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The Relationship Between Workplace Characteristics and Physical Activity in Workers with Low Occupational Activity

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The Relationship Between Workplace Characteristics and Physical Activity in Workers with Low Occupational Activity

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The Relationship Between Workplace Characteristics and Physical Activity in Workers with Low Occupational Activity

Victoria Flores Michalchuk

Abstract

Background: There is an increasing number of American workers that spend a larger portion of their time in occupations that involve primarily sedentary or light work. Physical activity has known benefits in lowering risk of chronic disease and improving overall health. However, most adults do not meet the recommended physical activity guidelines. The purpose of this dissertation study was to determine the relationship between the physical work environment, occupational activity, workplace characteristics, and physical activity in U.S. workers.

Methods: This study included one systematic review and two cross-sectional studies using 2015 National Health Interview Survey data on sociodemographic, health behaviors, health outcomes, and occupational characteristics of adult workers.

Findings: Overall, 25.2% of U.S. workers achieved sufficient leisure-time physical activity, and 27% in workers with low occupational activity. Age, male gender, higher education, higher income, normal BMI, workplace health promotion participation, and size of employer were associated with meeting leisure-time physical activity guidelines. In office workers, office and building designed for activity had the largest impact on physical activity among work environment characteristics.

Conclusion: The study findings indicate that the workplace can positively influence sufficient physical activity by implementing active design practices, health promotion programs, and ensuring workers of all incomes and education levels have the opportunity to participate in these programs.

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Chapter One

Introduction

Regular physical activity has known health benefits including preventive effects on chronic disease and lowers the risk for premature mortality. Specifically, physical activity reduces the risk of excessive weight gain, lowers the incidence of cardiovascular disease, hypertension, diabetes, and cancers (US Department of Health and Human Services, 2018). Additionally, physical activity can improve cognitive function, sleep, and reduce feeling of anxiety and depression (US Department of Health and Human Services, 2018). Unfortunately, the majority of adults in the United States (U.S.), do not meet the recommendations for physical activity. Only 24% of adults complete enough physical activity to meet the recommended guidelines (Healthy People 2030, 2018). This inadequate level of physical activity in U.S. adults places a health burden on the population resulting in higher health care expenditures. Aggregated healthcare expenditures (including expenditures for all services: inpatient, outpatient, emergency room, office-based, dental, vision, home health, prescription drug, and other) for those with inadequate levels of physical activity are $117 billion annually (Carlson et al, 2015).

The 2018 Physical Activity Guidelines for Americans defines physical activity as “any bodily movement produced by the contraction of skeletal muscles that increases energy expenditure above a basal level” (US Department of Health and Human Services, 2018). The guidelines consist of two components: aerobic and muscle-strengthening activity. The recommendations suggest that adults perform at least 150 minutes of moderate intensity activity or 75 minutes of vigorous intensity activity a week, or a combination of the two. Muscle-strengthening activities involve all the major muscle groups and are designed to strengthen the muscles of the body; this activity is recommended to be completed two or more days a week. Regular physical activity can be carried out in different settings and for different reasons, including transportation, leisure, and occupational physical activity. Regardless of the type or

duration of physical activity, for example, walking to the bus stop or an active occupation, each activity counts toward meeting the guideline goal and has health benefits. The new 2018 guidelines recommend that even short bursts of physical activity, less than 10 minutes, in any setting are beneficial to health.

Both a person's physical and social environments are known determinants of health behaviors such as physical activity (Glanz K, Bishop, 2010). In 2019, there were over 129 million full-time employed adults in the U.S. workforce who spent over seven hours a day at their place of employment (BLS, 2019a). However, over the past 60 years, the amount of physical activity required in the workday has rapidly decreased causing more workers to spend large amounts of time sitting during the day (Church et al., 2011). Currently, 80% of U.S. jobs are considered sedentary or involve light activity (Bureau of Labor Statistics [BLS], 2017). Given that the majority of worker jobs require little physical activity during the day, understanding the amount of leisure-time physical activity workers perform is important to optimizing worker health.

Previous literature has explored the relationship between job categories and physical activity. The prevalence rate of meeting physical activity guidelines was higher in workers who work in sedentary jobs compared to those working in jobs associated with higher levels of activity (Blackwell et al., 2016; Gu et al., 2016). On the other hand, a systematic review that examined the relationship of aerobic physical activity with occupational physical activity level, not job category, found that workers with higher levels of occupational physical activity had higher levels of aerobic activity than workers performing less occupational physical activity (Kirk & Rhodes, 2011).

In addition to job categories, Gu et al. (2016) found that workers at a larger company had a high prevalence of sufficient aerobic physical activity. A systematic review exploring the relationship between occupation and physical activity considered workplace characteristics such as hours worked and job demand measured by mental workload. Workers who worked 45 hours or more per week and those with high levels of mental job demand had lower levels of sufficient levels of physical activity (Kirk & Rhodes, 2011).

The risk of all-cause mortality can decrease even with small increases in physical activity in adults with a high volume of daily sitting time, (Ekelunc et al., 2016). Convenient environments and access to leisure facilities were positively correlated with increased physical activity (Poortinga, 2006). Therefore, the workplace can help workers in low activity jobs complete the recommended physical activity by creating programs and policies that promote a physically active culture and provide a physical environment with accessible spaces for physical activity. While previously literature has considered employment status and hours worked, occupational/job categories, job activity level, the current literature has not considered characteristics of the workplace such as workplace design, a culture of health promotion, work-life balance, job stability, job control, or job demand, in relation to physical activity. Therefore, the overall purpose of this research study is to examine the relationship between workplace characteristics and physical activity in U.S. workers. The specific aims are as follows:

Specific Aims

1. *Determine the relationship between the physical work environment and overall physical activity, work-related physical activity, and leisure-time physical activity in office workers*

2. *Examine the relationship between leisure-time physical activity and occupational activity among* U.S. workers.
3. *Identify the relationship between leisure-time physical activity and workplace and job characteristics among U.S. workers* with low occupational activity.

Significance

An understudied area of correlates with physical activity is workplace characteristics. If specific intervention is not given to increase physical activity in the workplace, sitting time is estimated to increase about 2% per year, and both leisure and work-related physical activity will decrease (Lindsay et al., 2016). Understanding the relationships between sociodemographic, job factors, workplace characteristics, and physical activity will provide occupational health professionals, researchers, and clinicians a holistic perspective on the impacts that the workplace has with physical activity. The findings of this research will help provide additional knowledge to the occupational health field to establish policies, culture, and environments that enable physical activity to improve the overall health and well-being of workers. The impact of this research study will help generate workplaces that promote physical activity in workers and enable worker health.

Theoretical Framework

The Total Worker Health (TWH) Worker Wellbeing Framework is a comprehensive framework that holistically defines, promotes, and evaluates well-being in workers using individual, societal, and environmental factors (Chari et al., 2018). This study will be based on the TWH Worker Wellbeing Framework to address the complexity of factors affecting worker health and workers' physical activity. The TWH Worker Wellbeing framework consists of five domains. The "*Work Evaluation and Experience*" domain encompasses the individuals'

experiences about the quality of their work-life and includes factors such as job demand and job control. The "*Workplace Policies and Culture*" domain refers to organizational policies such as salary, benefits, work-family balance and the workplaces' influence on worker well-being or health promotion. The "*Workplace Physical Environment*" domain refers to environmental design and physical safety conditions and includes desk type, office arrangement, building architecture and infrastructure, and outdoor landscape (Chari et al., 2018). Figure 1 shows the Total Worker Health Worker Wellbeing Framework applied to this study. Worker well-being exists within the Home, Community, and Society domain. Worker well-being is affected by workplace factors, health status, and personal factors. This study examined the association between physical activity and workplace factors guided by the TWH Worker Wellbeing framework to ensure a holistic view of the relationship between the workplace and physical activity.

Organization of the Dissertation

This dissertation includes a systematic review of the literature and two cross-sectional studies that examined the relationship between the workplace's environment, policies, and experience factors with physical activity in U.S. workers with low occupational activity, after controlling for workers' sociodemographics and health status. Chapter 2 provides a systematic review entitled "Systematic Review of the Influence of Physical Work Environment on Office Workers' Physical Activity Behavior" that assessed the existing literature and the physical workplace environment's relationship with physical activity in office workers. Chapter 3 present a study entitled "Prevalence of Leisure-Time Physical Activity and Associated Occupational Factors in U.S. Workers: Analysis of 2015 National Health Interview Survey" that analyzed a nationally representative, cross-sectional survey data from the 2015 National Health Interview

Survey (NHIS) to determine the relationship between workers' job intensity activity level and leisure-time physical activity. Chapter 4 presents a study entitled "The Relationship Between Workplace and Job Characteristics and Leisure-Time Physical Activity among U.S. Workers in Low Occupational Activity Jobs: Analysis of 2015 National Health Interview Survey" that analyzed 2015 NHIS data of workers who reported low occupational activity to determine the relationship between work policies and work experience factors with physical activity. Chapter 5 present a synthesis of the findings from three aims of this dissertation. Together, these studies will advance research targeted at increasing physical activity in workers who spend their workday in low activity jobs.

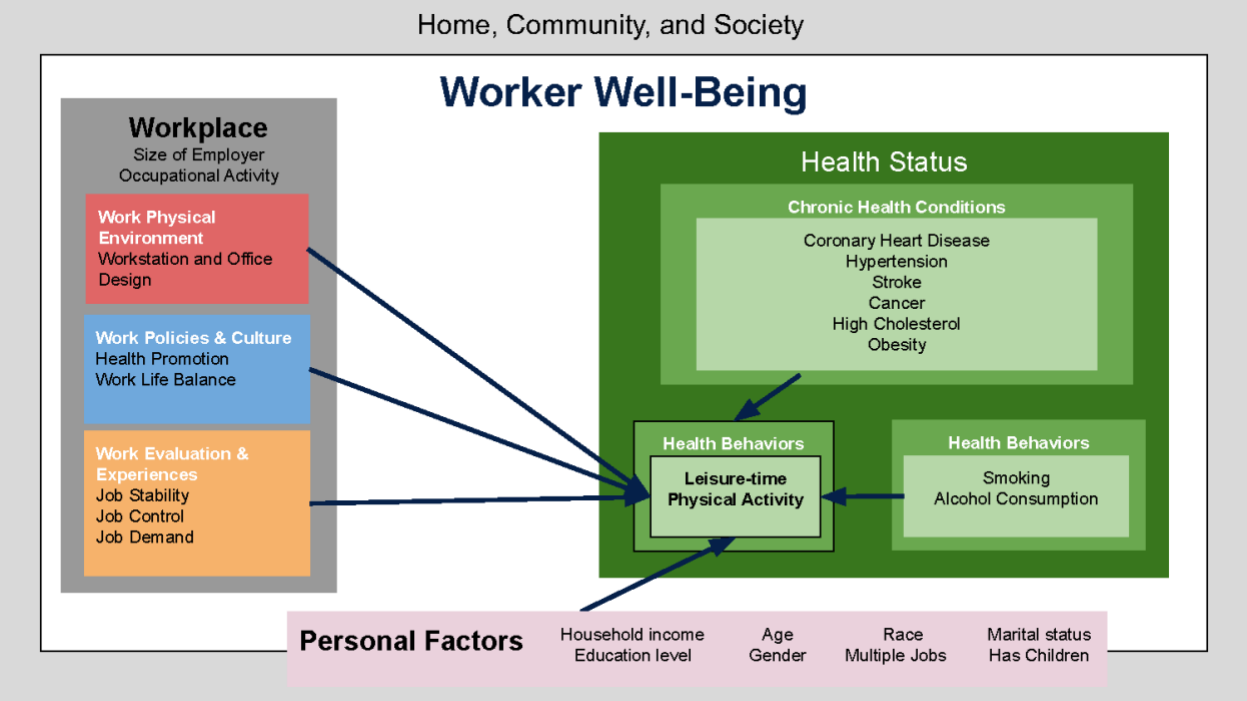

Figure 1.1. *Modified Total Worker Health Worker Well-being Framework*

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Chapter Two

Systematic Review of the Influence of the Physical Work Environment on Office Workers' Physical Activity Behavior

Abstract

Background: Many American workers spend over seven hours a day at work in primarily sedentary office work. Physical activity is a key aspect of optimizing health and preventing disease; yet, 80% of American adults do not meet the recommended guidelines for physical activity. In this systematic review, the relationship between physical work environment and physical activity among office workers was explored. *Methods:* Of the 321 studies screened, 26 studies met the eligibility criteria and were included for evaluation in this systematic review. Physical activity during the workday was measured using self-report surveys and electromechanical devices such as accelerometers. *Results:* Of the 26 studies, four were cross-sectional studies, 14 were quasi-experimental studies, and eight were randomized control trials. Physical work environments examined by the studies included different types of desk (n=16), office arrangements (n=5), and building design (n=5). In nine studies office environments and buildings work environments designed to promote activity using active design principles such as stairs and flexible workspaces were associated with increased physical activity. Sit-stand desk reduced overall sitting time, but had a minimal effect on physical activity.
Conclusions/Applications to Practice: Offices and buildings designed for activity had the largest impact on physical activity among office workers. To increase physical activity in office workers, focus should be placed on opportunities to increase incidental movement that can increase physical activity throughout the workday. Occupational health nurses should advocate workspace designs that can increase physical activity in workers.

Background

Regular physical activity is important in decreasing the risk of disease, optimizing health, and preventing chronic diseases such as type 2 diabetes, hypertension, osteoporosis, high blood cholesterol, coronary heart disease, stroke, and excess weight gain (Lollgen et al., 2009; Piercy et al., 2018; Warburton & Bredin, 2017). The physical activity guideline for Americans recommends adults perform at least 150 minutes of moderate-intensity aerobic activity a week or 75 minutes of vigorous-intensity aerobic activity a week, or a combination of the two (Piercy et al., 2018). Also recommended are muscle-strengthening activities involving all the major muscle groups at least 2 days a week. Despite the known benefits of physical activity, 80% of adults in the United States (U.S.) do not meet the physical activity guidelines. In the U.S., estimates are that nearly $117 billion in annual health care costs and 10% of all premature mortality are associated with failure to meet recommended physical activity levels (Carlson et al, 2014). Furthermore, recent systematic reviews suggest that engaging in excessive sedentary behavior increases the risk of morbidity and mortality, independent of physical activity (Ekelund et al., 2019; Ku et al., 2018).

Sedentary and light activity jobs have steadily increased over the past 60 years as the number of workers employed in service occupations that mostly entail sitting work has increased (Church, 2011). As of 2016, 80% of civilian jobs in the U.S. were considered sedentary or light work (Bureau of Labor Statistics [BLS], 2017). In 2019, there were over 129 million full-time employed adults in the U.S. workforce (BLS, 2019), and on average, workers in the U.S. spend over seven hours a day at their place of employment (Center for Disease Control and Prevention [CDC], 2017). Given the rapidly increasing number of office workers who engage in longer periods of sedentary behavior, the workplace will play an important role in promoting health and preventing chronic illnesses.

Over time, if targeted attention is not given to physical activity behavior in the workplace, sitting time is estimated to increase about 2% per year, and both leisure and work time physical activity will decrease (Lindsay et al., 2016). The decrease in labor intensive jobs paired with the decrease in leisure-time physical activity heightens the importance of understanding the influence of the physical work environment on the physical activity behavior of working adults, particularly workers with sedentary or light activity jobs. There is strong evidence that physical activity is a key aspect of optimizing health, and thus preventing disease. Therefore, the purpose of this systematic review was to determine the relationship between the physical work environment and overall physical activity, work-related physical activity, and leisure-time physical activity in office workers.

Methods

Protocol and Registration

This systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement and checklist guidelines (Moher et al., 2009).

Eligibility Criteria

Inclusion criteria for the systematic review were (1) studies that included office-based adult workers in the sample, (2) the setting was office-based, (3) physical work environment or office design was an independent variable, and (4) physical activity was an outcome. The physical activity measurement could be of any type and intensity of physical activity including steps, stepping, or walking time, as long as it was assessed in an office-based setting among adult workers. The following research designs were considered for the systematic review: cross-sectional, case-control, cohort, quasi-experimental, or randomized control. Qualitative studies were excluded from this review. Publications had to be in English-language peer-reviewed

journals. No time period for publication was set, which allowed for a broader scan of the literature in an understudied area of research.

Information Sources and Search

A pre-planned systematic search strategy was developed in collaboration with a medical librarian for use with three electronic databases: PubMed, Embase, and Web of Science. In addition, a hand search and reference list review were conducted. The last search date for each database was May 1, 2019. Appendix A shows detailed search terms for each database. The phrasing differed slightly for each database to account for official keywords, such as MeSH terms, used in each data base. In summary, the MeSH and keyword search terms used for PubMed included exercise (MeSH), physical activity, sedentary behavior, workplace (MeSH), work environment, interior design and furnishings office design (MeSH), workplace design, and sit-stand. In the PubMed search, exercise was used in addition to physical activity because it is defined as a MeSH term within PubMed and yielded a higher quantity of relevant articles. Search terms used for Embase and Web of Science included exercise, physical activity, sitting, standing, sedentary time, workplace, work environment, office worker, workstation, office, interior design and furnishings, office design, and workplace design. To increase the sensitivity of the search, both physical activity and sedentary behavior were included in the search terms.

Study Selection

The retrieved articles were imported into Endnote reference management software (Clarivate Analytics, 2018), duplicates were removed, and then the remaining articles were uploaded into Covidence systematic review software, which is recommended by Cochrane (Veritas Health Innovation, 2013). In the first phase of screening, the first author assessed study titles and abstracts using the eligibility criteria. For the titles or abstracts that did not contain

information about the specific study population (i.e. office workers) and the phenomenon of interest (i.e. physical activity), the full text was reviewed to determine its eligibility. In the next stage, the full text review was conducted by the first author.

Data Collection Process and Data Items

The following information was extracted from each of the studies included in the systematic review: study design, aims, sample characteristics including location, sample size, age, and gender, study design, intervention (if any), overall physical activity (physical activity measured all day), physical activity at work and study limitations (see Table 1 and 2). Natural-experiment studies and intervention studies that involved non-randomized pre- and post-comparisons without a control group were considered quasi-experimental studies. Physical activity measures included self-report surveys and electromechanical devices such as questionnaires and accelerometers.

Risk of Bias Within Studies

The risk of bias for each study included in the systematic review was assessed using the Joanna Briggs Appraisal Tool (Moola et al., 2017; Tufanaru et al., 2017). This assessment tool was designed to identify potential risk of bias within studies. A study was classified as "minimal risk" if there were 'yes' answers to 90% or greater to the tool's questions. A study was classified as "moderate risk" if there were 'yes' answers to 50% to 89% of the tool's questions.

Results

Study Selection

The study selection process is presented in Figure 1. The initial search yielded 493 records. After removing duplicates, the titles and abstracts of 321 records were reviewed; 285 records did not meet at least one of the eligibility criteria, yielding 36 records eligible for the next screening stage. Of these, 10 studies that did not meet all the eligibility criteria were

excluded, yielding a total of 26 studies for the systematic review. Studies were excluded for not specifying the type of work environment examined in the study (n=1), only describing the study protocol, but no results (n=3), not including physical activity as a study variable (n=3), and not including work environment as a study variable (n=3).

Study Characteristics

The 26 studies included in the systematic review were published between 2012 and 2019. Eight studies were randomized control trials, 14 were quasi-experimental studies, and four were cross-sectional studies. See Table 1 for sample characteristics and study methods of the 26 studies. The studies were conducted in several countries: The United States (n=9), Australia (n=8), Europe (n=6), Japan (n=1), Canada (n=1), and New Zealand (n=1). Sample sizes ranged from 11 to 1098; 69% (n=18) had a sample size between 11 and 49, 12% had a sample size between 50 and 99 (n=3), and 19% (n=5) had a sample size of 100 or greater. Study participants were mostly in middle adulthood; the mean age ranged from 32 to 51 years. A majority of the samples consisted of participants who were female and had a university education or higher. The studies took place at a variety of workplaces, with college/university being the most common work setting (n=7). The most common type of physical work environment design at baseline was seated desks (n=17), followed by sit-stand desk (n=3), and unassigned or open desk (n=3). Twenty-two of the 26 studies were intervention studies: eight randomized control trials and 14 quasi-experimental studies. See Table 1 for a description of the intervention focus in the 22 studies. The three types of physical work environment designs identified in the 22 intervention studies were desk-type (n=14), office-type (n=4), and building design (n=4). The 14 desk-type intervention studies examined sit-stand desk (n=8), set height standing desk (n=1), treadmill desk (n=4), and both sit-stand and treadmill desks (n=1).

The four office-type intervention studies examined office arrangement and office layout configurations (Candido et al., 2019; Maylor et al., 2018; Wahlstorm et al. 2019; Wallman-Sperlich et al., 2019). These studies reviewed spatial design characteristics such as how workstations were placed within the office space (i.e., assigned versus unassigned workstations), and how supplies such as trash cans and printers were arranged throughout the office. The setting for these studies included private offices, cubicles, and open neighborhood.

The four building design intervention studies compared the influence of office building design (active-building vs. traditional) on office workers' physical activity and sedentary behavior (Elyer et al., 2018; Engelen et al., 2016; Gorman et al., 2013; Jancey et al., 2016).

The duration of the 22 intervention studies ranged from 5 days to 18 months, but the vast majority of studies were between one and six months. The majority of these studies (n = 19) implemented interventions during all workdays. In one study on treadmill desk (Schuna et al., 2014), the frequency of the intervention was twice daily. In two studies on using a standing desk intervention (Miyachi et al., 2015) and treadmill desk intervention (Malaeb, et al., 2019), participants utilized the intervention during the workday at their discretion. A majority of the desk intervention studies used a sitting desk for the comparison group. In one study, sit-stand desk was the control activity that was compared to the treadmill desk intervention (Bergman et al., 2018). The office arrangement and building design intervention studies used previous work setting conditions or "traditional offices" as control activities.

