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The association between long work hours and leisure-time physical activity and obesity

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ABSTRACT

Obesity affects approximately one-third of all U.S. 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. This study sought to investigate the association between long work hours, leisure-time physical activity (LTPA), and obesity across levels of occupational activity in order to identify potentially vulnerable groups. Cross sectional analysis was performed in 2017 using data from the 2015 Georgia Behavioral Risk Factor Surveillance System and prevalence ratios were estimated across work hour and occupational activity groups. Ability to meet guidelines for LTPA did not differ significantly across work hour categories overall. 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). Results of interaction assessment demonstrate that the effects of work hours on obesity risk and meeting aerobic guidelines are significantly different across OA categories, indicating OA to be an effect modifier of the relationship between long work hours and obesity (χ^2: 13.33; *P*-value: < 0.001; χ^2: 4.42; *P*-value: < 0.05). Employees in intermediate activity occupations working long hours were found to be at the greatest risk for obesity. Further research is required to better understand the mechanisms impacting the relationship between long work hours, domains of physical activity, and obesity risk as well as to identify effective intervention and prevention programs for employees in intermediate activity occupations.

1. 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 (NHLBI Obesity Education Initiative Expert Panel on the Identification Evaluation and Treatment of Obesity in Adults (US), 1998). 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, mirroring trends nation-wide (Kasarda, 1995; Henderson, 2015).

Previous studies have estimated the association between long work hours and increased risk of obesity (Solovieva et al., 2013; Choi et al., 2010; Schulte et al., 2007; Yamada et al., 2002; Shields, 1999; Jang et al., 2013; Luckhaupt et al., 2014; Nakamura et al., 1998; Lallukka et al., 2005; Lallukka et al., 2008a). 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 (Solovieva et al., 2013). Significant effect sizes for the increased risk of obesity associated with long work hours range from 1.08 for those working > 40 h per week to 1.32 for those working > 50 h weekly (Gu et al., 2014; Choi et al., 2010; Lallukka et al., 2005).

Fewer studies have been conducted examining the mechanisms by which long work hours influence obesity risk. One explanation frequently proposed is that those working long hours have reduced opportunities for physical activity (Brownson et al., 2005; Church et al., 2011; Jans et al., 2007; Johnson et al., 1990; Trost et al., 2002; Burton and Turrell, 2000; Reichert et al., 2007; Welch et al., 2009). Many commonly cited barriers to meeting recommendations include a perceived lack of time due to work demands and responsibilities (Johnson et al., 1990; Trost et al., 2002; Burton and Turrell, 2000; Reichert et al., 2007; Welch et al., 2009). However, evidence on the subject is mixed, with some research indicating that longer work hours do, in fact, reduce incidence of regular physical activity (Burton and Turrell, 2000; Wu and Porell, 2000; Takao et al., 2003; Schneider and Becker, 2005; Popham and Mitchell, 2006; Artazcoz et al., 2009). Other research

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shows no negative associations (Shields, 1999; Grzywacz and Marks, 2001; Lallukka et al., 2004; Lallukka et al., 2008b; Angrave et al., 2015). Even among studies finding an effect, relationships are small in magnitude and/or only significant for certain subgroups (Burton and Turrell, 2000; Wu and Porell, 2000; Takao et al., 2003; Artazcoz et al., 2009). Some studies have demonstrated differences in effect across occupational groups, pointing to potential effect modification by occupation type, with findings indicating that those in professional-type occupations were more likely to work long hours and meet leisure-time physical activity (LTPA) recommendations (Burton and Turrell, 2000; Wu and Porell, 2000). Those employed in higher status positions, and of higher socioeconomic status (SES), engage in more sedentary behavior at work whereas those working in lower status positions report more occupational activity (OA), oftentimes resulting in higher levels of total physical activity for those in lower status occupations (Kirk and Rhodes, 2011; Steele and Mummery, 2003). Previous studies have not included detailed occupational activity measures in a large, statewide population, as most studies that have focused on occupation-related factors have categorized the variable hierarchically (i.e. White collar, blue collar, etc.). This study intended to investigate the association between long work hours, physical activity, and obesity across levels of OA, rather than hierarchical occupation, in order to identify potentially vulnerable groups based on job type. Based on findings from previous literature, we hypothesized that employees working long hours would be less likely to meet aerobic guidelines for physical activity, be more likely to be obese, and that these relationships would be significantly modified by occupation type.

2. Methods

This analysis was performed in 2017 using data from the 2015 Georgia Behavioral Risk Factor Surveillance System (BRFSS). The BRFSS is a yearly state-based cross-sectional surveillance system of telephone surveys that asks about health-related risk behaviors, chronic health conditions, and use of preventive services (Georgia Department of Public Health, 2016).

