demographic characteristics	Weighted prevalence of meeting aerobic guidelines %	χ^2 p-value for group	Weighted prevalence of obesity %	χ^2 p-value for group
Race/Ethnicity		0.01		0.09
Non-Hispanic White	53.1		28.4	
Non-Hispanic Black	41.9		37.3	
Hispanic	38.9		31.9	
Other	37.4		20.5	
Sex		0.06		0.23
Male	50.7		29.0	
Female	44.3		32.9	
Age		0.07		0.14
18 - 24	44.1		18.3	
25 - 34	41.1		35.0	
35 - 44	45.6		30.4	
45 - 54	55.1		31.1	
55 - 64	52.0		34.8	
65+	42.5		25.9	
Education		<0.01		0.19
Did not graduate high school	34.2		30.6	
Graduated high school or attended some college	46.0		33.4	
Graduated from college or technical school	55.9		26.0	
Household Income		0.58		0.28
< $35,000	46.6		32.6	
$35,000 - $74,999	47.9		34.0	
≥ $75,000	51.1		27.8	
Poverty Status		0.20		<0.05
Above poverty level	48.5		35.1	
Below poverty level[1]	35.1		53.1	
Healthcare Coverage		0.54		0.80
Has coverage	48.3		29.6	
Does not have coverage	44.9		30.9	
Smoking status		0.91		0.52
Not current smoker	47.7		31.5	
Current smoker	47.2		28.7	
Occupational Activity[2]		<0.01		0.80
High activity	40.5		27.8	
Intermediate activity	42.4		29.7	
Low activity	54.1		31.0	

1. Defined as at or below 100% of the poverty line

2. Occupational activity classifications provided in Table 1 of the appendix

Table 3. Mean work hours by potential covariates, 2015 Georgia BRFSS

Demographic characteristics	Weighted mean work hours (SE)	χ^2 p-value for group
Race/Ethnicity		0.07
Non-Hispanic White	43.8 (0.5)	
Non-Hispanic Black	43.5 (0.8)	
Hispanic	39.6 (2.2)	
Other	46.3 (2.7)	
Sex		<0.01
Male	46.2 (0.6)	
Female	40.3 (0.7)	
Age		<0.01
18 - 24	37.8 (2.0)	
25 - 34	42.8 (1.0)	
35 - 44	46.3 (1.0)	
45 - 54	45.2 (0.8)	
55 - 64	43.4 (0.8)	
65+	34.5 (1.3)	
Education		0.15
Did not graduate high school	41.2 (1.8)	
Graduated high school or attended some college	42.9 (0.6)	
Graduated from college or technical school	45.3 (0.6)	
Household Income		<0.01
< $35,000	39.9 (0.9)	
$35,000 - $74,999	44.9 (0.8)	
≥ $75,000	46.6 (0.7)	
Poverty Status		<0.01
Above poverty level	43.5 (0.6)	
Below poverty level[1]	31.4 (2.4)	
Healthcare Coverage		<0.05
Has coverage	43.9	
Does not have coverage	40.9	
Smoking status		0.85
Not current smoker	43.4 (0.5)	
Current smoker	43.6 (1.1)	
Occupational Activity[2]		<0.01
High activity	40.5	
Intermediate activity	42.6	
Low activity	45.3	

1. Defined as at or below 100% of the poverty line
2. Occupational activity classifications provided in Table 1 of the appendix

Table 4. Distribution of work hours in sample population, 2015 Georgia BRFSS

Work hours per week	**Unweighted sample size**	**Unweighted (*n* = 1,425) (%)**	**Weighted (*n* = 2,709,568) (%)**
<40	331	23.2	21.8
40 - 44	503	35.3	36.3
45 - 49	104	7.3	7.7
50 - 54	217	15.2	14.4
> 55	270	18.9	19.8

Table 5. Prevalence of meeting aerobic guidelines by work hour categories and occupation activity (OA) levels, 2015 Georgia BRFSS