Four studies were non-intervention studies using a descriptive, correlational cross-sectional research design (Carr et al., 2016; Lindberg et al., 2018; McGann et al., 2015; Renaud et al., 2018). These studies focused on three types of physical work environment designs: desk-type, office-type, and building design. In these studies, the association with workers' physical

activity level was examined on the type of sit-stand desk (Carr et al., 2016), sit-stand desk usage (Renaud et al, 2018), different corridor and staircase designs (McGann et al., 2015), and office arrangements (Lindberg et al., 2018). In their analyses, three studies did not control for any confounding factors and only Lindberg et al. (2018) controlled for gender and work type, defined as self-reported computer dominated job or non-computer dominant job. See Table 1 for a summary description of the four non-intervention studies included in this systematic review.

Physical Activity and Sedentary Behavior Measurements

Table 2 lists the physical activity measurement tools used in the 26 studies included in this systematic review. Three studies used only subjective self-report measures (Engelen et al., 2016; Renaud et al, 2018; Wallman-Sperlich et al., 2019), and 13 studies used only objective measures (Candido et al., 2019; Carr et al., 2016; Gilson et al., 2012; Gorman et al., 2013; Koepp et al., 2013; Lindberg et al., 2018; Mansoubi et al, 2016; Maylor et al., 2018; Miyachi et al., 2015; Schuna et al., 2014; Tobin et al., 2016; Wahlstorm et al., 2019; Zhu et al., 2018). Both subjective and objective physical activity measures were used simultaneously in 10 studies (Bergman et al., 2018; Chau et al., 2014; Chau et al., 2016; Dutta et al., 2019; Dutta et al., 2014; Eyler et al., 2018; Jancey et al., 2016; Malaeb et al., 2019; McGann et al., 2015; Pierce et al., 2019). Subjective physical activity was measured using the Occupational Sitting and Physical Activity Questionnaire (OSPAQ) in five studies and the International Physical Activity Questionnaire (IPAQ) in two studies. Other self-report physical activity measures included the Active Australia Questionnaire, the Baecke Questionnaire for Habitual Physical Activity, the Workforce Sitting Questionnaire (WSQ), and the Marshall Sitting Questionnaire. A single item question was also used to measure physical activity.

Objective physical activity was measured using one or more electromechanical devices. Eight studies used only the ActivPaL accelerometer (Chau et al., 2014; Tobin et al., 2016; Maylor et al., 2018; Gorman et al., 2013; Eyler et al., 2018); three studies used only the ActiGraph accelerometer to measure physical activity (Jancey et al., 2016; McGann et al., 2015; Schuna et al., 2014); and four studies used a combination of the two electromechanical devices to measure physical activity (Bergman et al., 2018; Chau et al., 2016; Mansoubi et al., 2016; Wahlstorm et al., 2019). Nine studies used other types of electromechanical devices: Fitbit Charge2 accelerometer, Modular Signal Recorder accelerometer, Gruve accelerometer, Armband accelerometer by SenseWear, Actical accelerometer, EcgMove3 accelerometer, Actimaker accelerometer, or a Keep Walking-Stay Fit pedometer. Of the 26 studies, 24 studies measured sedentary behavior in addition to physical activity behavior.

Randomized Control Intervention Study Findings

Table 2 displays the study findings of the 26 studies included in the systematic review. Among the eight randomized control trials, findings were reported on overall physical activity in two studies (Bergman et al., 2018; Miyachi et al., 2015), physical activity at work in two studies (Chau et al., 2014; Tobin et al., 2016) and both overall and at work physical activity in four studies (Dutta et al., 2014; Maylor et al., 2018; Pierce et al., 2019; Schuna et al., 2014). Four sit-stand desk intervention studies found that providing sit-stand desks had a little effect on workers' overall or work-related physical activity when compared to traditional-sitting desks (Chua et al., 2014; Dutta et al, 2014; Pierce et al., 2018; Tobin et al., 2016). Results ranged from a 13 min/day increase in stepping time at work (Chua et al., 2014) to a 2.1 minutes/8-hour workday increase in stepping time (Tobin et al., 2016). The sit-stand desk interventions did, significantly decreased workers' overall sitting time. Compared to the traditional desk groups, the net reduction in sitting

time during the workday ranged from 4.8 minutes/hour (Dutta et al., 2014) to 99.9 minutes/day (Tobin et al., 2016). Miyachi and colleagues (2015) found a significant increase in overall time spent in light physical activity in the standing desk intervention group compared to the traditional sitting desk group.

Workers using a treadmill desk as the intervention in two randomized control trials resulted in statistically significant increases in light physical activity (Begman et al, 2018; Schuna et al., 2014). Compared to workers in the sit-stand desk group, workers in the treadmill desk intervention group engaged in walking for additional 22 minutes/day (Begman et al, 2018). In treadmill desk users compared to sitting desk users, the net significant increase in overall light physical activity was 1.6 minutes/hour and 2.9 minutes/hour for light physical activity at work (Schuna et al., 2014). However, there were no significant changes in moderate- or vigorous-intensity physical activity among workers using a treadmill desk in any of the randomized control studies. As compared to the sitting desk group, workers in a multicomponent intervention that incorporated environmental changes to the office layout significantly increased their stepping time at work by 12 minutes/day (Maylor, 2018). No significant changes, however, were found in overall stepping time, overall physical activity, overall sitting time, or sitting time at work between control and intervention group participants.

Quasi-Experimental Intervention Study Findings

Among the 14 quasi-experimental studies included in the systematic review, overall physical activity was reported in one study (Malaeb et al., 2019), work-related physical activity was reported in 11 studies (Candido et al., 2019; Chau et al., 2016; Dutta et al., 2019; Eyler et al., 2018; Gilson et al., 2012; Gorman et al., 2013; Jancey et al., 2016; Mansoubi et al., 2016; Wahlstorm et al., 2019; Wallman-Sperlich et al., 2019; Zhu et al., 2018), and both overall and

work-related physical activity were reported in two studies (Koepp et al., 2013; Engelen et al., 2016). Sit-stand desk intervention studies found no significant effect on office workers' stepping time, light physical activity, or moderate to vigorous levels of overall or work-related physical activity (Chau et al., 2016; Gilson et al., 2012; Mansoubi et al., 2016; Zhu et al., 2018). In one study, there was a significant decrease in sitting time at work (Mansoubi et al., 2016).

Treadmill desk interventions were found to significantly increase office workers' walking time at work and decrease sedentary behaviors in the short- and long-term. Koepp et al. (2013) found that at 12-month follow up, workers in the treadmill desk intervention group increased the average walking time at work from 70 minutes/workday to 109 minutes/workday and decreased the average daily sedentary time by 43 minutes/workday). In another study using a treadmill desk intervention, the intervention increased the overall step count among office workers from the baseline assessment (Malaeb et al., 2019) but the researchers did not report the p-value. Zhu et al. (2018) found that a treadmill desk intervention decreased workers' average sitting time by 53 minutes/workday at 18 months post-intervention.

Among the three studies that used office design modifications as interventions, two studies found significant effects on workers' physical activity. In Wahlstorm et al.'s (2019) study, workers in flex offices significant increased their walking time at work from 39 minutes/workday at baseline to 47 minutes/workday as well as moderate- to vigorous-intensity physical activity at work from 19 minutes/workday at baseline to 27 minutes/day at 18 months post-intervention. Wallman-Sperlich et al. (2019) also found a significant decrease in average sitting time at work after 7 months of workers participating in an office design modification intervention that included adding sit-stand desk, 26 treadmill desk, sit-stand meeting space, shared trash bis, and sit-stand break tables.

The four quasi-experimental studies that used building design interventions showed a significant increase in workers' light physical activity (Eyler et al., 2018; Engelen et al., 2016: Gorman et al., 2013; Jancey et al., 2016). The average minutes spent in light activities at work increased from 35 minutes/workday at baseline to 57 minutes/workday post-intervention in the study by Jancey (2016). On the other hand, none of the studies found a significant change in time steps at work or in overall time spent engaging in moderate- to vigorous-intensity physical activity. There, however, were increasing trends in stepping time at work, time spent engaging in moderate- or vigorous-intensity activity at work, and total average steps per day for office workers in the intervention group (Eyler et al., 2018; Gorman et al., 2013; Jancey et al., 2016).

Non-Intervention Study Findings

Among the four cross-sectional studies, one study reported findings on overall physical activity and work-related physical activity (Renaud et al., 2018), and three studies reported findings on only work-related physical activity (Carr et al., 2016; Lindberg et al., 2018, McGann et al., 2015). Two studies examined the relationship between having sit-stand desks and workers' physical activity behavior. In a study by Carr and colleagues (2016), using a sit-stand desk, compared to sitting-desks, was significantly associated with increased standing time at work and decreased sitting time at work, but not associated with walking time at work.

Renaud et al. (2018) found that walking time at work was greater in employees that used their sit-stand desk more often (*less than once per week, but at least once a month; once or twice per week; three to four times per week; once or twice per day; three or more times per day*) than those who did not utilize the sit-stand desk features. Sit-stand desk users also met the physical activity guidelines (moderate to vigorous physical activity $\geq$150 minutes per week) more often than workers who did not use the sit-stand desk features. In the studies that compared the office

or building design floor plan, physical activity time at work was greater among employees working in buildings with accessible stairwells compared to buildings without accessible stairwells (McGann et al., 2015) and also greater in flex office spaces compared to private or cubical cell offices (Lindberg et al., 2018).

Risk of Bias

Tables 3a, 3b, and 3c present the summary of the risk of bias organized by study design type based on the Joanna Briggs Critical Appraisal Tool for Bias (Moola et al., 2017; Tufanaru et al., 2017). The eight randomized control studies had a moderate risk of bias because allocation to the intervention groups could not be concealed nor could participants be blinded to their intervention assignment. Tobin et al. (2016) did not describe the study's randomization procedure determining how participants were chosen for the study, nor did they describe how study participants were assigned the sit-stand desk intervention. Among the 14 quasi-experimental studies, 12 studies had a minimal risk of bias and two studies had a moderate risk of bias. Eleven of the 14 quasi-experimental studies conducted pre-post comparisons and did not have a control group. Engelen et al. (2016) and Eyler (2018) did not compare the baseline buildings for similarities or differences in desk type, square footage, stairwells, or amenities in the pre-phase before group moved to their new work environments (post-phase). Among the four cross-sectional studies, three had a minimal risk of bias and one study that did not measure how long employees used a sit-stand desk had a moderate risk of bias (Renaud, et al, 2018).

Discussion

This systematic review aimed to identify the relationship between the physical work environment and overall physical activity, work-related physical activity, or leisure-time physical activity in office workers. After reviewing 26 studies, this systematic review found that work environments built with active design principles are the most likely to result in increasing

workers' physical activity at work. Participants in work environments with flexible space and open floor plans with active design building principles spent more time walking and engaging in light physical activity at work than those in traditional spaces (Candido et al., 2019; Eyler et al., 2018; Gorman et al., 2013; Jancey et al., 2016; Wahlstorm et al., 2019). Office workers in these environments were consistently the most physically active at work even after 12 months or longer follow-up periods (Eyler et al., 2018; Wahlstorm et al., 2019).

"Active design" is a newer building design concept that includes environmental and structural design, policy, and workplace culture to create an environment that promotes physical activity, promotes active living and improve the quality of life of building occupants (Center for Active Design, 2010). The build design encourages movement by including features such as central staircases, shared and centralized facilities such as breakrooms, bathrooms, printers, and trash cans, and shared and diverse workspaces for sitting and standing work. Our review results align with a previous review showing that programs promoting incidental physical activity within and around the workplace had the strongest potential to increase physical activity of workers (Marshall, 2004). A recent systematic review of workplace physical activity interventions in working adults found that lifestyle-based interventions to increase physical activity had issues of the lack of compliance and low participation (Mulchandani et al., 2019). Unlike sit-stand or treadmill desk-based interventions that require participant adherence, office arrangement and building designs with active design guidelines focus on providing more opportunities for incidental activity and therefore encourage more movement and less sitting (Center for Active Design, 2010).

Another noteworthy finding of this systematic review is the overlap between physical activity and sedentary behavior. This systematic review was focused on changes in physical

activity; however, 23 of the 26 studies assessed sedentary behaviors among office workers. This pattern aligns with the literature; many previous intervention studies measured sedentary time or sedentary behavior as a primary outcome and physical activity as a secondary outcome (MacDonald et al., 2018; Prince et al., 2019). However, sedentary behavior and physical activity are two independent concepts that are related but not interchangeable (Thive et al., 2018). The results of this systematic review showed that a desk-type intervention had the greatest impact on decreasing sitting time, but little effect on increasing physical activity. Although changing a worker's desk can reduce sitting time, changes made to desk and workstations alone may not simultaneously change physical activity behavior.

The findings of this systematic review highlight a wide range of physical activity measures used and variations in reporting of these outcomes across the 26 studies. Physical activity was measured using 17 unique methods in the studies included in this systematic review. More than half of the studies (n=15) only measured work-related physical activity. Additionally, the data analysis methods varied across the studies; some studies reported the percentage of time in work-related, leisure, or overall physical activity, others reported minutes per day or minutes per workday of work-related, leisure, or overall physical activity, while others reported stepping time or step counts. Additionally, some studies used physical activity intensity categories such as light physical activity or moderate physical activity, while others used walking. These variations in physical activity measurement and physical activity reporting make it difficult to compare study results.

Strengths and limitations

This is the first systematic review that examined the physical workplace as the phenomenon of interest in relation to workers' physical activity. A strength of this systematic

review included a comprehensive search strategy developed with a research librarian. Additionally, this systematic review included work-related, leisure-time, and overall physical activities to examine a more holistic understanding of physical activity in office workers. Despite the strengths of this systematic review, several limitations need to be acknowledged. First, this systematic review only searched three databases, gray literature was not searched, and non-English studies were excluded. Thus, there may be additional studies that were not included in this review, specifically white papers that exist in the building industry. Second, only eight of the 26 studies reviewed were randomized control trials. Although the overall quality of studies in this review was strong, based on the level of evidence the authors cannot confirm causality between physical work environment and office workers' physical activity behavior. After critical appraisal of all studies in this review, the overall quality of the evidence is strong. Given the nature of desk and office design physical environment intervention research, blinding researchers or participants is not feasible and quasi-experimental studies are more common and practical.

Implications for Occupational Health

Occupational health nurses and program managers have the opportunity to positively influence the work environment to promote regular physical activity of workers and prevent chronic diseases. Occupational health nurses should be aware of the important role of the physical work environment in physical activity behavior among workers. To increase physical activity in office workers or low activity occupations, the focus must shift from limiting sedentary behavior to increasing activity throughout the day. The findings from this review suggest that workplace wellness programs should target how the office space is built, not only encourage individual physical activity behaviors, to be the most effective. To achieve this level

of health promotion, occupational health nurses must engage with organization leaders to gain business support and company level policy change.

Conclusion

The results of this systematic review indicate that physical work environments built with active design principles are the most effective in increasing workers' physical activity. This review also identified that many studies did not assess physical activity outside of work time and thus, the relationship between the physical work environment and workers' overall physical activity level is unclear in the current literature. Future research is needed to determine the effect of activity design office environments on overall total physical activity in office workers. The findings from this systematic review will help shape evidence-based solutions that can increase physical activity while reducing sedentary time in office workers.

In Summary *(3 - 4 bulleted sentences covering important professional practice findings)*

- Physical work environments built with active design principles are the most likely to increase physical activity at work among office workers.
- Building design interventions increased incidental physical activity among office workers and were more effective than individual behavior focused interventions.
- Desk-type interventions had the greatest impact on office workers' sitting time and sedentary behavior, but had a little effect on their physical activity behavior.

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Table 2.1. *Study Characteristic and Methods*

	Sample Characteristics					Study Methods			Physical activity measure	
#	Author, Publishing Year	City, State, Country	Sample size (n)	Mean age (SD)	Female (%)	Study design	Study focus area	Study frequency & duration	Self-report	Objective
1	Chau, 2014	New South Wales, Australia	42	38 (11)	86	RCT	sit-stand desk vs sitting desk	4 weeks, All workdays	OSPAQ*	ActivPAL3 accelerometer
2	Dutta, 2014	Minnesota, USA	28	40 (NR)	68	RCT	sit-stand desk vs sitting desk	4 weeks, all workdays	OSPAQ* end of each week	1) Modular Signal Recorder (MSR) accelerometer 2) Gruve accelerometer
3	Schuna, 2014	Baton Rouge, Louisiana	41	40 (10)	98	RCT	shared treadmill desk vs sitting desk	3 months, twice daily for 45 minute sessions	None	ActiGraph
4	Miyachi, 2015	Tokyo, Japan	32	44 (10.2)	31	RCT	shared standing desk in open-space office vs sitting desk in open-space office	6 weeks, 10hrs/week	None	Actimarker accelerometer
5	Tobin, 2016	Perth, Australia	37	35 (10.5)	86	RCT	sit-stand desk vs sitting desk	4 weeks, all workdays	None	ActivPal accelerometer
6	Bergman, 2018	Umea, Sweden	80	51(6.8)	55	RCT	treadmill desk vs sit-stand desk	13 months, all workdays	Self-reported question	1) ActivPal accelerometer 2) ActiGraph accelerometer
7	Maylor, 2018	Bedfordshire, UK	896	43 (2.5)	57	RCT	multicomponent* policy and environmental changes vs usual work practices at sitting desk	8 weeks, all workdays	None	ActivPAL accelerometer
8	Pierce, 2019	Hastings, New Zealand	24	39 (9.5)	52	RCT	sit-stand desk vs sitting desk	6 weeks, all workdays	Baecke questionnaire for habitual physical activity	Keep Walking-Stay Fit Pedometer

	Sample Characteristics					Study Methods			Physical activity measure	
#	Author, Publishing Year	City, State, Country	Sample size (n)	Mean age (SD)	Female (%)	Study design	Study focus area	Study frequency & duration	Self-report	Objective
9	Gilson, 2012	Sydney, Australia	11	47 (9.8)	64	Quasi-Exp (pre/post)	move from sitting desk in open workspace to shared sit-stand desk in open workspace	5 days, all workdays	None	Armband accelerometer (SenseWear)
10	Gorman, 2013	Vancouver, CA	24	35 (8.1)	75	Quasi-Exp (pre/post)	building design - move from conventional sitting desk workplace to activity permissive workplace environment (sit-stand desk, staircases, cafe-style meeting rooms)	3-6 months in new environment, all workdays	None	ActivPAL accelerometer
11	Koepp, 2013	Minnesota, USA	36	42 (9.9)	69	Quasi-Exp (pre/post)	move from sitting desk to treadmill desk	12 months, all workdays	None	Actical accelerometer
12	Jancey, 2016	Perth, Australia	42	40 (11.93)	64	Quasi-Exp (pre/post)	building design - move from traditional office space to new Active Building design building (centralized breakroom and bathroom, open accessible staircase)	4 months, all workdays	online survey stair use	ActiGraph accelerometer
13	Chau, 2016	Sydney, Australia	31	33 (10.8)	45	Quasi-Exp (pre/post)	move from sitting desk to sit-stand desk	19 weeks, all workdays	1) Active Australia Questionnaire after 19 weeks 2) OSPAQ after 19 weeks	1) ActivPAL 2 accelerometer 2) ActiGraph accelerometer
14	Engelen, 2016	Sydney, Australia	34	NR	74	Quasi-Exp (pre/post)	building design - old office building to new health-promoting active building (accessible stairs and centralized break rooms and bathrooms)	2 months, all workdays	1) OSPAQ 2) "*How many day 30mins MVPA* in past week?*" completed at 2 months before and 2 months post move	N/A

	Sample Characteristics					Study Methods			Physical activity measure	
#	Author, Publishing Year	City, State, Country	Sample size (n)	Mean age (SD)	Female (%)	Study design	Study focus area	Study frequency & duration	Self-report	Objective
15	Mansoubi, 2016	UK	40	32 (8.6)	55	Quasi-Exp (pre/post)	move from sitting desk to sit-stand desk	3 months, all workdays	None	1) ActivPAL3 accelerometer 2) ActiGraph accelerometer
16	Eyler, 2018	Missouri, USA	143	NR	NR	Quasi-Exp (pre/post with control group)	building design - pre/post move to new active building (stairwell, natural light, sit-stand desk, common printing and receptible bin areas, and commuter showers) vs non-movers in adjacent building	12 months, all workdays	adapted International Physical Activity Questionnaire for workday	ActivPal accelerometer
17	Zhu, 2018	Arizona, USA	36	39 (11.3)	75	Quasi-Exp (pre/post with control group)	pre/post sit-stand desk and shared treadmill desk vs staff in siting desk in a different workspace	18 months, all workdays	None	ActivPal accelerometer
18	Candido, 2019	Sydney, Australia	20	NR	NR	Quasi-Exp (pre/post)	office arrangement design - move from assigned seating in open-plan configuration to unassigned activity-based working space (sit-stand desk, multipurpose spaces, biophilia)	average 82 days, all workdays	None	Fitbit Charge2 accelerometer
19	Dutta, 2019	Minnesota, USA	15	39 (9.7)	73	Quasi-Exp (pre/post)	move from sitting desk to sit-stand desk	12 months, all workdays	OSPAQ* at the end of each week for 2 weeks	Gruve accelerometer
20	Malaeb, 2019	Minnesota, USA	25	47 (NR)	92	Quasi-Exp (pre/post)	move from sitting desk to shared treadmill desk	2 weeks, 2.5hrs/workday	International Physical Activity Questionnaire Short Version weekly	Actical accelerometer