Of the 4678 adults who participated in the 2015 Georgia state BRFSS, 2082 were currently employed for wages or self-employed and therefore eligible to be asked occupation-related modules and 1539 provided valid responses regarding work hours (1–96 h weekly). After accounting for other study exclusions, a total of 1425 were included in this study. Those included in the sample had higher income and education and were younger, on average, than those who were excluded but did not vary significantly on other study outcomes, exposures, or potential covariates.

2.1. Measures

The two outcome variables were physical activity and obesity. Physical activity was assessed based on response to a series of validated questions related to the frequency, intensity, and duration of a respondent's physical activity behaviors (Yore et al., 2007). The series of questions related to moderate physical activity began by asking: *During the past week, other than your regular job, did you participate in any physical activities or exercises such as running, calisthenics, golf, gardening, or walking for exercise?* If a respondent answered yes, information about the type, frequency, and duration of the activity was then obtained. Vigorous physical activity was assessed in the same manner with vigorous activity defined as any activity that causes a large increase in breathing rate or heart rate such as running, aerobics, or heavy yard work. 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 (U.S. Department of Health and Human Services, 2008). Body mass index (BMI [kg/m^2]) was used to determine obesity status and calculated based on respondent's self-reported height and weight. A BMI of < 18.5 was considered underweight, a BMI > 18.5 and < 25.0 was considered normal weight, a BMI greater than or equal to 25.0 and < 30.0 was considered overweight, and a BMI greater than or equal to 30 was considered obese (Centers for Disease Control and Prevention, 2017).

Weekly hours of work were considered the exposure variable of interest. Work hours were divided into categories (< 40, 40–44, 45–49, 50–54, & ≥55 h/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 (Kirk and Rhodes, 2011). Information about respondents' current industry and occupation was collected in narrative form, assigned four-digit census Industry and Occupation codes and were then grouped into 20 industry groups, and 22 occupation groups according to Census 2002 Industry and Occupation Codes (United States Census Bureau, 2002). These categories were then subdivided into groups based on OA according to standardized accelerometer-derived categorizations which ranked occupations based on tertiles of activity (High, intermediate, low; Appendix Table 1; Steeves et al., 2015).

Several covariates were considered in this analysis. Self-reported data on race and ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, other), sex (male, female), age (18–24, 25–34, 35–44, 45–54, 55–64, ≥65 years), education (< high school, high school or some college, college or technical school degree or higher), and household income (< $25,000, $35,000–$74,999, ≥$75,000) were utilized as potential covariates. Poverty status was derived from respondents' reported income and household size, based on 2015 U.S. Census Bureau Federal Poverty Thresholds (United States Census Bureau, 2015). For this analysis, reported income (< $35,000, $35,000–$74,999, and ≥ $75,000) was collapsed into the midpoint value then divided by 2015 census poverty thresholds based on reported household size to obtain percentage poverty level (Hawaii Health Data Warehouse, 2006). 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. Health care coverage was dichotomized (yes, no) based on response to the question: *Do you have any kind of health-care coverage including health insurance, prepaid plans such as HMOs, or government plans such as Medicare, or Indian Health Service?* 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 (dichotomized as none and current smokers).

2.2. Statistical analysis

To represent the Georgia civilian, noninstitutionalized population over the age of 18 years, estimates were weighted using Georgia BRFSS individual sample adult record weights (Georgia Department of Public Health, 2016). Statistical methods included the use of descriptive parameters, Pearson's χ^2 test, prevalence ratios, and interaction assessment. Prevalence ratios (PRs) 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, with the reference value set as the prevalence for those working 40–44 h weekly. Other models were tested with covariates including age, sex, race and ethnicity, education, health care coverage, smoking status, and poverty status based on previous literature, analyses of directed acyclic graphs (DAGs), and stepwise model selection approach. Interaction was assessed by comparing the −2 log likelihoods of models including an interaction term between work hours and OA categories to those without the term for both physical activity and obesity outcomes. Data were analyzed using SAS 9.3 and SAS-callable SUDAAN 11.0.