Occupational activity[1]	**Work hours**	**Weighted prevalence of meeting aerobic guidelines % (95% CI)**	**Unadjusted model PR (95% CI)**
High OA	< 40	30.7 (15.7, 45.6)	0.91 (0.47, 1.76)
	40 - 44	33.8 (18.6, 49.1)	Ref.
	45 - 49	70.7 (31.5, 100.0)	**2.09 (1.02, 4.27)**
	50 - 54	57.1 (32.0, 82.2)	1.69 (0.90, 3.17)
	> 55	50.9 (29.5, 72.2)	1.50 (0.81, 2.78)
Intermediate OA	< 40	47.1 (33.0, 61.1)	1.13 (0.76, 1.68)
	40 - 44	41.6 (30.8, 52.4)	Ref.
	45 - 49	53.2 (30.0, 76.4)	1.28 (0.77, 2.12)
	50 - 54	34.3 (20.5, 48.0)	0.82 (0.51, 1.33)
	> 55	40.4 (27.1, 53.8)	0.97 (0.64, 1.48)
Low OA	< 40	52.1 (41.3, 62.9)	1.04 (0.80, 1.35)
	40 - 44	50.0 (42.2, 57.8)	Ref.
	45 - 49	55.0 (38.2, 71.7)	1.10 (0.78, 1.55)
	50 - 54	54.7 (43.7, 65.8)	1.10 (0.85, 1.41)
	> 55	61.3 (51.3, 71.4)	1.23 (0.98, 1.54)

1. Occupational activity classifications provided in Table 1 of the appendix

Table 6. Distribution of BMI (kg/m^2) categories by work hours, 2015 Georgia BRFSS

Work hours	Unweighted sample size (n = 1,425)	Total weighted sample size (n = 2,709,568)	Weighted prevalence underweight %	Weighted prevalence normal weight %	Weighted prevalence overweight %	Weighted prevalence obesity %
< 40	331	591,894	1.4	41.3	32.0	25.4
40 - 44	503	982,819	1.2	29.7	38.3	30.8
45 - 49	104	207,986	0.0	19.7	34.2	46.1
50 - 54	217	389,077	1.1	23.2	44.1	31.7
> 55	270	537,792	0.3	28.6	41.1	30.0

Table 7. Prevalence of obesity by work hour categories and occupation activity (OA) levels, 2015 Georgia BRFSS

Occupational activity[1]	**Work hours per week**	**Weighted prevalence of obesity (%, 95% CI)**	**Unadjusted model PR (95% CI)**
High OA	< 40	23.3 (7.7, 39.0)	0.74 (0.33, 1.68)
	40 - 44	31.6 (16.6, 46.5)	Ref.
	45 - 49	42.5 (0.0, 86.9)	1.35 (0.43, 4.23)
	50 - 54	9.8 (0.0, 23.6)	0.31 (0.07, 1.37)
	> 55	39.5 (18.1, 60.9)	1.25 (0.61, 2.57)
Intermediate OA	< 40	28.7 (16.8, 40.5)	1.28 (0.74, 2.20)
	40 - 44	22.5 (14.5, 30.4)	Ref.
	45 - 49	31.5 (7.8, 55.1)	1.40 (0.61, 3.21)
	50 - 54	44.1 (27.8, 60.5)	**1.97 (1.18, 3.28)**
	> 55	33.9 (20.5, 47.3)	1.51 (0.89, 2.57)
Low OA	< 40	23.4 (14.4, 32.3)	**0.61 (0.40, 0.95)**
	40 - 44	38.1 (30.2, 46.0)	Ref.
	45 - 49	53.5 (37.0, 70.1)	1.41 (0.97, 2.04)
	50 - 54	27.7 (17.3, 38.0)	0.73 (0.47, 1.11)
	> 55	18.8 (11.8, 25.8)	**0.49 (0.32, 0.76)**

1. Occupational activity classifications provided in Table 1 of the appendix

Chapter III.