	Sample Characteristics					Study Methods			Physical activity measure	
#	Author, Publishing Year	City, State, Country	Sample size (n)	Mean age (SD)	Female (%)	Study design	Study focus area	Study frequency & duration	Self-report	Objective
21	Wahlstorm, 2019	Sweden	86	48 (10.3)	86	Quasi-Exp (pre/post)	office arrangement design - move from assigned sitting desk to 1) cell office with PA promotion program or 2) flex office in active design office space (sit-stand meeting space, 26 treadmill desk, shared trash bins, and sitting and standing break tables) with PA promotion program	18 months, all workdays	None	1) ActivPal accelerometer worn 24hrs/day for 7 consecutive days 2) ActiGraph accelerometer worn during waking hours for 7 consecutive days
22	Wallmann-Sperlich, 2019	Krefeld, Germany	23	39 (10)	75	Quasi-Exp (pre/post)	office arrangement design - move from sitting desk open space to new active office space (sit-stand desk, natural lighting, ventilation, significant numbers of plants, views, and recycled and non-synthetic materials, possibilities for sitting and standing, and features permitting PA)	7 months, all workdays	1) Marshall Sitting Questionnaire one month before relocation and 3 months and 7 months after relocation 2) OSPAQ* one month before relocation and 3 months and 7 months after relocation	None
23	McGann, 2015	Australia	111	45 (NR)	77	Cross sectional	building design - compared 3 building styles (placement of shared spaces, staircases, and floor plan arrangement)	N/A	OSPAQ*	ActiGraph accelerometer
24	Carr, 2016	Midwest, USA	69	44 (10.7)	74	Cross sectional	compared sit-stand desk for $\geq$6 months users to sitting desk users	N/A	None	ActivPAL3 accelerometer

	Sample Characteristics					Study Methods			Physical activity measure	
#	Author, Publishing Year	City, State, Country	Sample size (n)	Mean age (SD)	Female (%)	Study design	Study focus area	Study frequency & duration	Self-report	Objective
25	Lindberg, 2018	USA	231	44 (12.2)	50	Cross sectional	office arrangement design - compared desk types (private, cubicle, open bench)	N/A	None	EcgMove3 accelerometer
26	Renaud, 2018	Europe	1098	47 (7.8)	35	Cross sectional	compared PA in sit-stand desk users to sitting desk users	N/A	1) Workforce Sitting Questionnaire 2) OSPAQ* 3) Single Physical Activity guidelines question	None

Note. NR = Not reported, SD = Standard deviation, RCT= Randomized control trial, Quasi-Exp = Quasi-Experimental study, PA = Physical activity

*Multicomponent intervention included education presentation, brainstorming session, step challenge, health check report individual meeting, software prompts to move, weekly telephone support, and changes to work environment such as relocation of trash bins and printers

Table 2.2. *Physical Activity Results, Main Findings, and Limitations*

#	Author, Year	Physical activity results: Overall	Physical activity results: At work	Main findings	Study limitations
1	Chau, 2014	NR	1) Net difference in stepping time (NR, p=0.433) min/day at work from baseline to post-intervention: 13 min/day (p=0.127) change in intervention and 2 min/day (p=0.823) change in control group (OSAPQ). 2) Net difference in stepping time (NR, p=0.453) min/day at work from baseline to post-intervention: 11 min/day (p=0.081) change in intervention and 3 min/day (p=0.596) change in control (ActivPal).	Sit-stand desk reduce overall sitting time, but have no effect on step time or PA at work.	- short term follow-up - convenience sample - no blinding - no objective measure for frequency or duration of activity.
2	Dutta, 2014	1) Increase in activity units (AU) from baseline to post intervention in total activity: 237,729 AU/hour (p>0.05) in intervention group versus 236,445 AU/hour (p>0.05) in control group (Gruve).	1) Increase in AUs in work activity from baseline to post intervention: 229,156 AU/hour (p<0.05) in intervention group versus 210,245 AU hour (p<0.05) in control group (Gruve).	Sit stand desk used over 4 months significantly reduced sitting time and increase standing and light activity during work hours.	- no blinding - short term follow-up - small sample
3	Schuna, 2014	1) 1.6 min/hr (95% CI 0.5, 2.8) increase in light PA from baseline to post-intervention between the control and intervention group 2) -0.1min/hr (95% CI -0.5, 0.4) decrease in moderate-to-vigorous PA from baseline to post-intervention between the control and intervention group	1) 2.9 min/hr (95% CI 0.9, 5.0) increase in light PA from baseline to post-intervention between the control and intervention group 2) -0.4min/hr (95% CI -0.9, 0.1) decrease in MVPA from baseline to post-intervention between the control and intervention group	Shared treadmill workstations decreased sedentary time and improved low-intensity and light PA behavior but not moderate-to-vigorous activity during the workday and overall in overweight/obese office workers.	- only used overweight/obese workers - short term follow-up

#	Author, Year	Physical activity results: Overall	Physical activity results: At work	Main findings	Study limitations
4	Miyachi, 2015	1) Change in total time spent on total PA (p=NR): 544.6 (±117.5) min/day after intervention versus 536.1(±117.0) min/day in control group. 2) Change in total time spent on light PA (p=0.019) min/day daily from baseline to post-intervention: 481.9 (±116.0) min/day after intervention versus 479.1 (±113.5) min/day in control group. 3) Change in total time spent on moderate PA (p=NR) min/day daily from baseline to post-intervention: 58.2 (±20.7) min/day after intervention versus 53.4 (±17.0) min/day in control group. 4) Change in total time spent on vigorous PA (p=NR) min/day daily from baseline to post-intervention: 4.6 (±11.1) min/day after intervention versus 3.6 (±11.6) min/day in control group.	NR	Installation of sit-stand desk in increases time spent on overall PA, especially PA during weekdays.	- minimal control over daily work load - objective measure unable to duration of standing - short term intervention and follow-up - small sample size
5	Tobin, 2016	NR	1) Net difference in stepping time by 2.1 minutes/8-hr workday (p=0.761) in intervention group from baseline to post-intervention relative to control group.	A significant reduction in sitting time, but no change in the amount of time participants spent stepping at work.	- short term study period - small sample size - unmeasured confounders such as work or life stress - outcomes measured during working hours only

#	Author, Year	Physical activity results: Overall	Physical activity results: At work	Main findings	Study limitations
6	Bergman, 2018	1) Increase in daily walking time (22 min/weekday, p=0.00045) from baseline to 13 months 2) Increase in daily light-activity PA time (3 min/weekday, p=0.005) from baseline to 13 months 3) Change in daily MVPA activity time (2 min/weekday, p=0.23) from baseline to 13 months	NR	Treadmill workstations increased daily walking time among overweight or obese office workers compared to those with a sit-stand desk. However moderate-to-vigorous PA decreased over the study period with the largest decrease in the intervention group after 13 months.	- different companies had various health promotion programs during intervention periods - lack of blinding - only used overweight/obese workers - different companies had various health promotion programs during intervention periods
7	Maylor, 2018	1) Net increase in stepping time (1.0 min/day, p=0.770) from baseline to 8 weeks	1) Net increase in stepping time at work (12 min/workday, p<0.001) from baseline to 8 weeks	Decrease in prolonged sitting time at workout and increase in steps per day using an individual, organization, and environmental intervention approach without the use of a sit-stand desk.	- only one worksite used - unable to measure effect of individual interventions - outcomes measured during working hours only
8	Pierce, 2019	1) No change in leisure PA associated with intervention (NR, p=0.039)	1) Increase in steps taken at work (NR, p<0.001) from baseline to 8 weeks associated with intervention.	Adding electronic adjustable height desk to the workplace was associated with increase steps at work, decrease in sitting time at work, and no change in leisure time PA	- small sample size - pedometers unable to detect postural changes - pedometers unable to capture intensity level of PA - shorten version of the Baecke questionnaire has not been previously assessed.

#	Author, Year	Physical activity results: Overall	Physical activity results: At work	Main findings	Study limitations
9	Gilson, 2012	NR	1) Net difference in % of time at work spent in light-activity PA (0.8%, 95% CI -6.8, 7.9) from baseline to post intervention 2) Net difference in % of time at work spent in MVPA (-0.7%, 95% CI -1.8, 2.3) from baseline to post intervention	Desk had no overall effect on sedentary time or PA time at work.	- armband accelerometer did not capture posture changes - small sample size - short measurement period - participants shared the intervention desk
10	Gorman, 2013	NR	1) Net increase in stepping time 1.2 min/workday (p=0.748) at work from baseline to post-intervention	Post move to an activity-permissive work space office worker had less time sitting and more time standing, but no change in stepping time or PA during work time.	- change to PA outside work hours were not accessed - bias within sample population due to nature of their industry - timing of data collection pre-move was not described
11	Koepp, 2013	1) Change in average daily PA (NR, p=NR) from baseline to post-intervention: 4,205 AU/day (p=<0.001) at 12 months of intervention, 4,460 AU/day (p=<0.001) at 6 months of intervention, and 3,353 AU/day (p=<0.001) at baseline.	1) Change in walking time (NR, p=NR) at work from baseline to post-intervention: 70 min/workday (p=<0.001) at baseline, 128 min/workday (p=<0.001) at 6 months of intervention, and 109 min/workday (p=<0.001) at 12 months of intervention.	Overall PA and walking time at work increased over the course of a year in employee's with access to a walking treadmill desk and had no significant impact on work performance.	- treadmill desk scatter throughout the office did not allow for community support among users - small sample size - unlike similar studies that report PA in METs or intensity categories, PA is only reported in Activity Units (AU)

#	Author, Year	Physical activity results: Overall	Physical activity results: At work	Main findings	Study limitations
12	Jancey, 2016	NR	1) Change in the average min/workday time spent doing light activity at work ($p<0.001$) from baseline to post-intervention: 57.16 min/workday (95% CI 52, 63) after intervention and 35.13 min/workday (95% CI 32, 39) at baseline. 2) Change in the average min/workday time spent doing moderate activity at work ($p=0.109$) from baseline to post-intervention: 39.72 min/workday (95% CI 35, 45) after intervention and 36.13 min/workday (95% CI 33, 40) at baseline. 3) Change in the average min/workday time spent doing vigorous activity at work ($p=0.658$) from baseline to post-intervention: 0.29 min/workday (95% CI 0.11, 0.53) after intervention and 0.33 min/workday (95% CI 0.16, 0.54) at baseline.	Average time spent doing light activity at work increased, time spent standing at work increased, and sitting time at work decreased.	- no control group - large loss to follow-up - did not measure PA outside of work
13	Chau, 2016	NR	1) Net difference in walking time (-8min/workday, $p=0.679$) at work from baseline to post-intervention: -21 min/day ($p=0.144$) change in intervention versus -13min/day ($p=0.287$) change in control (OSPAQ). 2) Net difference in heavy labor time (14 min/workday, $p=0.125$) at work from baseline to post-intervention: 11 min/day ($p=0.396$) change in intervention versus -3min/day ($p=0.749$) change in control (OSPAQ).	No changes in walking time or PA, but sit-stand desk did reduce sitting and increase standing time.	- small convenience sample - data loss from accelerometer device malfunction - non-adherence to wearing accelerometer device

#	Author, Year	Physical activity results: Overall	Physical activity results: At work	Main findings	Study limitations
14	Engelen, 2016	1) Decrease in number of days spend doing MVPA per week (p>0.05) at work from baseline to post-intervention: 4.6 days/week in intervention versus 4.9 days/week at baseline.	1) Change in % of time spent walking (p>0.05) at work from baseline to post-intervention: 11% of workday at baseline versus 10% of workday in intervention (OSPAQ). 2) No change in % of time spent on heavy labor at work from baseline to post-intervention: 0% of workday in intervention and 0% of workday at baseline (OSPAQ).	Workers sat less and new building provided more opportunities for incidental activity.	- no objective measure of PA - small sample size - large loss to follow-up - study did not compare the 4 baseline sites for differences at baseline
15	Mansoubi, 2016	NR	1) No change in stepping time at work from baseline to post-intervention (ActivPal). 2) No change in overall proportion of time spent in light activity on workdays from baseline to post-intervention (ActiGraph). 3) No change in overall proportion of time spent in MVPA on workdays from baseline to post-intervention (ActiGraph).	The use of sit-to-stand desk decreased sedentary time at work, increased light activity time at work, and had no effect on leisure time moderate PA.	- short term study period - small sample size - convenience sample
16	Eyler, 2018	NR	1) Increase in average steps/day (NR, p=0.99) from baseline to post-intervention in all groups: 1591 steps/day (p<0.001) change in movers, 928 steps/day (p=0.09) change in non-movers and 1756 steps/day (p=0.008) change in control.	PA increased in all study groups, it is unclear if building had an effect on PA.	- wellness challenge to track PA for cash incentives started at time of post data collection. - self selection bias in those that volunteered to wear accelerometer - unable to capture sample demographics - did not compare sitting and activity patterns at baseline for differences between groups

#	Author, Year	Physical activity results: Overall	Physical activity results: At work	Main findings	Study limitations
17	Zhu, 2018	NR	1) No change to light PA or MVPA at the workplace.	Sit-stand desk paired with motivational support decreased sitting time, increase standing time, and increase low intensity PA in the workplace and is sustainable for 18 months.	-Small sample -high attrition at 18 months
18	Candido, 2019	NR	1) Increase in average steps/day: 300 steps/day (p=NR) after relocation to new office environment.	The average steps per day increased after moving to a active building design environment	- selection bias in who volunteered to wear Fitbit. - PA data only collected from 20 volunteers
19	Dutta, 2019	NR	1) 24,748 AU/hr (95% CI: 7,150 - 42,347) increase at work after one year follow-up from baseline.	Overall PA during the work day remained about 12% higher, and sitting time remained reduced after 1-year of sit-stand desk relative to baseline.	- small sample size - blinding not achievable - low retention from original study
20	Malaeb, 2019	1) Increase in total PA step count in intervention group compared to baseline ($p<0.01$).	NR	Treadmill desk usage over 2 weeks increased overall step count and had positive body composition results.	- small sample size - all participants had BMI >25 - short intervention period - accelerometer counts not converted to METs or minutes of activity.

#	Author, Year	Physical activity results: Overall	Physical activity results: At work	Main findings	Study limitations
21	Wahlstorm, 2019	NR	1) Change in walking time (NR, p=0.001) min/workday from baseline to 18 month follow-up: 39 min/workday (95% CI: 35, 43) at baseline and 47 min/workday (95% CI: 44, 52) at 18 month follow-up in flex office; 42 min/workday (95% CI: 38, 46) at baseline and 41 min/workday (95% CI: 40, 46) at 18 month follow-up in cell office 2) Change in MVPA time (NR, p<0.001) min/workday from baseline to 18 month follow-up: 19 min/workday (95% CI: 15, 22) at baseline and 27 min/workday (95% CI: 23, 30) at 18 month follow-up in flex office; 16 min/workday (95% CI: 13, 19) at baseline and 19 min/workday (95% CI: 15, 22) at 18 month follow-up in cell office	Greatest increase in walking time, number of steps, and MVPA time during the workday compared to baseline occurred in flex offices. No changes in sitting time occurred.	- all employees had sit-stand before and after move regardless of office type - unbalanced distribution of gender and mangers between the two groups - utilization of provided health and wellness hour not measured - seasonal differences in moves were not accounted for
22	Wallmann-Sperlich, 2019	NR	1) Change in min/workday walking (p=0.33) from baseline to 7 months post intervention: 70.2 min/workday (95% CI: 30.7, 109.7) at baseline and 84 min/workday (95% CI: 50.1, 117.9) at post intervention measure.	Offices that were active and biophilic designed increased walking time and standing time and reduce sitting time during the workday.	- small sample size - high attrition - no objective PA measurement - PA intensity levels not measured
23	McGann, 2015	NR	1) Light-intensity PA was 4.6% in Building 1, 2.6% in building 2, and 3.3% in building 3. Building 1 has best quality staircases and corridors.	The building with the best quality staircase and participants had the highest mean step count per day and highest mean level of moderate PA.	- did not discuss the participants workstations or desk - did not provide PA measures per building

#	Author, Year	Physical activity results: Overall	Physical activity results: At work	Main findings	Study limitations
24	Carr, 2016	NR	1) Difference in average time walking hr/day at work in employees with sit-stand desk versus walking desk: 0.7 hrs/day in sit desk and 0.9 hrs/day in sit-stand desk (p=0.22)	Office employees with long term access to sit-stand desk stood 60 minutes during the work day than employees with only a sit desk.	- small sample size - limited generalizability - PA intensity levels not measured
25	Lindberg, 2018	NR	1) Workers in open bench seating exhibited 31.83% higher rates of PA than those in private offices (225.51mG; 95% CI: 137, 314). 2) Workers in open bench seating exhibited 20.16% higher rates of PA than those in cubicles (185mG; 95% CI: 67, 304).	Workers in open bench seating types had higher rates of PA than those in cubicles or private offices.	- cannot confirm causal relationship between office type and PA
26	Renaud, 2018	1) Meeting the guidelines for PA showed a positive trend with sit-stand desk users: 30% in non-users, 30% in monthly to weekly users, and 35% in daily users	1) Walking hours/week at work showed a positive trend with sit-stand desk users: 2.3hrs/week in non-users, 2.2hrs/week in monthly to weekly users, and 3.2 hrs/week in daily users.	Positive trend in overall PA, access trend of walking time at work, and decreased sitting time at work in those with long-term access to sit-to-stand desk.	- recall bias - social desirability - did not measure how long employees had used a sit-stand desk. - limited PA measurement

Note. NR = Not reported, OSPAQ= Occupational sitting and physical activity questionnaire, MVPA = Moderate to vigorous physical activity, A/U = Activity units, mG="milli-Gs (g-force), PA = Physical activity

Table 2.3a. *Joanna Briggs Critical Appraisal Tool for Bias in Randomized Control Trial Studies*

#	Author, Year	1) Was true randomization used for assignment of participants to treatment groups?	2) Was allocation to treatment groups concealed?	3) Were treatment groups similar at the baseline?	4) Were participants blind to treatment assignment?	5) Were those delivering treatment blind to treatment assignment?	6) Were outcomes assessors blind to treatment assignment?	7) Were treatment groups treated identically other than the intervention of interest?	8) Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analyzed?	9) Were participants analyzed in the groups to which they were randomized?	10) Were outcomes measured in the same way for treatment groups?	11) Were outcomes measured in a reliable way?	12) Was appropriate statistical analysis used?	13) Was the trial design appropriate, and any deviations from the standard RCT design (individual randomization, parallel groups) accounted for in the conduct and analysis of the trial?
1	Chau, 2014	Yes	No	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2	Dutta, 2014	Yes	No	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3	Schuna, 2014	Yes	No	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
4	Miyachi, 2015	Yes	No	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
5	Tobin, 2016	Unclear	Unclear	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
6	Bergman, 2018	Yes	No	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
7	Maylor, 2018	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
8	Pierce, 2019	Yes	No	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 2.3b. *Joanna Briggs Critical Appraisal Tool for Bias in Quasi-Experimental Studies*

#	Author, Publishing Year	1) Is it clear in the study what is the cause and what is the effect'	2) Were the participants included in any comparisons similar?	3) Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of	4) Was there a control group?	5) Were there multiple measurements of the outcome both pre and post the	6) Was follow up complete and if not, were differences between groups in terms of their follow	7) Were the outcomes of participants included in any comparisons measured in the	8) Were outcomes measured in a reliable way?	9) Was appropriate statistical analysis used?
9	Gilson, 2012	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
10	Gorman, 2013	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
11	Koepp, 2013	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
12	Jancey, 2016	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
13	Chau, 2016	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
14	Engelen, 2016	Yes	Unclear	Yes	No	No	Yes	Yes	Yes	Yes
15	Mansoubi, 2016	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes
16	Eyler, 2018	Yes	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Yes
17	Zhu, 2018	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
18	Candido, 2019	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
19	Dutta, 2019	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
20	Malaeb, 2019	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
21	Wahlstorm, 2019	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
22	Wallmann-Sperlich, 2019	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes

Table 2.3c. *Joanna Briggs Critical Appraisal Tool for Bias in Cross-Sectional Studies*

#	Author, Publishing Year	1) Were the criteria for inclusion in the sample clearly defined?	2) Were the study subjects and the setting described in detail?	3) Was the exposure measured in a valid and reliable wav?	4) Were objective, standard criteria used for measurement of the condition?	5) Were confounding factors identified?	6) Were strategies to deal with confounding factors stated?	7) Were the outcomes measured in a valid and reliable way?	8) Was Appropriate analysis used?
23	McGann, 2015	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
24	Carr, 2016	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
25	Lindberg, 2018	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
26	Renaud, 2018	Unclear	Yes	Yes	Unclear	Yes	Yes	Yes	Yes

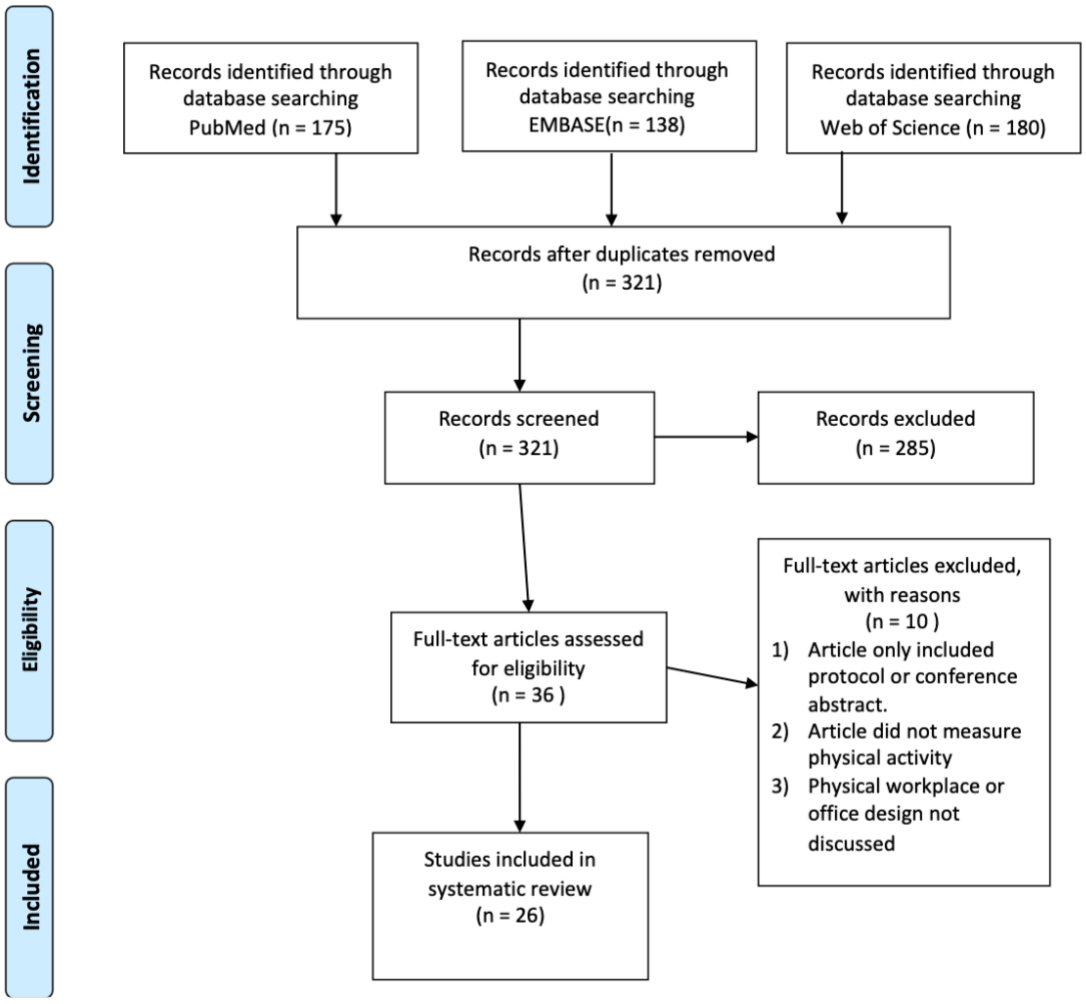

Figure 2.1. *Study Selection by Preferred Reporting Items for Systematic Reviews and Meta-Analyses*

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Appendix A.