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

Demographic Characteristics	Unweighted *n*	Unweighted (*n* = 1425) (%)	Weighted (*n* = 2,709,568) (%)
Race/Ethnicity			
White	943	66.7	58.1
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[a]			
< HS	74	5.2	10.7
HS or some college	693	48.7	58.6
College	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	716	93.5	91.0
Below poverty[b]	50	6.5	9.0
Healthcare coverage			
Yes	1277	89.9	84.2
No	144	10.1	15.8
Smoking status			
None	1200	84.7	81.3
Current	217	15.3	18.7
Aerobic guidelines			
Not met	715	50.2	52.2
Met[c]	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

[a] Defined as less than high school degree (< HS), high school or some college (HS or some college), college or technical degree or higher (College).
[b] Defined as at or below 100% of the poverty line.
[c] Defined as receiving 150 or more minutes of moderate physical activity per day or vigorous equivalent.

3. Results

Data were available for 1425 working adults in the state of Georgia, representing 2,709,568 people. The majority of the population was non-Hispanic white males age 35–54, less than half of the study population met aerobic guidelines for LTPA, and the overall prevalence of obesity was 30.8% (Table 1). Ability to meet aerobic guidelines varied significantly by race and ethnicity and education, however, obesity prevalence and mean work hours did not (Table 2). Mean work hours varied significantly across groups categorized on SES indicators such as income, poverty status, and healthcare coverage, however, obesity prevalence and ability to meet aerobic guidelines did not vary across these factors.

Work hours varied significantly across occupational activity groups with employees in low activity occupations reporting the longest weekly work hours on average (χ^2: 38.4; *P*-value: < 0.01; Table 2). In general, employees working longer hours were more likely to meet aerobic guidelines, with those working 45–49 h weekly the most likely to meet guidelines (PR: 1.30; 95% CI: 1.02, 1.65).

Results of interaction assessment indicate that the effect of work hours on obesity risk and meeting aerobic guidelines are significantly different across OA categories (χ^2: 13.33; *P*-value: < 0.001; χ^2: 4.42; *P*-value: < 0.05). Due to the presence of significant interaction, stratified results are presented across work hour and OA categories in Tables 3 & 4.

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 3). Employees working 45–49 h a week in high activity occupations were twice as likely to meet aerobic guidelines than those working 40–44 h weekly (PR: 2.09; 95% CI: 1.02, 4.27). Although effects were mostly not significant across work hour categories for those in intermediate and low activity occupations, the general trend indicated that workers reporting over 44 h weekly in low activity occupations were more likely to meet aerobic guidelines compared to those working 40–44 h weekly and employees working 50 h or more weekly in intermediate activity occupations were less likely to meet physical activity recommendations than those working 40–44 h weekly.

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 > 55 h weekly were approximately half as likely to be obese as those working 40–44 h weekly (PR: 0.49; 95% CI: 0.32, 0.76; Table 4). Employees working < 40 h weekly in low activity occupations were approximately 40% less likely to be obese than those working 40–44 h weekly (PR: 0.61; 95% CI: 0.04, 0.95). Employees in intermediate activity occupations working 50–54 h weekly were almost twice as likely to be obese than those working 40–44 h weekly (PR: 1.97; 95% CI: 1.18, 3.28). No significant differences or trends were found across work hour categories for workers in high activity occupations. The majority of employees in the study worked between 40 and 44 h weekly (Appendix Table 2). Employees working 45–49 h weekly had the highest prevalence of obesity across all occupations (46.1%; PR: 1.50, 95% CI: 1.09, 2.05; Appendix Table 3).

4. Discussion

This analysis found no overall association between work hours and LTPA and no overall effect of long work hours on obesity, however significant effects were found across OA categories, suggesting that physical activity at work, together with work hours, may affect obesity risk.

Overall, 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 (Johnson et al., 1990; Trost et al., 2002; Burton and Turrell, 2000; Reichert et al., 2007; Welch et al., 2009). Nonetheless, 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 (Burton and Turrell, 2000).

Although long work hours did not significantly affect ability to meet LTPA recommendations, obesity prevalence varied significantly by work hours for employees in intermediate and low activity occupations, potentially suggesting that LTPA is not the most predominant mediator in the relationship between long work hours and obesity. Instead, our results suggest that occupational activity may play a larger role. Employees in intermediate activity occupations such as healthcare support, sales, and transportation were more likely to be obese when working long hours compared to those working 40–44 h weekly and employees in low activity occupations such as office and administrative