Public Health Implications and Future Directions

Workers identified to be at the greatest increased risk for obesity when working long hours were those working in occupations requiring intermediate occupational physical activity. These positions included many service-oriented roles such as health care support, sales, and personal care and services. Previous work on occupational trends in the United States indicate that many former manufacturing workers may now work in service industry roles. It is plausible that reductions in occupation activity for these workers has resulted in increased risk of obesity, especially when subjected to long working hours. These individuals may have grown accustomed to their lifestyles while working higher activity occupations and never altered their leisure time activity to reflect the reductions in occupational physical activity upon transitioning to lower activity occupations.

Future work to better understand the mechanisms through which long work hours impact obesity risks for workers many benefit from national level data analysis. Conclusions from the analysis presented here are only applicable to workers in the state of Georgia, which may differ from national workers due to occupational trends in the state of Georgia. To better understand the impacts of increasing work hour trends for all Americans, a larger sampling frame is necessary. Findings from a national sample may also help to identify key differences in the effect of long work hours on obesity between Georgia and the rest of the country. Georgia, in particular, has been slower to transition away from manufacturing and goods-producing industries than other states, which may have impacted the results found in this analysis. If workers in the Georgia state BRFSS are more likely to have recently transitioned from high activity occupations to lower activity ones, these results may indicate a lag time in lifestyle change following occupation transitions. No information is provided in BRFSS on previous occupation or length of

current employment, therefore, further exploration of this topic would require identifying new relevant datasets or possibly data collection.

Another addition that could be provided by future work include additional analyses involving diet quality data. Physical activity is only one half of the energy equation, with nutrition making up the other portion. Results from this analysis indicate that reductions in leisure time physical activity associated with long work hours do not explain a large portion of the relationship between long work hours and increased obesity risks. Perhaps diet has a stronger impact on this relationship. It is plausible that those working longer hours may have less time for meal preparation and shopping for healthy foods, perhaps resulting in increased tendencies to make eating decisions out of convenience. Analysis of BRFSS fruit and vegetable consumption data could provide information on diet quality. However, to fully analyze the possibility of increased consumption of convenience foods, another dataset or data collection would be required, as BRFSS does not collect information on food purchasing location or frequency of fast food purchases. Other possible mechanisms through which long work hours may impact obesity may be increased stress associated with working long hours. It seems plausible that individuals working longer hours experience higher levels of stress, which may increase obesity risks. BRFSS does not collect information on work-related stress, necessitating the identification of other datasets or data collection for further investigation. In addition to exploring the possibility of a mechanistic role of diet or stress, future work may require more exploratory or hypothesis-generating work. Interviewing employees working long hours in various occupation types may help to identify potential themes and further elucidate the relationship between work hours and obesity risks.

The trend of increasing work hours may have large implications in obesity prevalence at the national level, despite relatively small effect sizes. An increased risk of 17% applied over a population may contribute substantially to prevalence of obesity over time. Further work is

needed to fully understand the relationship between work hours and obesity. Identifying other mechanisms through which work hours affect obesity may be important for the identification of potential interventions aimed at workers at the greatest risks for obesity.

Appendix

Table 1. Occupational activity (OA) classification of occupational groups reported in 2015 Georgia BRFSS

Occupational Activity	Occupation
High OA	Building and Grounds Cleaning and Maintenance
	Farming, Forestry, and Fishing
	Construction and Extraction
	Food Preparation and Serving
Intermediate OA	Business and Financial Operations
	Healthcare Support
	Personal Care and Services
	Sales and Related
	Installation, Repair, and Maintenance
	Production
	Transportation and Material Moving
Low OA	Management
	Architecture and Engineering
	Life, Physical, and Social Sciences
	Community and Social Services
	Legal
	Education
	Arts, Design, Entertainment, Sports, and Media
	Healthcare Practitioners and Technical
	Protective Services
	Office and Administrative Support
	Computer and Mathematical

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