Database Selection Criteria May 21, 2019

	Search Used	Article Found
Pubmed Search		
#1 Physical Activity	("exercise"[MeSH Terms] OR "exercise"[tiab] OR "physical activity"[tiab] OR "physical activities"[tiab] OR "Sedentary lifestyle" [tiab] OR Sedentary [tiab] OR "Sedentary behavior" [MeSH Terms] OR sitting [tiab] or standing [tiab])	480,995
#2 Work Env	("Workplace"[MeSH Terms] OR "Workplaces" [tiab] OR "work place" [tiab] OR "work places" [tiab] OR "Work Environment"[tiab] OR "work office" [tiab] OR worksite[tiab] OR worksites[tiab] OR office [tiab] OR workstation* [tiab])	98,885
#3 Work	("Interior design and furnishings" [MeSH Terms] OR "office design" [tiab] OR "workplace design" [tiab] OR "sit stand" [tiab])	4,863
#4	#1 AND #2 AND #3	176
#5	#4 AND ("0001/01/01"[PDAT] : "2019/05/01"[PDAT])	175
Embase		
#1	"exercise'/exp OR exercise OR 'physical activity'/exp OR 'physical activity' OR 'sitting'/exp OR sitting OR 'sedentary lifestyle'/exp OR 'sedentary lifestyle' OR 'sedentary time'/exp OR 'sedentary time' OR 'standing'/exp OR standing	942,716
#2	('workplace'/exp OR workplace OR 'work environment'/exp OR 'work environment' OR workstation OR 'work site' OR worksite* OR 'office worker'/exp OR 'office worker') AND ('office'/exp OR office)	5,859
#3	'furniture'/exp OR furniture OR 'interior design'/exp OR 'interior design' OR 'office design' OR 'workplace design' OR 'sit stand'	30,357
#4	#1 AND #2 AND #3	138

Web of Science		
#1	("exercise"[MeSH Terms] OR "exercise" OR "physical activity" OR "physical activities" OR "Sedentary lifestyle" OR Sedentary OR "Sedentary behavior" [MeSH Terms] OR sitting or standing)	838,343
#2	("Workplace"[MeSH Terms] OR "Workplaces" OR "work place" OR "work places" OR "Work Environment" OR "work office" OR worksite OR worksites OR office OR workstation*)	171,044
#3	("Interior design and furnishings" [MeSH Terms] OR "office design" OR "workplace design" OR "sit stand")	998
#4	#1 AND #2 AND #3	180
Hand Search		
		2

Chapter Three

Prevalence of Leisure-Time Physical Activity and Associated Occupational Factors in U.S. Workers: Analysis of 2015 National Health Interview Survey

Background

There are over 129 million full-time employed adults in the United States (U.S.) who spend over seven hours a day at their place of employment (Bureau of Labor Statistics [BLS], 2019a). Over the past 60 years, the amount of physical activity exerted by workers at the workplace, in particular office workers has rapidly decreased (Church et al., 2011); nowadays 80% of U.S. civilian jobs are classified as sedentary or light work (BLS, 2017). Given that workers' jobs require less amounts of physical activity at work, understanding the amount of leisure-time physical activity among workers is important.

Physical activity provides health benefits and lowers risk of heart disease, stroke, type 2 diabetes, cancer, and weight gain (Lollgen et al. 2009). The 2nd Edition of the Physical Activity Guidelines for Americans (2018 Physical Activity Guidelines Advisory Committee; U.S. Department of Health and Human Services, 2018) recommends that adults perform at least 150 minutes of moderate-intensity aerobic activity or 75 minutes of vigorous-instensity aerobic activity a week, or a combination of the two called moderate-to-vigorous physical activity (MVPA). In addition, engaging in muscle-strengthening activities involving all the major muscle groups at least two days a week is recommended. Despite the known health benefits of physical activity, 80% of adults in the U.S. do not meet the recommendations for physical activity (Piercy & Troiano, 2018).

Evidence on the association between leisure-time physical activity (LTPA) and occupational physical activity is mixed. In studies that examined the association using occupation type, white-collar workers, which are traditionally low activity occupations, were found to have a higher prevalence of leisure-time MVPA than blue-collar workers (Gu et al., 2016; Gudnadottir et al. ,2019; Kirk & Rhodes, 2011; Prince et al., 2019). On the other hand, a systematic review that examined the relationship of LTPA or leisure-time MVPA with

occupational physical activity level found that workers who perform higher levels of occupational physical activity meet the LTPA recommendations more often than workers performing less occupational physical activity (Kirk & Rhodes, 2011). Previous studies using national samples of U.S. workers examined the prevalence of sufficient LTPA by type of industry or occupation, but the association with occupational physical activity was not examined (Gu et al., 2016).

Beyond occupational type or occupational activity, previous research found that sociodemographic factors such as female gender, non-white race/ethnicity, increased age, and no college education were associated with less engagement in aerobic physical activity among U.S. workers (Gu et al., 2016). In order to better understand barriers and facilitators to workers engaging in regular LTPA, the impact of the workplace environment and occupational factors must be considered, given the substantial amount of time spent at work among American adults.

Additionally, in the literature of LTPA, a common gap is identified in the approach. While the physical activity guidelines recommend both aerobic and muscle-strengthening activities, LTPA often references only the aerobic portion of the physical activity guidelines. For example, in two previous systematic reviews of broad occupational or industry group populations, neither defines LTPA as meeting both the aerobic and muscle-strengthening components of the guidelines (Prince et al., 2019; Kirk & Rhodes,2011). This limited definition of LTPA inaccurately estimates the prevalence of meeting LPTA and does not capture the full health benefits of meeting both aerobic and muscle-strengthen guidelines.

The purpose of this study was to examine the association of meeting physical activity guidelines with occupational characteristics using a nationally representative sample of U.S. workers. Specific aims were to 1) estimate the prevalence of meeting aerobic activity guidelines,

muscle-strengthening guidelines, and both guidelines (sufficient LTPA) by sociodemographic, health, workplace characteristics, and occupational categories among U.S. workers, 2) examine the relationship between sufficient LTPA and occupational physical activity, and 3) identify factors associated with sufficient LTPA.

Methods

Data Source and Study Sample

This study used Sample Adult, Person, and Family data from the 2015 National Health Interview Survey (NHIS), a cross-sectional in-person interview survey conducted annually to monitor health trends across the U.S. population. The NHIS included a supplemental questionnaire on occupational health in 1988, 2010, and 2015; this study used the most recent 2015 data (Center for Disease Control and Prevention [CDC], 2016a, p.58). The NHIS sampling design is random area probability sampling, coupled with an oversampling of Black, Hispanic, and Asian persons by a 2:1 ratio through targeting geographic areas with higher concentrations of these groups twice as often (CDC, 2014, p.12). The NHIS sampling excludes active Armed Forces personnel, incarcerated persons, people living in long-term care facilities, and U.S. nationals living outside of the country (CDC, 2020). The response rate was 55.2%. The 2015 NHIS sample contained a total of 33,672 adults aged 18 years or older. Of those, 14,216 adults who were retired adults and adults who had not worked in the past week were excluded from this analysis. This yielded a sample of 19,456 U.S. adult workers. After excluding for missing data, a final sample of 15,049 U.S. adult workers was included in this analysis.

Study Variables

Aerobic Activity, Muscle-Strengthening Activity, and Sufficient LTPA. LTPA was assessed by intensity, frequency, duration, and type. Aerobic activity is classified into moderate-intensity aerobic activity and vigorous-intensity aerobic activity (Piercy & Troiano, 2018).

Moderate-intensity aerobic activity was assessed by the questions "*How often do you do LIGHT OR MODERATE leisure-time physical activities for AT LEAST 10 minutes that can cause ONLY LIGHT sweating or a SLIGHT TO MODERATE increases in breathing or heart rate?*" and *"About how long do you do these moderate leisure-time physical activities each time?*" Vigorous-intensity aerobic activity was assessed with the questions "*How often do you do VIGOROUS leisure-time physical activities for AT LEAST 10 minutes that can cause HEAVY sweating or LARGE increases in breathing or heart rate?*" and *"About how long do you do these vigorous leisure-time physical activities each time?"* Frequency responses were recorded as the number of units per days, weeks, months, or year depending on the time unit the respondent chose. Duration responses were recorded as the number of minutes or number of hours. The frequency and duration responses were then transformed into a new variable: total minutes engaged in moderate or vigorous aerobic activity per week. Each minute of vigorous-intensity aerobic activity was counted as 2 minutes of moderate-intensity aerobic activity (2018 Physical Activity Guidelines Advisory Committee). The responses ranged from 10 to 720 minutes.

A dichotomous variable of meeting aerobic activity guidelines (≥150 minutes per week) was created from the total minutes. Muscle-strengthening activity was assessed with the question "*How often do you do leisure-time physical activities specifically designed to STRENGTHEN your muscles such as lifting weights or doing calisthenics?*" A dichotomous variable of meeting muscle-strengthening guidelines (≥ 2 days per week) was created. Based on the physical activity guidelines, the sufficient LTPA variable was created as a dichotomous variable based on whether the respondent met both recommendations or not.

Occupational Physical Activity. Occupational activity level was assessed by two questions: "*How often does your job involve standing or walking around*", and "*How often does*

your job involve repeated lifting, pulling, pushing, or bending" (hereafter called "physical exertion"). Response options for these questions included never, seldom, sometimes, often or always. Occupational physical activity is a composite variable combined the standing/walking and physical exertion variables and was categorized as sedentary, light, medium, or heavy work based on the U.S. Bureau of Labor Statistics definition of physical work demand exertion levels (BLS, 2019b).

Sedentary occupational physical activity was defined as work requiring physical exertion as never or seldom and standing/walking as never, seldom, or sometimes. Light occupational physical activity was defined as work requiring 1) physical exertion as never or seldom and standing/walking as often or always; or 2) physical exertion as sometimes and standing/walking as never, seldom, or sometimes. Medium occupational physical activity was defined as work requiring 1) physical exertion as often and standing/walking as any frequency; or 2) physical exertion as sometimes and standing/walking as often or always. Heavy occupational physical activity was defined as work requiring physical exertion as always were classified as "heavy" occupation physical activity regardless of standing/walking frequency.

Occupational Categories. The NHIS data include occupational categories coded from self-reported answers to the question "*What kind of work are you doing?"* based on the 2010 Standard Occupational Classification (U.S Census Bureau, 2021). Occupations are classified into one of 23 major groups.

Workplace Variables. Included were size of employer (1-49 employees, 50-249 employees, 250-499 employees, 500-999 employees, ≥1000 employees), working multiple jobs (yes or no), and workplace health promotion program availability and participation. Workplace health promotion program was assessed by the following two questions: "*In the past year, were*

health promotion programs made available to you by your employer?" (yes or no) and "*If yes, how often did you participate in any of these activities in the past year?*" (never, once to a few times, monthly, weekly, daily).

Sociodemographics. Sociodemographic variables included age (years), gender (male or female), race/ethnicity (Non-Hispanic White, Hispanic White, Black/African American, American Indian/Alaskan Native, Asian, or Multiracial), education (less than high school, high school or general education development (GED), Bachelor's degree or higher), household income ($0-$34,999, $35,000-$74,999, $75,000-$99,999, or ≥$100,000), marital status (married/living with partner or not), and having children (yes or no). Health variables included body mass index (BMI kg/m^2), history of smoking assessed by "ever smoked 100 cigarettes" (yes or no), history of alcohol usage (yes or no), and a history of chronic disease (i.e., coronary heart disease, hypertension, stroke, any type of cancer, diabetes, high cholesterol, obesity; yes or no).

Data Analysis

Data were analyzed using Stata 16 (StataCorp, 2019). Sample weights used in the complex sampling design of the 2015 NHIS were taken into consideration in the analysis. Descriptive statistics were computed to summarize the sample characteristics and study variables. Weighted prevalence (%) and 95% confidence intervals (CIs) for sufficient LTPA, met aerobic activity, and met muscle-strengthening were obtained by sociodemographic, health, workplace variables, and occupation categories. Weighted percent distribution of occupational physical activity was described by 23 occupation categories. Logistic regression analyses were used to examine the association between each study variable and sufficient LTPA as the primary outcome for this study. Statistical significance was determined at $p < .05$. The multivariable

model adjusted for all significant demographic, health, and workplace variables in the bivariate analyses. Crude and adjusted odds ratios (ORs) with 95% CIs were obtained.

Results

The study sample included 15,049 U.S. adult workers. Of the sample, 25.2% had sufficient LTPA, 55.3% met aerobic guidelines, and 28.4% met muscle-strengthening guidelines. Table 1 displays their weighted prevalence of LTPA, meeting aerobic guidelines, and meeting muscle-strengthening guidelines by sociodemographic characteristics, health factors, and workplace and occupational factors. The highest prevalence of sufficient LTPA was in younger workers, males, multiracial ethnicity, with a college degree or higher, higher household income, not married, with no children, normal weight, no history of chronic disease, non-smokers and drinks alcohol. These results were also evident in workers that met aerobic guidelines or met muscle-strengthening guidelines. Of the study sample, 26.8% had sedentary occupational physical activity, 21.6% had light occupational physical activity, 26% had medium occupational physical activity and 25.6% had heavy occupational physical activity. The prevalence of sufficient LTPA was highest among those who had a sedentary occupational activity job (28.4%), followed by light occupational activity (25.8%), medium occupational activity (25.1%), and heavy occupational activity (21.5%). The prevalence of sufficient LTPA was highest in workers with an employer size 500-999 employees (31.5%), in those working more than one job (29.2%), and in those with a workplace health promotion program (29.1%).

Figure 1 shows the distribution of occupational activity level within each occupational category. Ten out of 23 occupations (legal occupations, computer/mathematical occupations, business/finance operations occupations, arts/design/entertainment/sports and media occupations, architecture and engineering occupations, military specific occupations, office/administrative support occupations, management occupations, life/physical/social science occupations, and

community/social services occupations) had greater than 60% of participants reporting sedentary or light occupational activity.

Figure 2 shows the weighted prevalence of sufficient LTPA, met aerobic guidelines, and met muscle-strengthening guidelines by occupational category. The prevalence of meeting sufficient LTPA ranged from 53.5% to 15.6%. Sufficient LTPA was highest in military specific (53.5%), protective services (43.5%), and life, physical, and social science (38.4%) occupations; sufficient LTPA was lowest in health support (15.8%), installation, maintenance, and repair (15.7%), and building and ground cleaning maintenance (15.6%) occupations. These occupations were similar to those that had the highest prevalence of meeting the muscle strengthening guidelines: military specific (53.5%), protective services (46.6%), and legal (40.9%) occupations; meeting the muscle strengthening guidelines was lowest in construction and extraction (19.3%), building and ground cleaning maintenance (19.3%) occupations, and production occupations (18.7%). Meeting the aerobic guidelines was much higher among all occupations with a range from 72.5% to 42.4%. Meeting the aerobic guidelines was highest in life, physical, and social science (72.5%), computer and mathematical (67.6%), and legal (67.1%) occupations; meeting the aerobic guidelines was lowest in production occupations (43.2%), building and ground cleaning maintenance (42.8%), production (41.2%), and transportation and material moving (42.4%) occupations.

Table 2 shows unadjusted and adjusted models on the relationships between sufficient LTPA and sociodemographic, health, and workplace variables. In the unadjusted model, all variables showed significant associations with sufficient LTPA. The odds of sufficient LTPA was lower in workers with medium occupational activity (OR=0.85, 95% CI 0.74, 0.97) and heavy occupational activity (OR=0.69, 95% CI 0.60, 0.80) compared to workers with sedentary

occupational activity. Such significant differences by occupational activity level was no longer observed in the multivariable model adjusting for all significant variables in the bivariate analyses. Among sociodemographic variables, in the adjusted model, the odds of sufficient LTPA were significantly lower in those over 40 years old (OR=0.69, 95% CI 0.58, 0.82), Asians (OR=0.67, 95% CI 0.53, 0.85), workers that were married (OR=0.66, 95% CI 0.58, 0.74), and with children (OR=0.86, 95% CI 0.75, 0.98). The odds of sufficient LTPA were significantly higher in males (OR=1.52, 95% CI 1.38, 1.68) workers with a high school diploma (OR=1.61, 95% CI 1.23, 2.21) or bachelor's degree (OR=2.70, 95% CI 2.05, 3.56), and in a household income above $35,000 annual (OR=1.24, 95% CI 1.05, 1.46). As for health and health behavior factors, the odds of sufficient LTPA were significantly lower in workers that with obesity (OR=0.71, 95% CI 0.59, 0.86) and with a history of smoking (OR=0.79, 95% CI 0.71, 0.88). The odds of sufficient LTPA were significantly higher in workers with a history of alcohol usage (OR=1.41, 95% CI 1.24, 1.60).

In regards to workplace characteristics, workers with a workplace health promotion program were more likely to have sufficient LTPA than workers without a workplace health promotion program (OR=1.58, 95% CI 1.43, 1.74; data not shown in table). The odds of sufficient LTPA further increased with participation frequency and were four times higher in workers who participated weekly (OR=4.11, 95% CI 3.09, 5.46) or daily (OR=4.34, 95% CI 3.00, 6.29) than workers without a workplace health promotion program. Regarding the employer size, the odds of sufficient LTPA were significantly lower in workers employed at a workplace with 1000 or more employees compared to workplace with less than 50 employees (OR=0.74, 95% CI 0.62, 0.88). Working multiple jobs was not associated with sufficient LTPA.

Discussion

This study investigated the level of LTPA and the relationship with occupational physical activity among U.S. workers using a nationally representative sample of 15,049 workers from the 2015 NHIS. This study found that only 24.6% achieved sufficient LTPA; this low prevalence was largely due to the low prevalence of meeting the muscle-strengthening activity guidelines (27.8%). Approximately half (54.2%) met the guidelines for aerobic activity. This study found that sufficient LTPA among workers was significantly associated with various factors including sociodemographic, health, and workplace factors.

This study examined both occupational activity and occupational categories in relation to LTPA. Previous research on the relationship is mixed, and the outcome dependent on whether sufficient LTPA was compared to occupational categories or the level of occupational activity. The findings of this study align in that both reported low occupational activity and sedentary job categories both correlated with sufficient LTPA. The study observed a linear trend between occupational physical activity level and sufficient LTPA, but a significant association between occupational activity and sufficient LTPA did not remain in the multivariable model. This aligns with a previous systematic review that measured occupational activity using accelerometer and found workers with low occupational activity had higher LTPA (Prince et al., 2019; Steeves et al., 2015). This study also examined occupational or job categories in relation to LTPA. This study identified 10 out of 23 occupations where participants report dominantly sedentary to low occupational activity, for which LPTA needs to be more encouraged for health benefits (Prince et al., 2019). The identified occupational categories align with the list of low occupational activity occupations provided by Steeves et al.'s study (2015). This study found a variability in sufficient LTPA within workers in these occupations, which ranged 22.9% to 48.7%. Nine of the occupational categories had sufficient LTPA prevalence rates that were greater than the overall

sample prevalence for sufficient LTPA. This finding aligns with previous studies that found workers in job categories associated with sedentary work had a higher prevalence of sufficient LTPA (Blackwell et al., 2016; Gu et al., 2016; Kirk & Rhodes, 2011). Unlike the other sedentary job categories, office and administrative support was the only occupational category that had a prevalence of sufficive LPTA lower than the overall sample prevalence. The prevalence of meeting the aerobic guidelines and muscle-strengthening guidelines was also lower than the overall sample prevalence in this sample of workers. Further research is needed to understand why workers LTPA in this job category differs from workers in other sedentary jobs.