Table 2
Prevalence of meeting aerobic guidelines, obesity, and mean work hours 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	Weighted mean work hours (SE)	χ^2 *P*-value for group
Race/Ethnicity		0.01		0.09		0.07
White	53.1		28.4		43.8 (0.5)	
Black	41.9		37.3		43.5 (0.8)	
Hispanic	38.9		31.9		39.6 (2.2)	
Other	37.4		20.5		46.3 (2.7)	
Sex		0.06		0.23		< 0.01
Male	50.7		29.0		46.2 (0.6)	
Female	44.3		32.9		40.3 (0.7)	
Age		0.07		0.14		< 0.01
18–24	44.1		18.3		37.8 (2.0)	
25–34	41.1		35.0		42.8 (1.0)	
35–44	45.6		30.4		46.3 (1.0)	
45–54	55.1		31.1		45.2 (0.8)	
55–64	52.0		34.8		43.4 (0.8)	
65 +	42.5		25.9		34.5 (1.3)	
Education[a]		< 0.01		0.19		0.15
< HS	34.2		30.6		41.2 (1.8)	
HS or some college	46.0		33.4		42.9 (0.6)	
College	55.9		26.0		45.3 (0.6)	
Household income		0.58		0.28		< 0.01
< $35,000	46.6		32.6		39.9 (0.9)	
$35,000–$74,999	47.9		34.0		44.9 (0.8)	
≥ $75,000	51.1		27.8		46.6 (0.7)	
Poverty status		0.20		< 0.05		< 0.01
Above poverty	48.5		35.1		43.5 (0.6)	
Below poverty[b]	35.1		53.1		31.4 (2.4)	
Healthcare coverage		0.54		0.80		< 0.05
Yes	48.3		29.6		43.9	
No	44.9		30.9		40.9	
Smoking status		0.91		0.52		0.85
None	47.7		31.5		43.4 (0.5)	
Current	47.2		28.7		43.6 (1.1)	
Occupational activity[c]		< 0.01		0.80		< 0.01
High	40.5		27.8		40.5	
Intermediate	42.4		29.7		42.6	
Low	54.1		31.0		45.3	

[a] Defined as less than high school degree (< HS), high school or some college (HS or some college), college or technical degree or higher (College).
[b] Defined as at or below 100% of the poverty line.
[c] Defined as receiving 150 or more minutes of moderate physical activity per day or vigorous equivalent.

Table 3
Prevalence of meeting aerobic guidelines, unadjusted, and adjusted prevalence ratios by work hour categories and occupation activity (OA) levels, 2015 Georgia BRFSS.

Occupational activity[a]	Work hours per week	Weighted frequency (*n*)	Weighted prevalence of meeting aerobic guidelines % (95% CI)	Unadjusted model PR (95% CI)	Model 1 PR (95% CI)[b]
High OA	< 40	141,842	30.7 (15.7, 45.6)	0.91 (0.47, 1.76)	0.91 (0.44, 1.91)
	40–44	125,128	33.8 (18.6, 49.1)	Ref.	Ref.
	45–49	21,532	70.7 (31.5, 100.0)	2.09 (1.02, 4.27)	2.05 (1.07, 3.92)
	50–54	52,221	57.1 (32.0, 82.2)	1.69 (0.90, 3.17)	1.61 (0.81, 3.20)
	> 55	67,919	50.9 (29.5, 72.2)	1.50 (0.81, 2.78)	1.23 (0.55, 2.77)
Intermediate OA	< 40	163,947	47.1 (33.0, 61.1)	1.13 (0.76, 1.68)	1.14 (0.73, 1.79)
	40–44	305,812	41.6 (30.8, 52.4)	Ref.	Ref.
	45–49	64,206	53.2 (30.0, 76.4)	1.28 (0.77, 2.12)	1.09 (0.64, 1.84)
	50–54	113,146	34.3 (20.5, 48.0)	0.82 (0.51, 1.33)	0.63 (0.38, 1.03)
	> 55	159,527	40.4 (27.1, 53.8)	0.97 (0.64, 1.48)	0.76 (0.48, 1.21)
Low OA	< 40	174,091	52.1 (41.3, 62.9)	1.04 (0.80, 1.35)	1.06 (0.82, 1.36)
	40–44	392,646	50.0 (42.2, 57.8)	Ref.	Ref.
	45–49	94,395	55.0 (38.2, 71.7)	1.10 (0.78, 1.55)	1.08 (0.74, 1.58)
	50–54	197,165	54.7 (43.7, 65.8)	1.10 (0.85, 1.41)	1.01 (0.77, 1.33)
	> 55	238,436	61.3 (51.3, 71.4)	1.23 (0.98, 1.54)	1.18 (0.93, 1.49)

[a] Occupational activity classifications provided in Appendix Table 1.
[b] Model 1 controls for age, sex, race, and education.

support, management, and education, were less likely to be obese when working long hours compared to those working 40–44 h a week. These findings suggest that occupational activity may modify the relationship between long work hours and obesity. Previous studies have indicated that employees working long hours may be at increased risk of developing obesity and many have suggested that this relationship could be mediated by reduced opportunities to participate in LTPA (Jang et al., 2013; Luckhaupt et al., 2014; Park et al., 2014). While this study did not find evidence of an effect of long work hours on LTPA, our data suggests that occupational activity acts as an effect modifier in the

Table 4
Prevalence of obesity, unadjusted, and adjusted prevalence ratios by work hour categories and occupation activity (OA) levels, 2015 Georgia BRFSS.