The second major finding in this study focused on workplace health promotion programs. This study found 47.7% of workers had a workplace health promotion program offered to them by their employer. This study findings suggest the benefit of workplace health promotion programs and the importance of frequent participation in order to meet the LTPA guidelines. Workers who had health promotion programs in their workplace had higher odds of sufficient LTPA than those who had not. This aligns with previous literature suggesting that individuals are more likely to engage in positive health behaviors when they are surrounded with a supportive and encouraging environment (Chari et al., Golden & Earp, 2012), and a previous systematic review that found workplace health promotion activities focused on exercise programs, counselling, or health messaging increased physical activity (Malik, Blake, Suggs., 2013).

This study also showed that the prevalence of sufficient LTPA was associated with workers who participated in the workplace health promotion programs daily or weekly, indicating the importance of frequent participation. Nonetheless, this study found that only 4.6% reported daily or weekly participation, indicating a need for interventions to improve participation in workplace health promotion programs.

Lastly, an unexpected finding of this study was sufficient LTPA was lower in workers who worked at a workplace with 1000 or more employees than workers who worked at a workplace with less than 50 employees. This finding differs from a previous study in U.S workers (Gu et al., 2016). However, Gu et al. (2016), considered larger employers to be worksites consisting of 250 or more employees. Our study took a more detailed approach to worksite size and found differences between 250-499 employees, 500-999 employees, and more than 1000 employees. There were no sociodemographic differences among workers at a workplace with 1000 or more employees in this study. Additionally, the percentage of workers who had a health promotion programs was highest in workers at employers with 1000 workers (79%) compared to smaller worksites (77% in 500-999 employees, 71% in 250-499 employees, 54% in 50-249 employees, and 29% in 1-49 employees). Further research is needed to understand why sufficient LTPA was significantly lower in workers at employers with 1000 workers despite the higher availability of health promotion programs at larger worksite.

Strengths of this study include its sample, measurement of sufficient LTPA, and assessment of occupational activity. This study used a large and diverse sample that supports the generalizability of the study findings to the general U.S. worker population. Unlike previous studies that used only occupational categories (Gu et al., 2016; Steeves et al., 2012) this study examined occupational activity levels as well as occupational categories. Additionally, previous studies (Gu et al., 2016; Gudnadottir et al., 2019; Prince et al., 2019) mostly considered only aerobic activity guidelines when measuring LTPA but this study examined for both aerobic and muscle strengthening guidelines. This study had several limitations. First, this study only captured self-reported LTPA. Individuals may have overestimated the amount of time spent doing LTPA (Fukuoka et al., 2016; Schuna et al., 2013). Moreover, the NHIS questionnaire does

not provide participants with any recall time frame when asking about LTPA and this could further exacerbate recall bias. Secondly, this study created the occupational activity variable based on BLS definitions (BLS, 2019b) and the variable may be subject to misclassification. Particularly, the BLS uses both frequency of lifting and the weight of lifted objects when categorizing work exertion levels, but the NHIS questions only ask frequency of lifting at work and do not use weight references. This limited the ability to directly align the occupational activity variable with BLS definitions. Lastly, as a cross-sectional study, this study cannot determine the causality between physical activity and workplace and occupational factors.

Implications for Occupational Health

Occupational health providers have the opportunity to promote total physical activity in workers thought targeted interventions such as health promotion programs. The findings from this study suggest that workplace health promotion programs are beneficial for workers to achieve sufficient LTPA. Occupational health providers should advocate for workplace health promotion programs to increase the percentage of workers who have such programs offered to them. Although this study was not able to identify the workplace health promotion topics or level of intervention, the findings support the importance of workplace health programs positively influencing health behaviors such as LTPA in American workers (CDC, 2016b; CDC,2017). Additionally, results showed that increased participation frequency was linked with higher prevalence of sufficient LTPA. Therefore, regardless of topic, the findings of this study highlight that occupational health nurses should focus on improving daily to weekly participation rates of workplace health promotion programs to yield the most benefits.

Conclusion

Despite the known benefits of regular physical activity, this study showed that only 24.6% of U.S. workers met the guidelines for sufficient LTPA. The prevalence of LTPA varied by occupation categories but occupational activity level was not a significant factor for engaging in sufficient LTPA. This study also highlighted that frequent workplace health promotion participation is a key factor in achieving sufficient LPTA, but less than half of workers reported having health promotion programs available to them at their workplace. Workplaces should strive to offer health promotion programs that encourage daily or weekly participation of all workers. The findings of this study help provide additional knowledge on LTPA by occupational categories and occupational activity to the occupational health field. Occupational categories provide a more detail breakdown of workers and give more insights into LTPA than categorical occupational activity levels. These findings enable the occupational health field to establish policies, culture, and environments that encourage physical activity to improve the overall health and well-being of workers. The study finding will help occupational health professional efforts to generate workplaces that promote physical activity in workers and enable worker health.

Table 3.1. *Weighted Prevalence of Sufficient Leisure-Time Physical Activity (LTPA by Sociodemographic, Health, and Workplace Characteristics among U.S. Workers (n=15,049)*

	All	Sufficient LTPA		Met aerobic		Met strength	
Variable	%	%	(95% CI)	%	(95% CI)	%	(95% CI)
Total		25.2	(24.3, 26.1)	55.3	(54.2, 56.4)	28.4	(27.5, 29.3)
Age							
18-29	24.7	31.0	(28.8, 33.4)	61.5	(59.0, 64.0)	34.1	(31.8, 36.5)
30-39	22.4	29.0	(26.9, 31.1)	58.8	(56.7, 60.8)	31.7	(29.6, 33.8)
40-49	21.6	23.1	(21.1, 25.2)	55.0	(52.6, 57.3)	25.7	(23.7, 27.9)
50-60	22.2	19.6	(17.9, 21.5)	49.2	(46.8, 51.7)	23.3	(21.4, 25.4)
60+	9.1	19.0	(16.5, 21.7)	46.5	(43.4, 49.7)	24.0	(21.2, 27.0)
Gender							
Female	47.0	21.4	(20.3, 22.6)	52.6	(51.2, 53.9)	24.5	(23.2, 25.8)
Male	53.0	28.7	(27.4, 30.0)	57.9	(56.3, 59.5)	32.0	(30.8, 33.3)
Race with Hispanic ethnicity							
White, Non-Hispanic	66.3	26.4	(25.2, 27.5)	57.8	(56.5, 59.2)	29.6	(28.4, 30.8)
White, Hispanic	14.0	21.7	(19.4, 24.2)	48.8	(46.1, 51.5)	24.4	(22.1, 27.0)
Black/African American	12.3	24.4	(22.0, 27.1)	49.9	(46.9, 53.0)	27.8	(25.1, 30.7)
Indian(American)/Alaska Native	1.1	26.1	(19.0, 34.7)	52.3	(43.7, 60.8)	31.5	(23.6, 40.7)
Asian	6.1	21.7	(18.5, 25.3)	54.4	(50.1, 58.5)	25.3	(22.0, 28.9)
Multiracial	0.3	32.4	(19.0, 49.4)	67.4	(50.5, 80.7)	32.4	(19.0, 49.4)
Highest education completed							
Less than high school diploma	8.1	12.5	(10.0, 15.6)	37.1	(33.2, 41.1)	15.7	(13.0, 19.0)
High school diploma or GED	53.4	21.0	(19.9, 22.2)	49.8	(48.2, 51.4)	24.0	(22.8, 25.2)
Bachelor's degree or higher	38.5	33.7	(32.2, 35.2)	66.9	(65.3, 68.4)	37.2	(35.7, 38.8)
Household Income							
$0 - $34,999	19.9	18.6	(16.9, 20.5)	45.2	(42.9, 47.6)	21.5	(19.7, 23.3)
$35,000 - $74,999	30.4	22.0	(20.4, 23.7)	50.5	(48.6, 52.5)	25.4	(23.7, 27.2)
$75,000 - $99,999	15.3	26.8	(24.2, 29.6)	58.8	(55.9, 61.6)	30.3	(27.6, 33.1)
$100,00 and over	34.4	31.1	(29.4, 32.9)	64.0	(62.3, 65.7)	34.3	(32.5, 36.1)
Married or living with partner							
Yes	64.3	23.1	(22.0, 24.3)	54.6	(53.2, 56.0)	26.2	(25.1, 27.4)
No	35.7	29.0	(27.3, 30.7)	56.8	(54.9, 58.7)	32.4	(30.6, 34.1)
Has children in household							
Yes	40.9	23.2	(21.6, 24.8)	54.6	(52.8, 56.4)	26.0	(24.5, 27.6)
No	59.1	26.6	(25.4, 27.8)	55.9	(54.5, 57.3)	30.1	(28.9, 31.3)
BMI (kg perm^2)							
Underweight (<18.5)	1.4	19.6	(13.9, 27.1)	55.6	(46.4, 64.4)	23.3	(16.8, 31.5)
Normal weight (18.5 - 24.99)	33.9	28.9	(27.3, 30.6)	61.0	(59.4, 62.7)	32.1	(30.4, 33.9)
Overweight (25-29.99)	34.3	27.6	(25.9, 29.3)	57.3	(55.5, 59.1)	30.5	(28.8, 32.2)
Obese (≥30)	30.4	19.5	(17.8, 21.4)	47.6	(45.5, 49.7)	23.1	(21.3, 25.0)

	All	Sufficient LTPA		Met aerobic		Met strength	
Variable	%	%	(95% CI)	%	(95% CI)	%	(95% CI)
History of chronic disease							
Yes	52.4	21.5	(20.2, 22.8)	50.5	(49.0, 52.1)	24.9	(23.6, 26.2)
No	47.6	29.3	(27.9, 30.7)	60.7	(59.1, 62.2)	32.3	(30.9, 33.7)
Ever smoked 100 cigarettes							
Yes	33.7	20.6	(19.3, 22.1)	50.7	(48.9, 52.5)	23.6	(22.2, 25.1)
No	66.3	27.5	(26.4, 28.7)	57.7	(56.3, 59.2)	30.9	(29.7, 32.0)
Alcohol usage							
Yes	24.9	33.2	(31.2, 35.3)	64.9	(62.7, 67.1)	36.0	(34.0, 38.1)
No	75.1	22.6	(21.5, 23.6)	52.2	(51.0, 53.5)	25.9	(24.9, 27.0)
Occupational physical activity							
Sedentary	26.8	28.4	(26.5, 30.3)	61.3	(59.3, 63.2)	31.3	(29.4, 33.3)
Light	21.6	25.8	(23.6, 28.0)	56.1	(53.5, 58.6)	28.8	(26.8, 31.0)
Medium	26.0	25.1	(23.2, 27.1)	53.9	(51.6, 56.1)	28.8	(26.8, 30.9)
Heavy	25.6	21.5	(19.7, 23.4)	50.0	(47.7, 52.3)	24.6	(22.8, 26.5)
Size of employer							
1-49 employees	47.8	23.3	(21.9, 24.8)	52.9	(51.3, 54.5)	26.3	(24.9, 27.8)
50-249 employees	24.9	26.2	(24.4, 28.1)	55.7	(53.4, 57.9)	29.4	(27.6, 31.3)
250-499 employees	7.3	26.8	(23.4, 30.5)	55.6	(51.5, 59.6)	30.7	(27.0, 34.7)
500-999 employees	6.6	31.5	(27.7, 35.6)	59.7	(55.6, 63.5)	34.9	(31.2, 38.8)
≥1000 employees	13.4	26.0	(23.6, 28.6)	61.4	(58.4, 64.2)	29.6	(26.9, 32.5)
Work multiple jobs							
Yes	8.4	29.2	(26.1, 32.5)	58.0	(54.4, 61.5)	33.7	(30.1, 37.5)
No	91.6	24.8	(23.9, 25.8)	55.1	(53.9, 56.3)	27.9	(26.9, 29.0)
Workplace health promotion offered							
Yes	47.7	29.7	(28.4, 31.1)	61	(59.5, 62.5)	33.2	(31.9, 34.6)
No	52.3	21.1	(19.9, 22.4)	50.2	(48.6, 51.8)	24.0	(22.8, 25.3)
Workplace health promotion participation							
No health promotion offered	52.3	21.1	(19.9, 22.4)	50.2	(48.6, 51.8)	24.0	(22.8, 25.3)
Never	20.0	25.9	(23.8, 28.2)	55.8	(53.4, 58.1)	29.7	(27.5, 32.0)
A few times	7.0	28.1	(24.7, 31.7)	61.8	(57.7, 65.8)	31.5	(28.0, 35.1)
Monthly	16.0	27.9	(25.6, 30.2)	61.6	(59.3, 63.9)	31.1	(28.9, 33.4)
Weekly	2.7	56.5	(50.3, 62.4)	78.9	(73.6, 83.4)	61.6	(55.6, 67.2)
Daily	1.9	54.3	(46.6, 61.8)	83.8	(77.3, 88.8)	55.8	(48.2, 63.2)

Note. Sufficient LTPA is meeting both aerobic and muscle-strengthening guidelines. Meeting aerobic guidelines is >150 minutes of moderate to vigorous activity per week. Meeting strength guidelines is performing muscle-strengthening activities >2 per week.

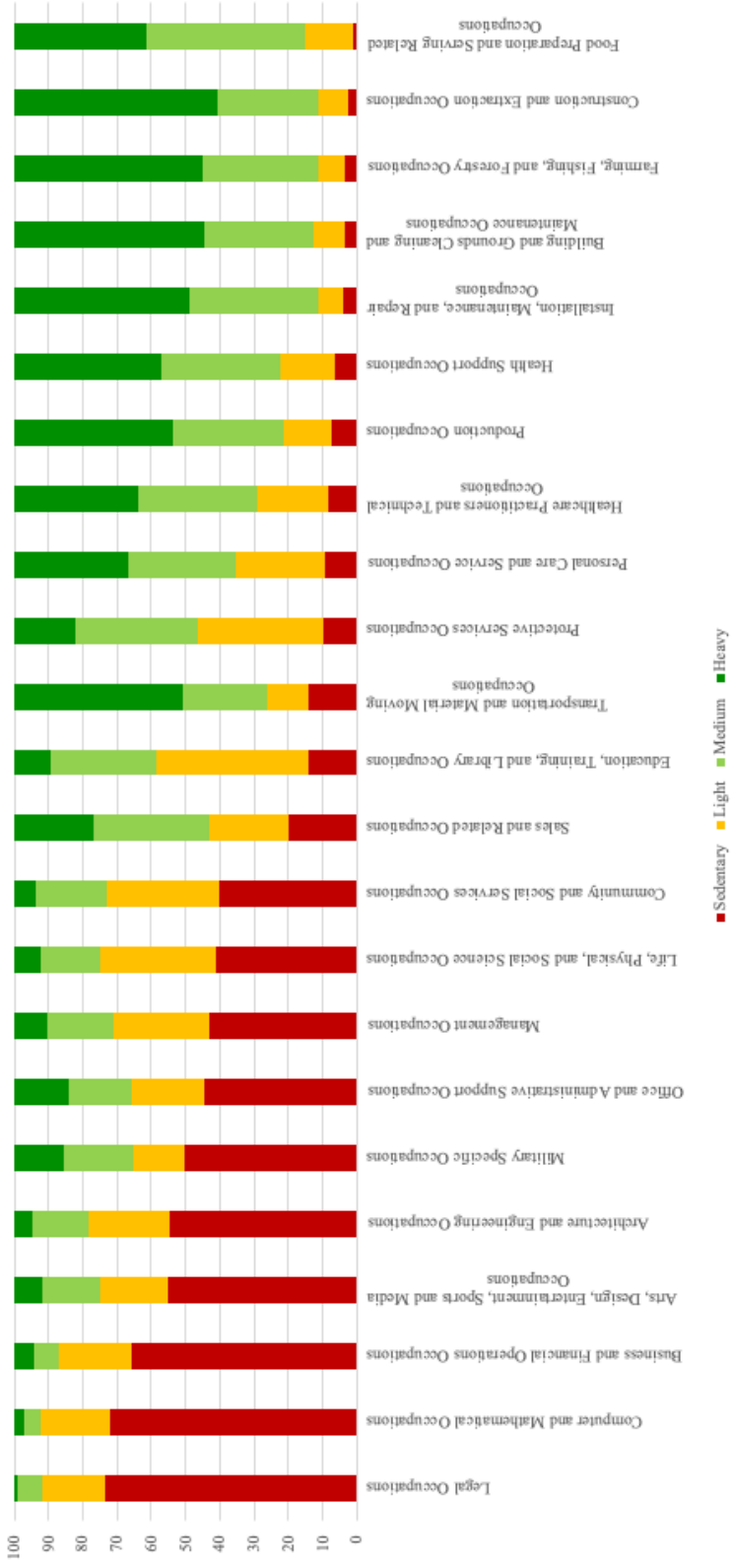
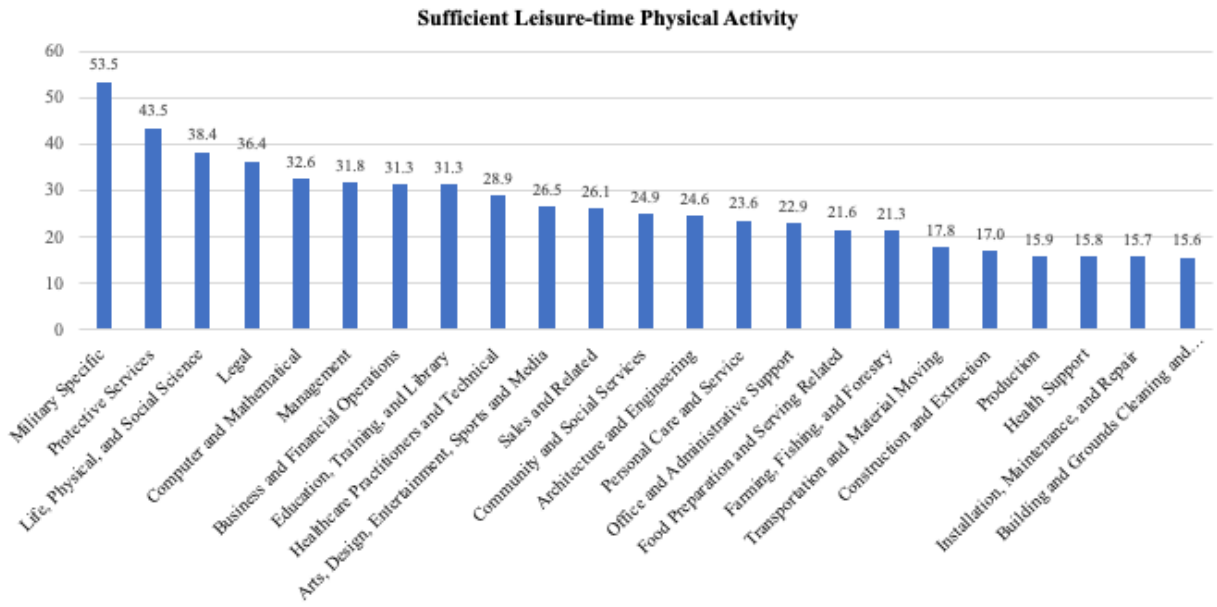
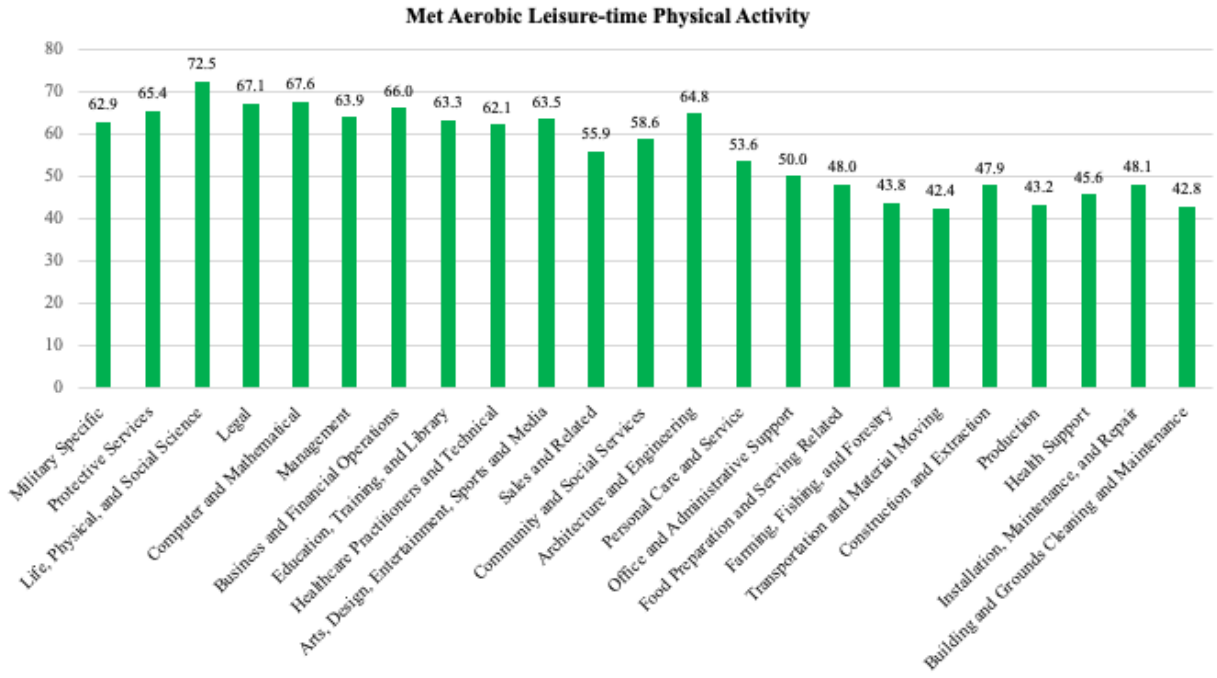


Figure 3.1. *Weighted Distribution of Occupational Physical Activity by Job Categories*