Occupational activity[a]	Work hours per week	Weighted frequency (*n*)	Weighted prevalence of obesity (%, 95% CI)	Unadjusted model PR (95% CI)	Model 1 PR (95% CI)[b]
High OA	< 40	141,842	23.3 (7.7, 39.0)	0.74 (0.33, 1.68)	0.79 (0.33, 1.89)
	40–44	125,128	31.6 (16.6, 46.5)	Ref.	Ref.
	45–49	21,532	42.5 (0.0, 86.9)	1.35 (0.43, 4.23)	1.21 (0.34, 4.36)
	50–54	52,221	9.8 (0.0, 23.6)	0.31 (0.07, 1.37)	0.37 (0.08, 1.70)
	> 55	67,919	39.5 (18.1, 60.9)	1.25 (0.61, 2.57)	1.63 (0.74, 3.60)
Intermediate OA	< 40	163,947	28.7 (16.8, 40.5)	1.28 (0.74, 2.20)	1.23 (0.68, 2.20)
	40–44	305,812	22.5 (14.5, 30.4)	Ref.	Ref.
	45–49	64,206	31.5 (7.8, 55.1)	1.40 (0.61, 3.21)	1.17 (0.58, 2.38)
	50–54	113,146	44.1 (27.8, 60.5)	1.97 (1.18, 3.28)	2.09 (1.18, 3.68)
	> 55	159,527	33.9 (20.5, 47.3)	1.51 (0.89, 2.57)	1.66 (0.93, 2.97)
Low OA	< 40	174,091	23.4 (14.4, 32.3)	0.61 (0.40, 0.95)	0.65 (0.41, 1.02)
	40–44	392,646	38.1 (30.2, 46.0)	Ref.	Ref.
	45–49	94,395	53.5 (37.0, 70.1)	1.41 (0.97, 2.04)	1.45 (0.97, 2.16)
	50–54	197,165	27.7 (17.3, 38.0)	0.73 (0.47, 1.11)	0.79 (0.52, 1.20)
	> 55	238,436	18.8 (11.8, 25.8)	0.49 (0.32, 0.76)	0.54 (0.34, 0.85)

[a] Occupational activity classifications provided in Appendix Table 1.
[b] Model 1 controls for age, sex, race, and education.

relationship, affecting employees differently across occupations. This is a potentially important point, as research on occupational trends in Georgia indicates that many workers formerly employed in manufacturing and goods-producing roles may now be employed in service roles (Kasarda, 1995). As total employment in intermediate activity occupations continues to rise in upcoming decades, further research is needed to identify mechanisms and mediators of these relationships, evaluate obesity prevention and intervention programs, and guide policy recommendations.

More research is needed with nationally representative data to better identify mechanisms and mediators of the relationships between long work hours, physical activity, and obesity risks. The mediating role of physical activity in the relationship between long work hours and obesity is still unclear and more comprehensive data on domains of physical activity and occupational factors will be required to elucidate these mechanisms. Additionally, evaluations of programs designed to increase physical activity and reduce obesity risks for employees in intermediate activity occupations would be useful both to further increase our understanding of the mechanisms involved, as well as to provide evidence that occupation-related obesity risks are modifiable in the context of intermediate activity occupations. The majority of current worksite health promotion efforts to prevent obesity focus on employees in low activity occupations, such as those in office and administrative support roles. However this study suggests that employees in intermediate activity occupations, such as sales and transportation workers, may be at the greatest risk, necessitating intervention and prevention program work in the context of these occupations.

Strengths of this study included the addition of OA categories in the analysis and greater granularity of work hour categories than previous studies. Additionally, this study included a large state-wide sample of working adults, the largest possible for this specific analysis. A national sample for this study was impossible because the exposure variable was contained in an optional module of BRFSS. Examining both occupation type and work hours is only possible in five states for the year 2015: those that contained both the social context module and the industry and occupation module.

Despite the strengths of this study, there are at least four key limitations. First, BRFSS uses self-report data with may have resulted in an underestimation in both overall prevalence of obesity and physical inactivity. Evidence for the validity of inferences comparing the BRFSS physical activity questionnaire with accelerometer data are fair to poor (kappa ≤ 0.31 for all measures) but test-retest reliability is fair to moderate for moderate-intensity activity (kappa = 0.35–0.53) and substantial for vigorous-intensity and meeting recommended activity guidelines (kappa = 0.67–0.86) (Yore et al., 2007). However, this evidence for validity of inferences from the BRFSS questionnaire is similar to results from previous validation studies of other physical activity questionnaires (Jacobs et al., 1993). Additionally, 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 (Niedhammer et al., 2000).

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 and self-selection 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. In this analysis, BRFSS state-level weighting was used to ensure that the sample weights summed to population totals for key demographics within Georgia (Iachan et al., 2016). Although great care is taken in BRFSS weighting methodology, self-selection bias may persist, presenting a possibility of biased estimates.

Additionally, the cross-sectional nature of this analysis is vulnerable to the possibility of reverse causation. It is possible that individuals self-select into more sedentary occupations due to disabilities or injuries that prevent them from working in more physically demanding occupations.

Lastly, at the time of this analysis, diet indicators such as alcohol, fruit, and vegetable consumption were not available and were not provided. The inability to consider diet indicators as a potential confounder presents a limitation because these are associated with both the study exposure, occupational groups and work hours, as well as the study outcomes, obesity and LTPA.

5. Conclusions

Results of this study indicate the occupational activity acts as an effect modifier in the relationship between long work hours and physical activity, with employees in intermediate activity occupations at the greatest risk for obesity when working long hours. These employees may be particularly vulnerable to physical inactivity, weight gain, and obesity, presenting an opportunity for future intervention work.

Conflict of interest

No financial disclosures or conflicts of interest are reported by the authors of this paper.

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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

Appendix Table 2
Distribution of work hours in study population, 2015 Georgia BRFSS.

Work hours per week	Unweighted sample size	Unweighted (n = 1425) (%)	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

Appendix Table 3
Distribution of BMI (kg/m2) categories by work hours, 2015 Georgia BRFSS.

Work hours	UnW n[a]	Wt n[b]	Wt under[c] %	Wt normal[d] %	Wt over[e] %	Wt obesity[f] %
< 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

[a] UnW: Unweighted (n = 1425).
[b] Wt: Weighted (total n = 2,709,568).
[c] Under weight BMI: < 18.5.
[d] Normal weight BMI: 18.5–24.9.
[e] Overweight BMI: 25.0–29.9.
[f] Obese BMI range: ≥30.0.

References

Angrave, D., Charlwood, A., Wooden, M., 2015. Long working hours and physical activity. J. Epidemiol. Community Health 0, 1–7. http://dx.doi.org/10.1136/jech-2014-205230.

Artazcoz, L., Cortès, I., Escribà-Agüir, V., Cascant, L., Villegas, R., 2009. Understanding the relationship of long working hours with health status and health-related behaviours. J. Epidemiol. Community Health 63 (7), 521–527. http://dx.doi.org/10.1136/jech.2008.082123.

Brownson, R.C., Boehmer, T.K., Luke, D.A., 2005. Declining rates of physical activity in the United States: what are the contributors? Annu. Rev. Public Health 26 (1), 421–443. http://dx.doi.org/10.1146/annurev.publhealth.26.021304.144437.

Burton, N.W., Turrell, G., 2000. Occupation, hours worked, and leisure-time physical activity. Prev Med (Baltim). 31 (6), 673–681. http://dx.doi.org/10.1006/pmed.2000.0763.

Centers for Disease Control and Prevention. Body Mass Index (BMI). https://www.cdc.gov/healthyweight/assessing/bmi/adult_bmi/index.html. Published 2017.

Choi, B., Schnall, P., Yang, H., et al., 2010. Sedentary work, low physical job demand, and obesity in US workers. Am. J. Ind. Med. 53, 1088–1101. http://dx.doi.org/10.1002/ajim.20886.

Church, T.S., Thomas, D.M., Tudor-Locke, C., et al., 2011. Trends over 5 decades in U.S. occupation-related physical activity and their associations with obesity. PLoS One 6 (5), 1–7. http://dx.doi.org/10.1371/journal.pone.0019657.

Georgia Department of Public Health. Georgia Behavioral Risk Factor Surveillance System (BRFSS). https://dph.georgia.gov/georgia-behavioral-risk-factor-surveillance-system-brfss. Published 2016.

Grzywacz, J., Marks, N., 2001. Social inequalities and exercise during adulthood: toward an ecological perspective source. J. Health Soc. Behav. 42 (2), 202–220.