Sufficient Leisure-time Physical Activity
60
50
40
30
20
10
0
53.5
43.5
38.4
36.4
32.6
31.8
31.3
31.3
28.9
26.5
26.1
24.9
24.6
23.6
22.9
21.6
21.3
17.8
17.0
15.9
15.8
15.7
15.6
Military Specific
Protective Services
Life, Physical, and Social Science
Legal
Computer and Mathematical
Management
Business and Financial Operations
Education, Training, and Library
Healthcare Practitioners and Technical
Arts, Design, Entertainment, Sports and Media
Sales and Related
Community and Social Services
Architecture and Engineering
Personal Care and Service
Office and Administrative Support
Food Preparation and Serving Related
Farming, Fishing, and Forestry
Transportation and Material Moving
Construction and Extraction
Production
Health Support
Installation, Maintenance, and Repair
Building and Grounds Cleaning and…


Met Aerobic Leisure-time Physical Activity
80
70
60
50
40
30
20
10
0
62.9
65.4
72.5
67.1
67.6
63.9
66.0
63.3
62.1
63.5
55.9
58.6
64.8
53.6
50.0
48.0
43.8
42.4
47.9
43.2
45.6
48.1
42.8
Military Specific
Protective Services
Life, Physical, and Social Science
Legal
Computer and Mathematical
Management
Business and Financial Operations
Education, Training, and Library
Healthcare Practitioners and Technical
Arts, Design, Entertainment, Sports and Media
Sales and Related
Community and Social Services
Architecture and Engineering
Personal Care and Service
Office and Administrative Support
Food Preparation and Serving Related
Farming, Fishing, and Forestry
Transportation and Material Moving
Construction and Extraction
Production
Health Support
Installation, Maintenance, and Repair
Building and Grounds Cleaning and Maintenance

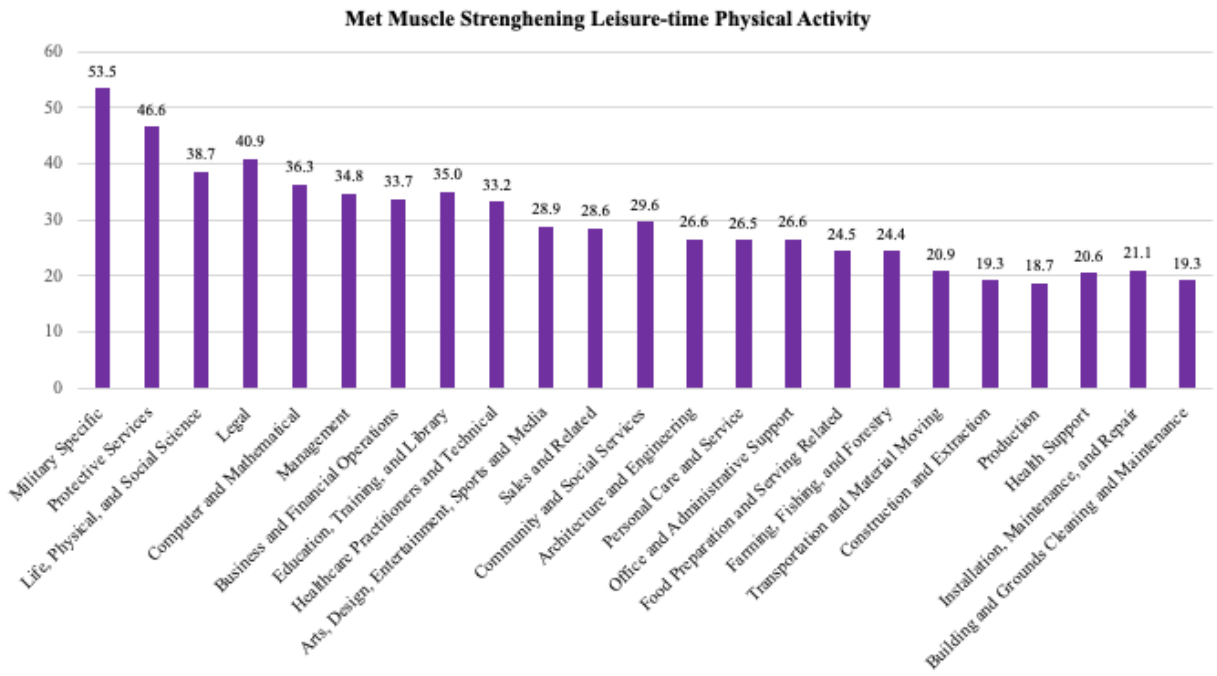


Figure 3.2. *Weighted Prevalence of Sufficient Leisure-time Physical Activity by Job Categories*

Table 3.2. *Association Between Achieving Sufficient Leisure Time Physical Activity and Occupational Physical Activity, Among U.S. Workers (n= 15,049)*

	Sufficient LTPA (unadjusted model)			Sufficient LTPA (adjusted model)		
Variables	OR	(95% CI)	*p*	OR	(95% CI)	*p*
Occupational Physical Activity						
Sedentary	1.00			1.00		
Light	0.88	(0.76, 1.02)	0.063	0.95	(0.82, 1.11)	0.553
Medium	**0.85**	**(0.74, 0.97)**	**<0.001**	1.07	(0.92, 1.24)	0.406
Heavy	**0.69**	**(0.60, 0.80)**	**<0.001**	1.01	(0.86, 1.18)	0.915
Age						
18-29	1.00			1.00		
30-39	0.91	(0.78, 1.05)	0.197	0.92	(0.78, 1.08)	0.300
40-49	**0.67**	**(0.57, 0.78)**	**<0.001**	**0.69**	**(0.58, 0.82)**	**<0.001**
50-60	**0.54**	**(0.46, 0.64)**	**<0.001**	**0.54**	**(0.45, 0.64)**	**<0.001**
60+	**0.52**	**(0.42, 0.64)**	**<0.001**	**0.52**	**(0.41, 0.66)**	**<0.001**
Gender						
Female	1.00			1.00		
Male	**1.47**	**(1.35, 1.61)**	**<0.001**	**1.52**	**(1.38, 1.68)**	**<0.001**
Race with Hispanic ethnicity						
White, Non-Hispanic	1.00			1.00		
White, Hispanic	**0.77**	**(0.66, 0.9)**	**0.001**	1.05	(0.89, 1.24)	0.576
Black/African American	0.90	(0.78, 1.05)	0.174	1.06	(0.90, 1.24)	0.496
Indian(American)/Alaska Native	0.99	(0.65, 1.49)	0.948	1.26	(0.78, 2.03)	0.352
Asian	**0.77**	**(0.63, 0.96)**	**0.018**	**0.67**	**(0.53, 0.85)**	**0.001**
Multiracial	1.34	(0.65, 2.75)	0.429	1.31	(0.65, 2.67)	0.448
Highest education completed						
Less than high school diploma	1.00			1.00		
High school diploma or GED	**1.85**	**(1.42, 2.42)**	**<0.001**	**1.61**	**(1.23, 2.12)**	**0.001**
Bachelor's degree or higher	**3.54**	**(2.74, 4.58)**	**<0.001**	**2.70**	**(2.05, 3.56)**	**<0.001**
Household income						
$0 - $34,999	1.00			1.00		
$35,000 - $74,999	**1.23**	**(1.06, 1.44)**	**0.008**	**1.24**	**(1.05, 1.46)**	**0.011**
$75,000 - $99,999	**1.60**	**(1.34, 1.91)**	**<0.001**	**1.58**	**(1.28, 1.96)**	**<0.001**
$100,00 and over	**1.98**	**(1.7, 2.29)**	**<0.001**	**1.87**	**(1.55, 2.25)**	**<0.001**
Married or living with partner						
Yes	**0.74**	**(0.66, 0.82)**	**<0.001**	**0.66**	**(0.58, 0.74)**	**<0.001**
No	1.00			1.00		

	Sufficient LTPA (unadjusted model)			Sufficient LTPA (adjusted model)		
Variables	OR	(95% CI)	*p*	OR	(95% CI)	*p*
Has children in household						
Yes	**0.83**	**(0.74, 0.93)**	**0.001**	**0.86**	**(0.75, 0.98)**	**0.022**
No	1.00			1.00		
BMI (kg perm^2)						
Underweight (<18.5)	**0.60**	**(0.4, 0.91)**	**0.017**	0.64	(0.41, 1.00)	0.052
Normal weight (18.5 - 24.99)	1.00			1.00		
Overweight (25-29.99)	0.94	(0.83, 1.06)	0.292	0.99	(0.87, 1.14)	0.922
Obese (≥30)	**0.60**	**(0.52, 0.68)**	**<0.001**	**0.71**	**(0.59, 0.86)**	**<0.001**
History of Chronic Disease						
Yes	**0.66**	**(0.6, 0.73)**	**<0.001**	0.91	(0.78, 1.07)	0.267
No	1.00			1.00		
Ever smoked 100 cigarettes						
Yes	**0.69**	**(0.62, 0.76)**	**<0.001**	**0.79**	**(0.71, 0.88)**	**<0.001**
No	1.00			1.00		
Alcohol usage						
Yes	**1.71**	**(1.53, 1.91)**	**<0.001**	**1.41**	**(1.24, 1.60)**	**<0.001**
No	1.00			1.00		
Size of employer						
1-49 employees	1.00			1.00		
50-249 employees	**1.17**	**(1.03, 1.32)**	**0.016**	0.99	(0.87, 1.13)	0.874
250-499 employees	1.20	(0.98, 1.48)	0.073	0.94	(0.75, 1.17)	0.573
500-999 employees	**1.51**	**(1.23, 1.86)**	**<0.001**	1.10	(0.88, 1.37)	0.399
≥1000 employees	1.16	(0.99, 1.35)	0.058	**0.74**	**(0.62, 0.88)**	**0.001**
Multiple jobs						
Yes	**1.25**	**(1.06, 1.48)**	**0.009**	1.15	(0.97, 1.37)	0.105
No	1.00			1.00		
Workplace Health Promotion Participation						
No health promotion offered	1.00			1.00		
Never	**1.31**	**(1.15, 1.49)**	**<0.001**	**1.24**	**(1.06, 1.44)**	**0.006**
A few times	**1.39**	**(1.23, 1.58)**	**<0.001**	**1.36**	**(1.11, 1.67)**	**0.004**
Monthly	**1.52**	**(1.19, 1.94)**	**0.001**	**1.30**	**(1.11, 1.51)**	**0.001**
Weekly	**4.65**	**(3.61, 5.98)**	**<0.001**	**4.11**	**(3.09, 5.46)**	**<0.001**
Daily	**4.21**	**(3.08, 5.77)**	**<0.001**	**4.34**	**(3.00, 6.29)**	**<0.001**

Note. Sufficient LTPA is meeting both moderate-to-vigorous activity and muscle strengthening activity guidelines.

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Chapter Four

The Relationship Between Workplace and Job Characteristics and Leisure-Time Physical Activity among U.S. Workers in Low Occupational Activity Jobs: Analysis of 2015 National Health Interview Survey

Background

Changes in the work environment have rapidly reduced the amount of physical activity required during the workday over the past 60 years (Church et al., 2011), resulting in 80% of United States (U.S.) civilian jobs being classified as sedentary or light work (Bureau of Labor Statistics [BLS], 2017). Simultaneously, U.S. workers face increasing psychological workloads and job demands, which can negatively impact health (Chandola et al., 2006; Kirk & Rhodes, 2011; Kivimäki et al, 2015; Sihawong et al., 2016). Regular physical activity is important in maintaining health and minimizing the risk of chronic diseases such as type 2 diabetes, hypertension, osteoporosis, high blood cholesterol, coronary heart disease, stroke, cancer, and obesity (Lollgen et al., 2009; Piercy & Troiano, 2018; Warburton & Bredin, 2017). Additionally, regular physical activity is known to help prevent disease (Posadzki et al., 2020), manage disease (Colberg et al., 2016), and research is emerging on reversing chronic disease (Bodai et al., 2018; Doughty et al., 2017; Sagner et al., 2014). The 2018 Physical Activity Guidelines for Americans recommend that adults complete 150 minutes of moderate-intensity aerobic activity or 75 minutes of vigorous-intensity aerobic activity a week, and two days a week of muscle-strengthening activities (2018 Physical Activity Guidelines Advisory Committee; 2018). Yet, only 23.2% of U.S. adults and 24.6% of U.S. workers meet the recommendations for physical activity (Center for Disease Control and Prevention [CDC], 2020). In the U.S., nearly $117 billion in annual health care costs and 10% of all premature mortality are associated with failure to meet the recommended levels of physical activity (Carlson et al, 2015).

It is unclear how sedentary job or the level of occupational activity affects workers' engagement in leisure time physical activity (LTPA). Previous studies using occupational categories have found mixed results on the relationship between occupational activity and sufficient LTPA. Some studies found that the prevalence of meeting the physical activity

guidelines was higher for sedentary occupational categories (Blackwell & Clarke, 2016; Gu et al., 2016) whereas in another study, the prevalence of meeting aerobic activity guideline was higher in heavy labor occupational categories (Gudnadottir et al., 2019). Similarly, in studies considering occupational activity, prevalence of meeting the aerobic guideline has been both higher in workers in the low occupational activity (Prince et al., 2019; Steeves et al., 2015), and higher in workers who reported heavy labor (Kirk & Rhodes, 2011; Kruger et al., 2006). Performing LTPA is important for all workers, but particularly important for office-based workers who have prolonged low occupational physical activity (i.e., primarily office/desk work). These workers were shown to have a higher health risk, as evidenced by higher waist-to-hip ratios than all other workers (Prince et al., 2019). This increased health risk among low occupational activity workers heightens the importance of performing physical activity in their leisure time.

Regular engagement in physical activity can be affected by multiple personal and workplace factors. Previous studies found that female, non-white, older, and less educated workers had higher risks of being physically inactive and not meeting the guidelines for physical activity (Blackwell & Clarke, 2016; Gu et al., 2016; Gudnadottir et al., 2019). Studies has also shown that workplace factors such as larger company size, low work demand, low job stress, higher job control, not working in excess of a 40hr work week, and satisfaction with work-home balance are associated with increased prevalence of sufficient LTPA (Gu et al., 2016; Kirk & Rhodes, 2011; Kouvonen, et al., 2013; Lallukka et al., 2004). Previous studies using nationally representative samples did not fully examine associations between sufficient LTPA and various workplace or job characteristics, such as size of employer, health promotion program, work-life balance, working multiple jobs, job stability, or job autonomy (Blackwell & Clarke, 2016;

Kruger et al., 2006; Steeves et al., 2015). Furthermore, the effects of workplace and job factors on sufficient LTPA have been understudied among U.S. workers with low occupational activity. Given the substantial amount of time that U.S. adults spend in the workplace, understanding workplace characteristics differences and workers' LTPA is important.

The purpose of this study was to examine the relationships of sufficient LTPA with workplace and job characteristics among U.S. workers who reported low occupational activity using a nationally representative sample. Considering the complexity of factors that can affect worker health and workers' LTPA, this study was based on the Total Worker Health (TWH) Worker Wellbeing Framework (Chari et al., 2018). Figure 1 outlines the conceptual framework of this study. An assumption of this holistic framework is that workers' health and behaviors, such as LTPA, are influenced by their physical work environment, workplace policies and culture, work experiences, and health status. Therefore, this study examined various work and workplace factors such as size of the workplace, workplace health promotion program, work-life balance, working more than one job, and workplace experiences including job stability, job control, and job demand. The specific aims of the study were to 1) estimate the prevalence of meeting the physical activity guidelines (aerobic activity, muscle-strengthening activity, and sufficient LTPA) by sociodemographic, health, and workplace and job characteristics, and 2) identify factors associated with sufficient LTPA among U.S. workers with low occupational physical activity.

Methods

Data Source and Study Sample

This study used 2015 National Health Interview Survey (NHIS) Sample Adult, Person, and Family public data including sociodemographics, health status, health behaviors, and

occupational characteristics variables. The NHIS is an annual cross-sectional in-person interview survey administered to monitor health trends across the U.S. population. The NHIS uses an area probability sampling design that oversamples black, Hispanic, and Asian persons by a 2:1 ratio through targeting geographic areas with higher concentrations of these minority groups twice as often (CDC, 2014, p.4). The sample excludes active Armed Forces personnel, those incarcerated, living in long-term care facilities, or U.S. nationals living outside of the country (CDC, 2020b). The 2015 NHIS sample had a 55.2% response rate and contained a total of 33,672 adults aged 18 years or older. The inclusion criteria for this study was adults who were currently employed and who had job involving low occupational activity (sedentary or light) based on the Bureau of Labor Statistic's (BLS) physical work demand exertion levels (BLS, 2019). First, retired adults and adults who had not worked in the past week (n=14,216) were excluded from the sample. The occupational physical activity level was determined using the following two questions on physical exertion and walking/standing: "How often does your job involve repeated lifting, pulling, pushing, or bending?" and "How often does your job involve standing or walking around?" (never, seldom, sometimes, often or always). Sedentary occupational physical activity was defined as meeting both physical exertion as never or seldom and walking/standing as never, seldom, or sometimes. Light occupational physical activity was defined as meeting one of the following two conditions: 1) physical exertion as never, seldom and standing/walking as often or always; or 2) physical exertion as sometimes and standing/walking as never, seldom, or sometimes.

The final sample for this study consisted of 7,217 U.S workers with low occupational physical activity, including 3,269 workers with sedentary occupational activity and 3,948 workers with light occupational activity.

Study Variables

Sufficient LTPA. LTPA was assessed for aerobic and muscle-strengthening activities. Vigorous-intensity aerobic activity was assessed using the question "How often do you do VIGOROUS leisure-time physical activities for AT LEAST 10 minutes that can cause HEAVY sweating or LARGE increases in breathing or heart rate?" and "About how long do you do these vigorous leisure-time physical activities each time?" Moderate-intensity aerobic activity was assessed using the questions "How often do you do LIGHT OR MODERATE leisure-time physical activities for AT LEAST 10 minutes that can cause ONLY LIGHT sweating or a SLIGHT TO MODERATE increases in breathing or heart rate?" and "About how long do you do these moderate leisure-time physical activities each time?" The frequency and duration responses were transformed into minutes engaged in moderate or vigorous intensity aerobic activity per week. The total aerobic activity time was calculated as the total minutes a participant engaged in moderate or vigorous physical activity per week where each minute of vigorous aerobic activity equated to 2 minutes of moderate aerobic activity. Based on the CDC guidelines for aerobic physical activity (Piercy & Troiano, 2018), the met aerobic activity variable was dichotomized so yes, was defined as respondents that performed $\geq$150 minutes per week of aerobic physical activity.

Muscle-strengthening activity was assessed using the question "How often do you do leisure-time physical activities specifically designed to STRENGTHEN your muscles such as lifting weights or doing calisthenics?" Following the CDC guidelines for muscle-strengthening physical activity (2018 Physical Activity Guidelines Advisory Committee; 2018), the met muscle-strengthening activity variable was dichotomized where yes, was defined as respondents

that performed strengthening exercises 2 or more days per week. Finally, sufficient LTPA was defined as meeting both aerobic and muscle-strengthening activity guidelines.

Workplace and Job Characteristics. Occupational categories were determined from self-reported answers to the question "What kind of work are you doing?" Responses were classified into one of 23 major groups base on the 2010 Standard Occupational Classification categories (U.S Census Bureau, 2021). Size of employer was asked by the question "How many people work at your main employer location?" The responses were collapsed to 1-49 employees, 50-249 employees, 250-499 employees, 500-999 employees, or 1000 or more employees. *The Workplace Policies and Culture* domain was measured by workplace health promotion and work-life balance. Workplace health promotion program availability and participation were asked by "Were health promotion programs made available to you by your employer?" (yes or no) and "How often did you participated in any of these the activities in the past year?" (never, once to a few times, monthly, weekly, or daily). Work-life balance was assessed by the question "The demands of my job interfere with my personal or family life?" The responses were collapsed to low work-life balance (strongly agree or agree) or high work-life balance (disagree or strongly disagree). The *Work Evaluations and Experiences* domain was measured by job stability, job control, and job demand. Job stability was assessed by "Are you worried about losing your current job?" with responses as high job stability (no) and low job stability (yes). Job control was assessed by "My job allows me to make a lot of decisions on my own?" The responses were collapsed to high job control (strongly agree or agree) or low job control (disagree or strongly disagree). Job demand was assessed by "I have enough time to get the job done?" The responses were collapsed to low job demand (strongly agree or agree) or high job demand (disagree or strongly disagree).

Sociodemographics, Comorbidity, and Health Behaviors. Sociodemographic variables included age, gender, race/ethnicity, education, household income, multiple jobs, marital status, and having children in your household. Working multiple jobs was assessed by the question "do you work more than one job?" (yes or no). Marital status responses were dichotomized into married (married or living with partner) and not married (widowed, divorced, separated or never married). Having children in your household responses were dichotomized into yes (the respondent is a parent of a child residing in the family, or there are minor children residing in the family but the respondent is not their parent) and no (there are no minor children residing in the family). History of chronic disease (yes or no) was determined by any history of coronary heart disease, hypertension, stroke, cancer, high cholesterol, or obesity. Body Mass Index (BMI) was calculated from self-reported height and weight and categorized to underweight (BMI <18.5 kg/m^2), normal weight ($18.5 \leq$ BMI < 25 kg/m^2), overweight ($25 \leq$ BMI < 30 kg/m^2), and obese (BMI $\geq$30 kg/m^2). For health behaviors, history of smoking was assessed by "have you ever smoked 100 cigarettes in your entire life" (yes or no), and alcohol use (yes or no) was defined by >3 drinks per week in the past year.