Gu, J.K., Charles, L.E., Bang, K.M., Ma, C.C., Andrew, M.E., Violanti, J.M., Burchfiel, C.M., 2014. Prevalence of obesity by occupation among US workers: the National Health Interview Survey 2004–2011. J. Occup. Environ. Med. 56 (5), 516–528.

Hawaii Health Data Warehouse, 2006. HHDW BRFSS Poverty Level Methodology. 1, 1–7.

Henderson, R., 2015. Industry employment and output projections to 2024. Mon Labor Rev. 1–5. https://www.bls.gov/opub/mlr/2015/article/industry-employment-and-output-projections-to-2024.htm.

Iachan, R., Pierannunzi, C., Healey, K., Greenlund, K.J., Town, M., 2016. National weighting of data from the behavioral risk factor surveillance system (BRFSS). BMC Med. Res. Methodol. 16 (1), 1–12. http://dx.doi.org/10.1186/s12874-016-0255-7.

Jacobs, D.R., Ainsworth, B.E., Hartman, T.J., Leon, A.S., 1993. A simultaneous evaluation of 10 commonly used physical activity questionnaires. Med. Sci. Sports Exerc. 25 (1), 81–91. http://dx.doi.org/10.1249/00005768-199301000-00012.

Jang, T.W., Kim, H.R., Lee, H.E., Myong, J.P., Koo, J.W., 2013. Long work hours and obesity in Korean adult workers. J. Occup. Health 55 (5), 359–366 (doi:DN/JST.JSTAGE/joh/13-0043-OA [pii]).

Jans, M.P., Proper, K.I., Hildebrandt, V.H., 2007. Sedentary behavior in Dutch workers. Differences between occupations and business sectors. Am. J. Prev. Med. 33 (6), 450–454. http://dx.doi.org/10.1016/j.amepre.2007.07.033.

Johnson, C.A., Corrigan, S.A., Dubbert, P.M., Gramling, S., 1990. Perceived barriers to exercise and weight control practices in community women. Women Health 16 (3–4),

177–191.
Kasarda, J., 1995. “Industrial Restructuring and the Changing Location of Jobs” in State of the Union: America in the 1990s. Russell Sage Foundation, New York.
Kirk, M.A., Rhodes, R.E., 2011. Occupation correlates of adults' participation in leisure-time physical activity: a systematic review. Am. J. Prev. Med. 40 (4), 476–485. http://dx.doi.org/10.1016/j.amepre.2010.12.015.
Lallukka, T., Sarlio-Lähteenkorva, S., Roos, E., Laaksonen, M., Rahkonen, O., Lahelma, E., 2004. Working conditions and health behaviours among employed women and men: the Helsinki health study. Prev Med (Baltim). 38 (1), 48–56. http://dx.doi.org/10.1016/j.ypmed.2003.09.027.
Lallukka, T., Laaksonen, M., Martikainen, P., Sarlio-Lähteenkorva, S., Lahelma, E., 2005. Psychosocial working conditions and weight gain among employees. Int. J. Obes. 29 (8), 909–915. http://dx.doi.org/10.1038/sj.ijo.0802962.
Lallukka, T., Sarlio-Lähteenkorva, S., Kaila-Kangas, L., Pitkäniemi, J., Luukkonen, R., Leino-Arjas, P., 2008a. Working conditions and weight gain: a 28-year follow-up study of industrial employees. Eur. J. Epidemiol. 23 (4), 303–310. http://dx.doi.org/10.1007/s10654-008-9233-7.
Lallukka, T., Lahelma, E., Rahkonen, O., et al., 2008b. Associations of job strain and working overtime with adverse health behaviors and obesity: evidence from the Whitehall II Study, Helsinki Health Study, and the Japanese Civil Servants Study. Soc. Sci. Med. 66 (8), 1681–1698. http://dx.doi.org/10.1016/j.socscimed.2007.12.027.
Luckhaupt, S.E., Cohen, M.A., Li, J., Calvert, G.M., 2014. Prevalence of obesity among U.S. workers and associations with occupational factors. Am. J. Prev. Med. 46 (3), 237–248. http://dx.doi.org/10.1016/j.amepre.2013.11.002.
Nakamura, K., Shimai, S., Kikuchi, S., et al., 1998. Increases in body mass index and waist circumference as outcomes of working overtime. Occup. Med. 48, 169–173.
NHLBI Obesity Education Initiative Expert Panel on the Identification Evaluation and Treatment of Obesity in Adults (US), 1998. Clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults: executive summary. Am. J. Clin. Nutr. 68, 899–917.
Niedhammer, I., Bugel, I., Bonenfant, S., Goldberg, M., Leclerc, A., 2000. Validity of self-reported weight and height in the French GAZEL cohort. Int. J. Obes. 24 (9), 1111–1118. http://dx.doi.org/10.1038/sj.ijo.0801375.
Park, Sohyun, Pan, Liping, Lankford, T., 2014. Relationship between employment characteristics and obesity among employed U.S. adults. Am. J. Health Promot. 28 (6), 389–396. http://dx.doi.org/10.4278/ajhp.130207-QUAN-64.Relationship.
Popham, F., Mitchell, R., 2006. Leisure time exercise and personal circumstances in the working age population: longitudinal analysis of the British household panel survey. J. Epidemiol. Community Health 60 (3), 270–274. http://dx.doi.org/10.1136/jech.2005.041194.
Reichert, F.F., Barros, A.J.D., Domingues, M.R., Hallal, P.C., 2007. The role of perceived personal barriers to engagement in leisure-time physical activity. Am. J. Public Health 97 (3), 515–519. http://dx.doi.org/10.2105/AJPH.2005.070144.
Schneider, S., Becker, S., 2005. Prevalence of physical activity among the working population and correlation with work-related factors: results from the first German national health survey. J. Occup. Health 47 (5), 414–423. http://dx.doi.org/10.1539/joh.47.414.
Schulte, P.A., Wagner, G.R., Ostry, A., et al., 2007. Work, obesity, and occupational safety and health. Fram Heal Matters. 97 (3), 428–436. http://dx.doi.org/10.2105/AJPH.2006.086900.
Shields, M., 1999. Long working hours and health. Health Rep. 11, 33–48.
Solovieva, S., Lallukka, T., Virtanen, M., Viikari-Juntura, E., 2013. Psychosocial factors at work, long work hours, and obesity: a systematic review. Scand. J. Work Environ. Health 39 (3), 241–258. http://dx.doi.org/10.5271/sjweh.3364.
Steele, R., Mummery, K., 2003. Occupational physical activity across occupational categories. J. Sci. Med. Sport 6 (4), 398–407. http://dx.doi.org/10.1016/S1440-2440(03)80266-9.
Steeves, J.A., Tudor-Locke, C., Murphy, R.A., King, G.A., Fitzhugh, E.C., Harris, T.B., 2015. Classification of occupational activity categories using accelerometry: NHANES 2003–2004. Int. J. Behav. Nutr. Phys. Act. 12 (1), 89. http://dx.doi.org/10.1186/s12966-015-0235-z.
Takao, S., Kawakami, N., Ohtsu, T., 2003. Occupational class and physical activity among Japanese employees. Soc. Sci. Med. 57 (12), 2281–2289. http://dx.doi.org/10.1016/S0277-9536(03)00134-5.
Trost, S.G., Owen, N., Bauman, A.E., Sallis, J.F., Brown, W., 2002. Correlates of adults' participation in physical activity: review and update. Med. Sci. Sports Exerc. 34 (12), 1996–2001. http://dx.doi.org/10.1249/01.MSS.0000038974.76900.92.
U.S. Department of Health and Human Services, 2008. Physical activity guidelines for Americans. Pres Counc Phys Fit Sport Res Dig. 9 (4), 1–8. http://dx.doi.org/10.4085/1062-6050-44.1.5.
United States Census Bureau. Census 2002 Industry and Occupation Codes. https://www.bls.gov/tus/iocodes.htm. Published 2002.
United States Census Bureau. Poverty Thresholds. https://www.census.gov/data/tables/time-series/demo/income-poverty/historical-poverty-thresholds.html. Published 2015.
Welch, N., McNaughton, S., Hunter, W., Hume, C., Crawford, D., 2009. Is the perception of time pressure a barrier to healthy eating and physical activity among women? Public Health Nutr. 12 (7), 888–895. http://dx.doi.org/10.1017/S1368980008003066.
Wu, B., Porell, F., 2000. Job characteristics and leisure physical activity. J Aging Health. 12 (4), 538–559. http://dx.doi.org/10.1177/089826430001200405.
Yamada, Yuichi, Masao, Ishizaki, Ikiko, T., 2002. Prevention of weight gain and obesity in occupational populations: a new target of health promotion services at worksites. J. Occup. Health 44 (6), 373–384.
Yore, M.M., Ham, S.A., Ainsworth, B.E., et al., 2007. Reliability and validity of the instrument used in BRFSS to assess physical activity. Med. Sci. Sports Exerc. 39 (8), 1267–1274. http://dx.doi.org/10.1249/mss.0b013e3180618bbe.