Data Analysis

Data were analyzed using Stata 16 (StataCorp, 2019). The complex sampling design of the 2015 NHIS were taken into consideration and sample weights were used in the analysis. The weighted prevalence and 95% Confidence Intervals (CIs) of met aerobic activity, met muscle-strengthening activity, and sufficient LTPA were produced by sociodemographic, health factor, occupational categories, and workplace and job characteristics. Logistic regression was used to examine the association between sufficient LTPA and each job and workplace characteristic variable. Odds ratios (ORs) and 95% CIs were obtained. An alpha level of 0.05 was used to

determine significance. A multivariable model was constructed adjusting for all significant variables in the unadjusted models. Adjusted ORs (aOR) and 95% CI were obtained.

Results

The sample consisted of 7,217 low occupational activity workers, which accounted for 48% of workers in the 2015 NHIS sample. Of the low occupational activity workers, 59.0% met the aerobic guideline, 30.4% met the muscle-strengthening guideline, and 27.3% had sufficient LTPA (met both guidelines). Table 1 shows the weighted prevalence of sufficient LTPA, met aerobic activity, and met muscle-strengthening activity by sociodemographic characteristics, health factors, and workplace/job characteristic. The prevalence of sufficient LTPA was similar to the pattern of meeting the aerobic guidelines and meeting the muscle-strengthening guidelines.

The prevalence of sufficient LTPA was higher among males (32.4%) and workers that were not married (30.5%). Sufficient LTPA was highest in younger workers aged 18-29 (33.6%), and those that identified as White (28.6%). Sufficient LTPA prevalence increased with educational attainment (32.7% in Bachelor's degree of higher), and with higher household income (31.3% in those with income $\geq$\$100,000). The prevalence of sufficient LTPA was higher in workers with a normal weight (30.9%), no history of smoking (29.1%), and those that drank 3 or more alcoholic beverages in a week (35.6%). The prevalence of sufficient LTPA was higher in workers with a workplace health promotion program (31.9%) and notably higher in those that participated weekly (60.5%) or daily (56.0%) in a workplace health promotion program. Sufficient LTPA was highest in workers with an employer size 500-999 (34.6%) and lowest in workers with 1-49 employees (24.2%), and those worked multiple jobs (32.4%), and workers that felt they had high job control (28.1%).

Figure 1 displays the percentage of workers from the sample within each job category. All job categories were represented in this sample of low occupational activity workers. About one third of the sample were represented by workers in occupations categories of Office and Administrative Support (18.2%) or Management (13.8%). Table 2 displays the weighted prevalence of meeting the physical activity guidelines by job categories. The occupations with the highest prevalence of sufficient LTPA were military specific occupations (54.5%), life, physical, and social sciences (40.1%), and protective services (35.9%). The occupations with the lowest prevalence of sufficient LTPA were production occupations (12.8%), construction and extraction (12.2%), and health support (10.1%). This trend of occupational categories was similar in meeting the muscle-strengthening guidelines, differed for meeting the aerobic guidelines. The occupations with the highest prevalence of meeting the aerobic activity guidelines were life, physical, and social sciences (77.9%), architecture and engineering (69.9%), and computer and mathematical (68.2%). The occupations with the lowest prevalence of meeting the aerobic activity guidelines were health support (33.3%), farming, fishing and forestry (31.8%), and building and grounds cleaning (31.0%).

Table 3 displays the unadjusted and adjusted ORs of the association between sufficient LTPA and workplace and job characteristics. In the unadjusted model, all variables showed significant associations with sufficient LTPA except job stability and job demand. Among sociodemographic variables, in the adjusted model, the odds of sufficient LTPA were significantly lower in those over 50-60 years old (OR=0.61, 95% CI 0.47, 0.79), and those greater than 60 (OR=0.63, 95% CI 0.45, 0.87), Asians (OR=0.67, 95% CI 0.51, 0.87), and workers that were married (OR=0.68, 95% CI 0.57, 0.81). The odds of sufficient LTPA were significantly higher in males (OR=1.59, 95% CI 1.377, 1.85) workers with a bachelor's degree

(OR=2.71, 95% CI 1.25, 5.91), and in a household income of $75,000-$99,999 annual (OR=1.57, 95% CI 1.14, 2.18) and greater than $100,000 (OR=1.80, 95% CI 1.35, 2.40). As for health and health behavior factors, the odds of sufficient LTPA were significantly lower in workers that were obese (OR=0.66, 95% CI 0.52, 0.84) and with a history of smoking (OR=0.80, 95% CI 0.69, 0.94). The odds of sufficient LTPA were significantly higher in workers with a history of alcohol usage (OR=1.35, 95% CI 1.13, 1.60).

For workplace health promotion program, in the unadjusted model, the odds of sufficient LTPA was significantly increased in workers with a workplace health promotion program compared to those without a program (OR=1.59, 95% CI 1.43,1.77, *data not shown in table*), and notably increased with frequent program participation. In the adjust model, compared to those who had no health promotion, the odds of sufficient LTPA increased with participation in health promotion programs: a few times (aOR=1.34, 95% CI 1.03,1.74), monthly (aOR=1.25, 95% CI 1.02,1.54), weekly participation (aOR=4.87, 95% CI 3.36, 7.05), and daily participation (aOR=4.21, 95% CI 2.50, 7.08). For size of workplace, the odds of sufficient LTPA in the unadjusted model was highest in workers with an employer size of 500-999 employees compared to workers with an employer size of 1-49 employees (OR=1.60, 95% CI 1.32, 1.95); however, in the adjusted model, a significant difference was found only for workers in employers with 1000 or more employees (aOR= 0.71, 95% CI 0.56, 0.89) compared to worksites less than 50 employees. Working more than one job was significantly related to achieving sufficient LTPA (aOR= 1.35, 95% CI 1.05,1.72) compared to workers in only one job. Sufficient LTPA was higher in workers who reported high job control (OR=1.41, 95% CI 1.20, 1.67), and lower in workers who reported high work-life balance (OR=0.88, 95% CI 0.79, 0.98) compared to their

counterparts. However, job control and work-life balance and were not significant in the multivariable model.

Discussion

In this study using a nationally representative NHIS sample, only 27% of workers with low occupational activity met sufficient LTPA, 59% met the guidelines for aerobic activity, and 30% met the guidelines for muscle-strengthening. This prevalence is slightly higher than the prevalence of 25.2% among all U.S workers (Michalchuk, 2021), but below the Health People 2030 target of 28.4% (Health People 2030) of all U.S. adults. The relatively low prevalence of LTPA in this study was related to the low prevalence of meeting the muscle-strengthening guidelines as evident by higher prevalence of meeting aerobic activity. Meeting the muscle-strengthening guidelines is an important component of the physical activity guidelines to consider given its benefits of increasing muscle mass, helping with weight management, and bone density (2018 Physical Activity Guidelines Advisory Committee, 2018).

This study took a comprehensive approach to assess the complex relationship between physical activity and the workplace by using multiple workplace domains within the TWH Worker Wellbeing framework. However, of the multiple workplace factors examined in this study, only workplace size and health promotion had significant relationships with sufficient LTPA. Particularly, workplace health promotion program offering and participation were found as the most important factors for sufficient LTPA among workers with low occupational activity.

This study found that workers who had workplace health promotion programs available by their employer were more likely to achieve sufficient LTPA, regardless of participation compared to workers who did not have this offering. In this study 54.9% of workers had access to workplace health promotion programs, larger percentage than 47.7% of workers in the overall U.S. worker population (Michalchuk, 2021). This study also showed that frequent participation

in the program is a key to achieve sufficient LTPA. Workers who participated weekly to daily in workplace health promotion programs of any form had the greatest association with sufficient LTPA. To meet the recommended levels of physical activity, LTPA must be performed multiple days per week. This finding implies that workers benefit from the frequency of weekly to daily health promotion programs to reinforce positive health behaviors. This finding aligns with a previous systemic review of U.S. workers on workplace health promotion activities that covered exercise programs, counselling, or health messaging resulted in increased LTPA and meeting physical activity guidelines (Malik, Blake, Suggs., 2013).

Despite a higher prevalence of sufficient LTPA in workers with health promotion programs, this study found that only 61%% of workers who participated weekly and 56% of daily participants achieved sufficient LTPA. This may be due to a strong emphasis on aerobic activity programs as evidenced by 88% of weekly and 85% of daily participants meeting the aerobic guideline while only 62% of weekly and 58% of daily participants meeting the muscle-strengthening guideline. Given the strong association between workplace health programs and LTPA, workplaces should consider offering programs to their workers (CDC, 2016b) and creating work environments that support healthy behaviors. Previous literature has identified that individual surrounded by environments and social networks that support healthy behaviors are more likely to engage in healthy behaviors themselves (Chari et al., Golden & Earp, 2012). To support a healthy workforce, should focus on increasing physical activity and ensuring individuals maintain activity levels as they age to as part of a healthy lifestyle through workplace health promotion programs.

According to a Kaiser Family Foundation study, worksites with more than 1000 employees are the most likely to offer workplace wellness programs (2019). This study also

showed a consistent finding; 82% of workers at worksites with greater than 1000 employees had workplace health promotion programs, whereas only 43% of workers in worksites with less than 250 employees had such programs. Despite higher availability of health promotion programs at larger worksites, this study found the prevalence of sufficient LTPA was significantly lower in workers at employers with 1000 workers. There were no notable differences in sociodemographic characteristics among workers at these larger worksites. Previous literature suggest that larger employers may have more difficulties ensuring communications around workplace health promotion programs reach all employees and thus, enrollment and benefits gain from programs participation may be less than small or mid-size employers (Lier et al., 2019). Future research is needed to understand why sufficient LTPA is lower in these workers despite higher access to workplace health promotion programs.

Interestingly, working multiple jobs was associated with sufficient LTPA; this finding aligns with a previous study in U.S. workers (Gu et al., 2016). However, the finding is not consistent with previous literature of international worker populations that found long work hours posed a barrier to sufficient LTPA (Artazcoz et al., 2009; Popham & Mitchell, 2006; Burton & Turrell, 2000; Kirk & Rhodes, 2011). Further research is needed to elucidate the relationship between multiple jobs and sufficient LTPA in U.S workers populations.

This study found that level of educational attainment (U.S. Census Bureau, 2020) and household income (U.S. Census Bureau, 2019) were significant factors for sufficient LTPA among workers with low occupational physical activity and those levels were notably higher in this study sample than the general U.S. population. A previous study using 2008-2014 NHIS data also found the likelihood of meeting physical activity guidelines increased as education increased across all occupations (Blackwell & Clarke, 2016). Education levels and annual wages are

generally higher in jobs that require low occupational physical activity, such as management, legal, computer, finance, and architecture, than jobs requiring high physical labor (Statistica, 2019). When combined, these low activity occupational categories accounted for almost half of the sample and could explain the higher prevalence of sufficient LTPA, meeting aerobic guidelines, and meeting muscle-strengthening guidelines compared to previous studies (Gu et al., 2016; Michalchuk, 2021). When considering the two most represented occupational categories in the sample, there was a notable difference in their prevalence of sufficient LTPA between office and administrative support (22.5%) occupations and management occupations (34%). This finding occurred despite the two groups having relatively close levels of access to health promotion programs and equal frequency of participation. Upon further investigation, the two sample populations had evident differences in gender, education and income. The office and administrative support workers were predominantly female (82%), most had a high school diploma (70%), and household incomes less than $75,000 (65%). The workers in management occupations were evenly distributed among genders, most had bachelor's degree or higher (68%), and household incomes greater than $75,000 (72%). These findings suggest a need to provide workplace health promotion programs to low income workers with less education and encourage and educate these workers on benefits of sufficient LTPA.

Lastly, this study found Asians were significantly less likely to meet the recommended levels of physical activity through LTPA. This aligns with recent literature from major metropolitan areas within the U.S. that that showed Asians in the U.S. were the least physically active of all major racial or ethnic groups (Kao et al., 2016; Yi et al., 2015)

This study had the strength of using the large and diverse sample that supports the generalizability of the study findings to the U.S. worker population with low occupational

activity. It is the first study of its kind to holistically examine the workplace's environment, policies, and experience factors with physical activity in relation to the federal guidelines for physical activity. This study also had several limitations. First, both leisure-time physical activity and occupational physical activity were measured using self-report questions. Reporting or social desirability bias may have caused participants to exaggerate LTPA or alter the response to the occupational physical activity questions (Fukuoka et al., 2016; Schuna et al., 2013). While the guidelines for physical activity consider all domains (leisure-time, household, transportation, and occupational) towards meeting the physical activity guidelines, this study only considered LTPA. Additionally, this study defined low occupational physical activity using only two self-report questions on physical exertion and walking/standing. Thus, there may be a potential misclassification for occupational activity level. Secondly, regarding workplace health promotion programs, this study only measured offering and participation frequency. The types or content of intervention of workplace health promotion programs is unknown. Additionally, this cross-sectional study cannot determine causality between LTPA and any of the variables in the study. It remains unclear if workplace health promotion programs increased LTPA or if participants who perform LTPA regularly were more likely to choose to participate in workplace health promotion programs.

Implications for Occupational Health

Occupational health providers have the opportunity to promote physical activity in low occupational activity workers to help reduce their health risk attributed to their prolonged sedentary work. The findings from this study support the need to increase the number of workers who have workplace health promotion programs offered to them and improve participation rates to yield the greatest benefits. These programs play an important role in positively influencing

health behaviors such as LTPA in U.S. workers, especially those that have low occupational activity (CDC, 2016; CDC,2017). In developing workplace health promotion program, attention should be given to ensuring program availability and messaging reaches all workers, especially at larger worksites, and that programs reach low income workers.

Conclusion

Workers who have particularly low occupational physical activity jobs can have health benefits from frequent engagement in LTPA. However, this study found that only 27% of U.S. workers who reported low occupational physical activity performed sufficient LTPA. This study found that workplace health promotion participation had the largest association with sufficient LTPA, but only 53% of workers had access to these programs. Increased efforts by employers and occupational health professionals are needed to expand access to health promotion programs and for workers with low occupational activity in their workplaces and establish workplace culture and environments that encourage healthy behaviors such as physical activity. In particular, the need for these efforts are greater for workplaces with less educated and low-income workers as well as small workplaces. These workplaces can benefit from collaboration with occupational health professionals to increase health behaviors in their workers.

Additional research is needed to further explore why sufficient LTPA is lower in workers from the largest employers and the potential organizational barriers that might inhibit workplace health promotion participation in these larger employers. Additionally, future studies should consider work hours or if workers have multiple jobs as potential factors that correlate with sufficient LTPA to further understand this relationship. Lastly, longitudinal research is needed to determine if participation in a workplace health promotion program improves health outcomes such as chronic disease.

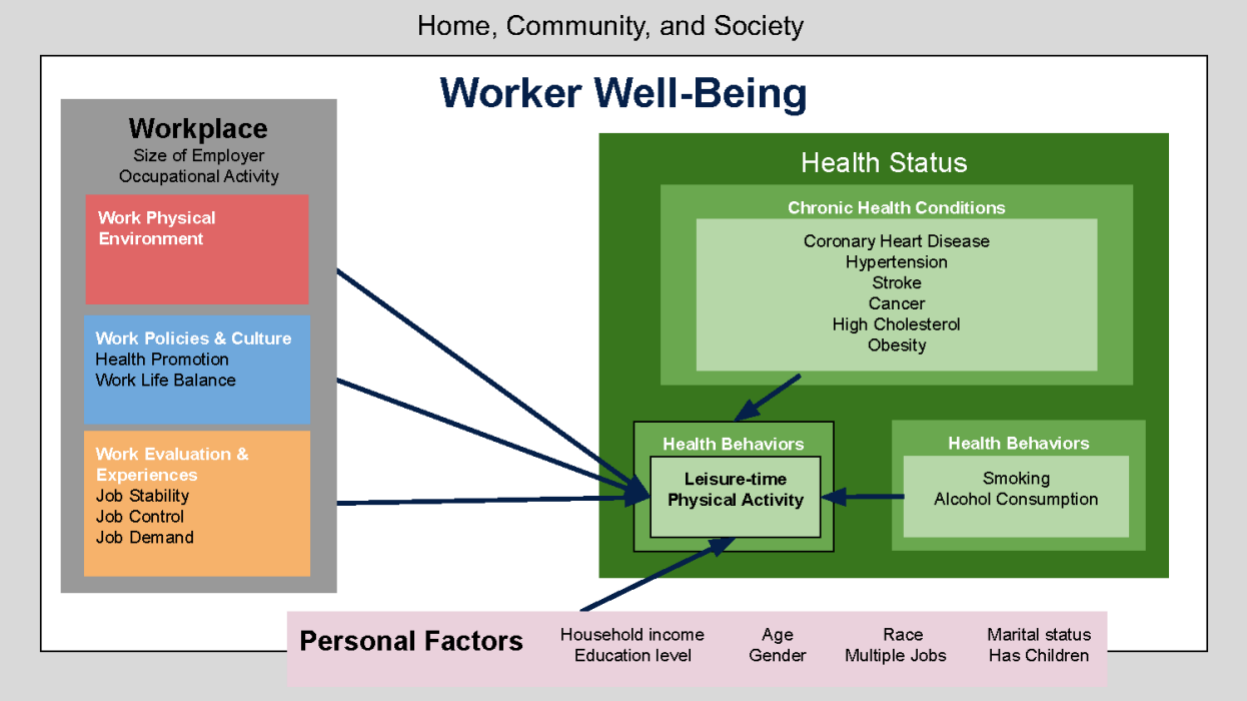

Figure 4.1. *Conceptual Framework of the Study*

Note. The study framework *modified* the *Total Worker Health Worker Well-being Framework*

Table 4.1. *Sample characteristics and weighted Prevalence of Meeting the Physical Activity Guidelines among U.S. Workers with Low Occupational Activity (n=7,217)*

	All	Sufficient LTPA n=1,970		Met aerobic n=4,258		Met strength n=2,194	
Variable	%	%	(95% CI)	%	(95% CI)	%	(95% CI)
Total		27.3	(25.9, 28.8)	59.0	(57.4, 60.5)	30.4	(28.9, 31.8)
Age							
18-29	19.2	33.6	(29.9, 37.5)	67.0	(63.2, 70.5)	36.2	(32.4, 40.2)
30-39	23.2	31.4	(28.4, 34.6)	61.7	(58.6, 64.7)	33.5	(30.4, 36.7)
40-49	23.2	26.1	(23.2, 29.2)	58.7	(55.5, 61.9)	29.1	(26.1, 32.3)
50-60	23.4	22.2	(19.6, 250)	53.6	(50.4, 56.8)	25.7	(22.9, 28.6)
60+	11.0	21.5	(18.1, 25.2)	51.8	(47.6, 55.9)	26.3	(22.6, 30.3)
Gender							
Female	51.7	22.7	(21.0, 24.5)	55.4	(53.5, 57.3)	25.8	(24.1, 27.7)
Male	48.3	32.4	(30.2, 34.8)	63.0	(60.7, 65.3)	35.3	(33.1, 37.6)
Race with Hispanic ethnicity							
White, Non-Hispanic	69.2	28.6	(26.8, 30.4)	61.4	(59.4, 63.3)	31.6	(29.9, 33.5)
White, Hispanic	10.8	23.9	(20.4, 27.9)	52.9	(48.8, 57.0)	26.7	(23.1, 30.8)
Black/African American	11.0	25.2	(21.3, 29.6)	51.5	(47.0, 55.9)	28.5	(24.5, 32.9)
American Indian/Alaska Native	0.8	28.0	(16.2, 43.8)	53.0	(38.7, 66.8)	30.1	(18.0, 45.7)
Asian	7.9	23.8	(19.7, 28.4)	57.3	(51.9, 62.6)	26.4	(22.5, 30.7)
Multiracial	0.3	23.3	(11.1, 42.3)	73.2	(49.0, 88.6)	23.3	(11.1, 42.3)
Highest education completed							
Some high school	3.9	11.0	(5.4, 21.0)	34.4	(26.9, 42.8)	12.6	(6.8, 22.2)
High school diploma or GED	39.9	21.4	(19.3, 23.6)	49.5	(47.0, 51.9)	24.5	(22.4, 26.7)
Bachelor's degree or higher	56.2	32.7	(30.7, 34.7)	67.6	(65.6, 69.4)	35.8	(33.8, 37.8)
Household income							
$0 - $34,999	14.3	19.2	(16.6, 22.0)	48.7	(45.1, 52.3)	21.4	(18.8, 24.3)
$35,000 - $74,999	24.8	24.6	(22.1, 27.3)	51.3	(48.5, 54.0)	28.2	(25.6, 31.0)
$75,000 - $99,999	14.8	27.2	(23.4, 31.4)	61.1	(56.9, 65.2)	30.5	(26.6, 34.6)
$100,00 and over	46.2	31.3	(29.0, 33.8)	65.7	(63.4, 68.0)	34.2	(31.9, 36.6)
Married or living with partner							
Yes	67.2	25.8	(23.9, 27.7)	58.0	(56.0, 60.0)	28.7	(26.9, 30.6)
No	32.8	30.5	(28.1, 33.0)	61.1	(58.6, 63.5)	33.7	(31.2, 36.2)
Has children in household							
Yes	39.5	26.2	(23.7, 28.8)	58.2	(55.7, 60.6)	28.9	(26.4, 31.5)
No	60.5	28.0	(26.4, 29.8)	59.6	(57.7, 61.4)	31.3	(29.6, 33.0)
BMI (kg perm^2)							
Underweight (<18.5)	1.3	16.8	(10.2, 26.4)	60.0	(47.4, 71.5)	22.1	(13.4, 34.3)
Normal weight (18.5 - 24.99)	36.4	30.9	(28.4, 33.5)	64.5	(62.2, 66.9)	34.3	(31.9, 36.9)
Overweight (25-29.99)	33.9	30.5	(28.0, 33.2)	62.7	(60.1, 65.2)	32.9	(30.4, 35.5)
Obese ($\geq$30)	28.3	20.3	(17.9, 22.9)	49.1	(46.0, 52.3)	23.6	(21.2, 26.3)

Variable	%	%	(95% CI)	%	(95% CI)	%	(95% CI)
History of chronic disease							
Yes	52.8	23.2	(21.4, 25.1)	54.0	(51.7, 56.3)	26.4	(24.6, 28.3)
No	47.2	31.9	(29.7, 34.1)	64.5	(62.4, 66.6)	34.7	(32.5, 36.9)
Ever smoked 100 cigarettes							
Yes	29.1	22.9	(20.8, 25.2)	55.2	(52.3, 58.0)	25.5	(23.3, 27.7)
No	70.9	29.1	(27.5, 30.9)	60.6	(58.7, 62.5)	32.3	(30.7, 34.1)
Alcohol usage							
Yes	24.8	35.6	(32.6, 38.7)	69.5	(66.7, 72.2)	37.8	(34.6, 41.0)
No	75.2	24.6	(23.1, 26.2)	55.6	(53.7, 57.4)	27.9	(26.4, 29.5)
Workplace health promotion offered							
Yes	54.9	31.9	(30.0, 33.9)	64.8	(62.8, 66.7)	35.0	(33.1, 37.0)
No	45.1	21.7	(19.8, 23.8)	52.0	(49.5, 54.4)	24.6	(22.6, 26.8)
Workplace health promotion participation							
No health promotion offered	45.1	21.7	(19.8, 23.8)	52.0	(49.5, 54.4)	24.6	(22.6, 26.8)
Never	21.0	29.8	(26.6, 33.3)	59.8	(56.5, 63.0)	33.5	(30.3, 36.9)
A few times	8.6	28.3	(23.9, 33.0)	64.4	(59.0, 69.5)	31.7	(27.2, 36.7)
Monthly	19.8	28.2	(25.3, 31.4)	64.1	(60.9, 67.1)	31.0	(28.1, 34.0)
Weekly	3.5	60.5	(52.9, 67.5)	87.7	(82.8, 91.3)	62.2	(54.7, 69.2)
Daily	2.1	56.0	(44.9, 66.5)	85.2	(75.4, 91.6)	57.5	(46.7, 67.7)
Size of employer							
1-49 employees	43.1	24.2	(22.1, 26.4)	54.3	(52, 56.5)	27.0	(24.9, 29.2)
50-249 employees	24.4	30.0	(27.2, 32.9)	60.7	(57.5, 63.8)	32.7	(29.9, 35.6)
250-499 employees	7.5	30.9	(25.8, 36.4)	61.7	(56.0, 67.0)	35.4	(30.2, 40.9)
500-999 employees	8.3	34.6	(29.4, 40.2)	63.2	(57.8, 68.2)	38.6	(33.4, 44.0)
$\geq$1000 employees	16.7	26.3	(22.9, 29.9)	65.5	(61.9, 69.0)	29.2	(25.7, 33.0)
Work-family balance							
High	77.0	27.9	(25.2, 30.7)	59.3	(57.5, 61.1)	30.2	(28.6, 31.9)
Low	23.0	27.1	(25.5, 28.8)	58.1	(54.9, 61.2)	30.6	(28.0, 33.5)
Works multiple jobs							
Yes	7.7	32.4	(27.4, 37.9)	63.7	(58.1, 68.9)	35.7	(30.5, 41.4)
No	92.3	26.9	(25.4, 28.4)	58.6	(57.0, 60.2)	29.9	(28.4, 31.4)
Job stability							
High	90.1	27.5	(26.1, 29.0)	59.3	(57.6, 61.0)	30.7	(29.3, 32.2)
Low	9.9	25.5	(21.4, 30.1)	56.4	(51.7, 60.9)	26.9	(22.8, 31.5)
Job control							
High	90.1	28.1	(26.6, 29.7)	59.8	(58.1, 61.5)	31.3	(29.8, 32.8)
Low	9.9	20.0	(16.5, 24.1)	51.9	(47.1, 56.7)	21.8	(18.2, 25.9)
Job demand							
High	15.1	27.3	(24.0, 30.8)	61.6	(57.8, 65.3)	30.4	(27.0, 34.0)
Low	84.9	27.3	(25.8, 28.9)	58.5	(56.8, 60.2)	30.3	(28.8, 31.9)

Note. Sufficient LTPA refers to both meeting both aerobic and muscle-strengthening guidelines. Meeting aerobic guidelines is >150 minutes of moderate to vigorous activity per week. Meeting strength guidelines is performing muscle-strengthening activities >2 per week.

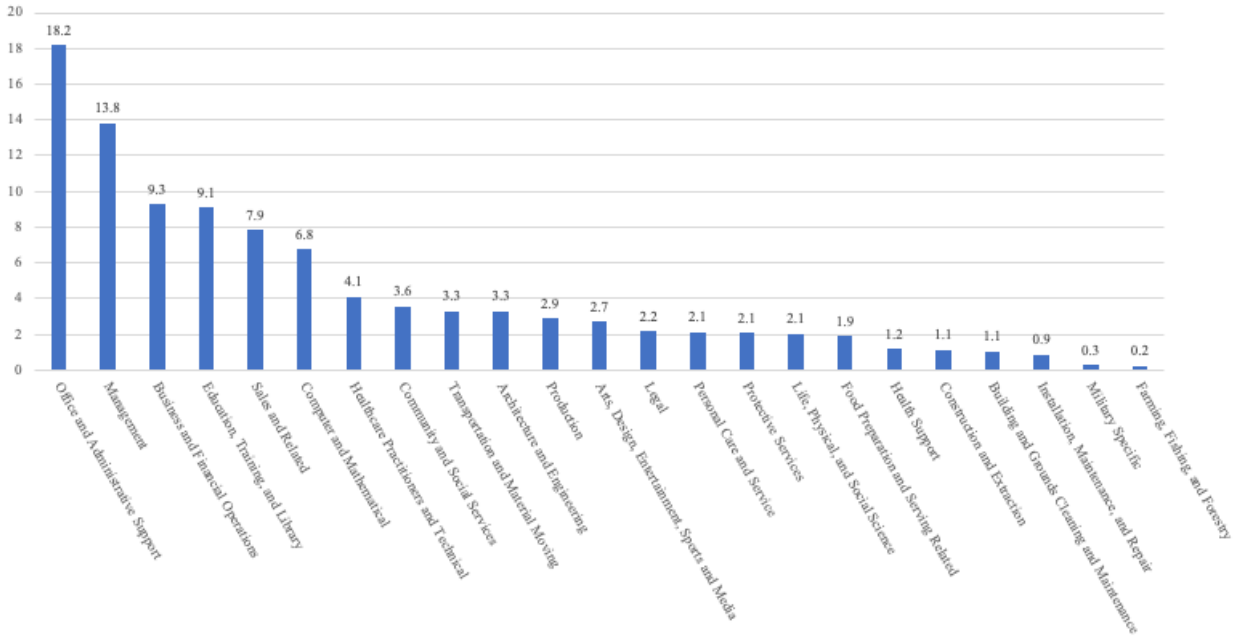

Figure 4.2. *Percentage of Workers in Each Job Categories among U.S. Workers with Low Occupational Activity (n=7,217)*

Table 4.2. *Weighted Prevalence of Meeting the Physical Activity Guidelines by Job Categories among U.S. Workers with Low Occupational Activity (n=7,217)*

	Sufficient LTPA n=1,970		Met aerobic n=4,258		Met strength n=2,194	
Job Categories	%	(95% CI)	%	(95% CI)	%	(95% CI)
Management	34.0	(30.1, 38.1)	65.5	(61.4, 69.3)	36.7	(32.9, 40.8)
Business and Financial Operations	31.7	(27.4, 36.3)	66.4	(61.5, 71.0)	34.0	(29.6, 38.7)
Computer and Mathematical	32.8	(27.7, 38.3)	68.2	(62.5, 73.3)	36.5	(31.6, 41.7)
Architecture and Engineering	26.0	(19.8, 33.4)	69.9	(62.8, 76.2)	27.9	(21.3, 35.6)
Life, Physical, and Social Science	40.1	(29.8, 51.3)	77.9	(67.0, 85.9)	40.2	(29.9, 51.4)
Community and Social Services	23.4	(16.8, 31.7)	59.9	(51.7, 67.5)	28.5	(21.4, 36.9)
Legal	34.8	(26.0, 44.8)	65.6	(55.6, 74.4)	39.7	(30.0, 50.4)
Education, Training, and Library	27.0	(23.1, 31.3)	60.5	(54.9, 65.8)	31.3	(27.1, 35.7)
Arts, Design, Entertainment, Sports and Media	27.0	(19.2, 36.6)	67.1	(58.0, 75.1)	28.1	(20.2, 37.6)
Healthcare Practitioners and Technical	24.7	(18.9, 31.6)	59.8	(52.8, 66.4)	30.8	(24.2, 38.2)
Health Support	10.0	(4.9, 19.6)	33.3	(22.3, 46.5)	12.9	(6.4, 24.3)
Protective Services	35.9	(23.7, 50.3)	55.7	(42.9, 67.8)	37.4	(25.2, 51.6)
Food Preparation and Serving Related	13.8	(8.0, 22.9)	51.1	(39.8, 62.3)	18.3	(10.7, 29.5)
Building and Grounds Cleaning and Maintenance	15.5	(6.3, 33.1)	31.0	(17.8, 48.3)	18.6	(8.8, 35.0)
Personal Care and Service	20.3	(12.9, 30.5)	48.5	(37.8, 59.3)	23.2	(15.1, 33.9)
Sales and Related	31.1	(26.6, 36.0)	61.9	(56.5, 67.0)	34.2	(29.3, 39.3)
Office and Administrative Support	22.4	(19.4, 25.8)	51.1	(47.2, 55.0)	25.7	(22.6, 29.0)
Farming, Fishing, and Forestry	15.7	(2.5, 57.1)	31.8	(12.9, 59.4)	17.8	(3.5, 56.5)
Construction and Extraction	12.2	(5.2, 26.0)	41.0	(28.0, 55.5)	14.7	(6.9, 28.4)
Installation, Maintenance, and Repair	20.2	(11.0, 34.1)	55.7	(40.2, 70.1)	20.2	(11.0, 34.1)
Production	12.8	(7.5, 20.9)	37.2	(28.4, 46.9)	14.4	(9.0, 22.3)
Transportation and Material Moving	15.7	(10.2, 23.4)	35.2	(27.3, 43.9)	17.4	(11.7, 25.1)
Military Specific	54.5	(25.5, 80.8)	55.7	(26.2, 81.6)	54.5	(25.5, 80.8)

Note. Sufficient LTPA refers to meeting both aerobic and muscle-strengthening guidelines. Meeting aerobic guidelines is >150 minutes of moderate to vigorous activity per week. Meeting strength guidelines is performing muscle-strengthening activities >2 per week.

Table 4.3. *Association Between Achieving Sufficient Leisure-time Physical Activity and Sociodemographic, Job and Workplace Characteristics among U.S. Workers with Low Occupational Physical Activity (n=7,217)*

	Sufficient LTPA (unadjusted model)			Sufficient LTPA (adjusted model)		
Variables	OR	(95% CI)	*p*	aOR	(95% CI)	*p*
Age						
18-29	1.00			1.00		
30-39	**0.85**	**(0.73, 0.99)**	**0.033**	0.93	(0.73, 1.2)	0.589
40-49	**0.72**	**(0.62, 0.85)**	**<0.001**	0.78	(0.59, 1.01)	0.062
50-60	**0.57**	**(0.48, 0.67)**	**<0.001**	**0.61**	**(0.47, 0.79)**	**0.000**
60+	**0.47**	**(0.38, 0.57)**	**<0.001**	**0.63**	**(0.45, 0.87)**	**0.006**
Gender						
Female	1.00			1.00		
Male	**1.64**	**(1.48, 1.81)**	**<0.001**	**1.59**	**(1.37, 1.85)**	**0.000**
Race with Hispanic ethnicity						
White (Non-Hispanic)	1.00			1.00		
White (Hispanic)	**0.65**	**(0.55, 0.77)**	**<0.001**	1.07	(0.84, 1.35)	0.574
Black/African American	**0.73**	**(0.62, 0.87)**	**<0.001**	1.04	(0.81, 1.34)	0.769
American Indian/Alaska Native	0.90	(0.53, 1.52)	0.688	1.06	(0.45, 2.51)	0.889
Asian	**0.74**	**(0.60, 0.90)**	**0.003**	**0.67**	**(0.51, 0.87)**	**0.003**
Multiracial	1.17	(0.55, 2.49)	0.685	0.66	(0.28, 1.56)	0.341
Highest education completed						
Less than high school diploma	1.00			1.00		
High school diploma or GED	**2.44**	**(1.67, 3.57)**	**<0.001**	1.94	(0.91, 4.15)	0.087
Bachelor's degree or higher	**4.86**	**(3.34, 7.07)**	**<0.001**	**2.71**	**(1.25, 5.91)**	**0.012**
Household income						
$0 - $34,999	1.00			1.00		
$35,000 - $74,999	**1.42**	**(1.21, 1.67)**	**<0.001**	1.27	(0.99, 1.63)	0.061
$75,000 - $99,999	**1.60**	**(1.33, 1.92)**	**<0.001**	**1.57**	**(1.14, 2.18)**	**0.006**
$100,00 and over	**1.99**	**(1.71, 2.31)**	**<0.001**	**1.80**	**(1.35, 2.40)**	**0.000**
Married or living with partner				0		
Yes	**0.81**	**(0.73, 0.90)**	**<0.001**	**0.68**	**(0.57, 0.81)**	**0.000**
No	1.00			1.00		
Has children in household						
Yes	**0.82**	**(0.73, 0.92)**	**<0.001**	0.90	(0.75, 1.08)	0.267
No	1.00			1.00		

	Sufficient LTPA (unadjusted model)			Sufficient LTPA (adjusted model)		
Variables	OR	(95% CI)	*p*	aOR	(95% CI)	*p*
BMI (kg perm2)						
Underweight (<18.5)	0.66	(0.44, 1.00)	0.050	**0.47**	**(0.25, 0.9)**	**0.023**
Normal weight (18.5 - 24.99)	1.00			1.00		
Overweight (25-29.99)	0.91	(0.80, 1.02)	0.115	1.00	(0.83, 1.21)	0.972
Obese (≥30)	**0.49**	**(0.42, 0.56)**	**<0.001**	**0.66**	**(0.52, 0.84)**	**0.001**
History of chronic disease						
Yes	**0.61**	**(0.55, 0.67)**	**<0.001**	0.87	(0.7, 1.09)	0.224
No	1.00			1.00		
Ever smoked 100 cigarettes						
Yes	**0.77**	**(0.68, 0.86)**	**<0.001**	**0.80**	**(0.69, 0.94)**	**0.005**
No	1.00			1.00		
History of alcohol						
Yes	**1.64**	**(1.46, 1.85)**	**<0.001**	**1.35**	**(1.13, 1.60)**	**0.001**
No	1.00			1.00		
Workplace health promotion participation						
No health promotion offered	1.00			1.00		
Never	**1.41**	**(1.23, 1.62)**	**<0.001**	**1.42**	**(1.15, 1.76)**	**0.001**
A few times	**1.38**	**(1.13, 1.68)**	**0.001**	**1.34**	**(1.03, 1.74)**	**0.030**
Monthly	**1.42**	**(1.23, 1.63)**	**<0.001**	**1.25**	**(1.02, 1.54)**	**0.036**
Weekly	**3.71**	**(2.88, 4.78)**	**<0.001**	**4.87**	**(3.36, 7.05)**	**0.000**
Daily	**4.49**	**(3.25, 6.21)**	**<0.001**	**4.21**	**(2.50, 7.08)**	**0.000**
Size of Employer						
1-49 employees	1.00			1.00		
50-249 employees	**1.34**	**(1.18, 1.53)**	**<0.001**	1.14	(0.95, 1.38)	0.160
250-499 employees	**1.40**	**(1.16, 1.71)**	**0.001**	1.01	(0.75, 1.35)	0.953
500-999 employees	**1.60**	**(1.32, 1.95)**	**<0.001**	1.20	(0.89, 1.61)	0.229
≥1000 employees	**1.28**	**(1.10, 1.49)**	**0.002**	**0.71**	**(0.56, 0.89)**	**0.003**
Work-family balance						
High	**0.88**	**(0.78, 0.99)**	**0.032**	1.03	(0.86, 1.23)	0.773
Low	1.00			1.00		
Multiple jobs						
Yes	**1.37**	**(1.15, 1.64)**	**<0.001**	**1.35**	**(1.05, 1.72)**	**0.018**
No	1.00			1.00		
Job stability						
High	0.99	(0.83, 1.18)	0.905	-		
Low	1.00			-		

	Sufficient LTPA (unadjusted model)			Sufficient LTPA (adjusted model)		
Variables	OR	(95% CI)	*p*	aOR	(95% CI)	*p*
Job control						
High	**1.40**	**(1.17, 1.68)**	**<0.001**	1.22	(0.93, 1.59)	0.149
Low	1.00			1.00		
Job demand						
High	1.10	(0.95, 1.26)	0.210	-		
Low	1.00			-		

OR= Odds Ratios, aOR= Adjusted Odds Ratios, NA=Not Applicable and not included in model.

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Chapter Five

Discussion

This dissertation study examined the relationship between workplace characteristics and physical activity in workers with low occupational activity. Chapter 2 of this dissertation examined the influence of the physical work environment on office-based workers from across the globe; Chapter 3 examine the prevalence of leisure-time physical activity (LTPA) and the association between job factors and LTPA in U.S. workers; Chapter 4 examined the relationship between workplace characteristics and LTPA in workers with low occupational activity. Previous literature has considered the relationship between physical activity and employment status, job activity level, job categories, hours worked, and job demand. In addition to these factors, this study included desk and office design, health promotion, work-life balance, job stability, job control, or job demand, as workplace characteristic in relation to physical activity.

Utilizing the Total Worker Health (TWH) Worker Wellbeing Framework (Chari et al., 2018), this study examined multiple factors reflecting the *Workplace Physical Environment* domain, *Workplace Policies and Culture* domain, and *Work Evaluation and Experience* domain in addition to personal factors to evaluate the relationship between workplace and physical activity. This study revealed new information about the relationship between workplace characteristics and workers' physical activity. This study found that workplace health promotion program and the level of workplace health programs addressed had a positive relationship with sufficient physical activity. Additionally, sufficient LTPA share similar findings with meeting aerobic activity guidelines and was directly determined by workers meeting the muscle-strengthening guidelines.

Workplace Physical Environment

The systematic review study (Chapter 2) identified physical workplace design as an important component of the relationship between the workplace and workers completing

physical activity. The 26 studies included in Chapter 2 showed the relationship between desk type, workstation or office design, and building design with the amount of physical activity office-based workers completed. Worksites have used these different physical environment interventions as part of their workplace health and ergonomics programing. The review results found that workers in spaces that implemented interventions higher within the hierarchy of controls were most active. While desk type did minimize sitting, it had little impact on physical activity. Participants in work environments with flexible or open floor plans and in buildings designed with active design principles had higher levels of activity compared to traditional assigned cubical-like office spaces. Similar to the findings from previous literature (Marshall, 2004), this review study found the concept of increasing physical activity by using design features such as prominent staircases, centralized break rooms and bathrooms, and centralized printers and trash bins can improve workers' physical activity.

Workplace Policies and Culture.

The workplace polices and culture domain includes workplace policies, programs, and practices that build a culture of health and can influence worker well-being. This study examined workplace health promotion program and work-family balance for the workplace policy and culture domain (Chapters 3 and 4). This study revealed a strong relationship between workplace health promotion and LTPA. The prevalence of achieving sufficient LTPA was highest in workers who participated weekly to daily in workplace health promotion programs in both the overall worker population, and in workers with low occupational activity. On the other hand, there was no association with work-family balance and LTPA. Previous research has found LTPA reduces stress and positively influences work-family balance (Clayton et al., 2014), and work-family balance is an important aspect of managing stress and overall health (Grzywacz et

al., 2008). However, in this study there was no direct relationship between work-family balance and LTPA.

Workplace health promotion is defined by the Centers for Disease Control and Prevention (CDC) as "*a coordinated set of programs, policies, benefits, and environmental supports designed to meet the health and safety needs of all employees*" (CDC, 2017a). Under this definition, employers can provide a variety of offerings including health education info sessions, smoking cessation groups, walking competitions, fitness discounts, farmers markets, stair promotion signage, blood pressure monitoring, and health apps. Although this study was not able to determine if the health promotion program offered by participants' workplace focused on physical activity, previous literature indicates that physical activity is the most common health-related behavior address by workplace health promotion programs (CDC, 2018). In this study, workers with a workplace health promotion program had significantly higher odds of meeting aerobic guidelines, muscle-strengthening guidelines, and completing sufficient LTPA than workers without these programs. Previous literature also showed that individuals in environments and surrounded by social networks that support healthy behaviors are more likely to engage in healthy behaviors (Chari et al., Golden & Earp, 2012). Additionally, frequent (weekly or daily) participation in workplace health promotion programs was related to sufficient LTPA as physical activity is needed multiple days a week to meet the physical activity guidelines.

Workplace Evaluation and Experience.

The workplace evaluation and experience domain reflects on workers' experiences including their perceived meaningfulness of work and their organization of their work influence their well-being. This study examined job stability, job control, and job demand for workplace

evaluation and experience domain on the relationship with LTPA among workers with low occupational activity (Chapter 4). While there was no significant relationship with any of those variables, this study observed a few important trends. First, sufficient LTPA and meeting aerobic activity guidelines were more prevalent in workers who were not worried about losing their current job. However, the prevalence of meeting muscle-strengthening guidelines was higher in those that felt they had low job stability. Second, a similar trend was observed regarding job control. Sufficient LTPA and meeting aerobic activity guidelines were more prevalent in those who reported their job allows them to make decisions on their own. Again, the prevalence of meeting muscle-strengthening guidelines was higher in those that felt they had low job control. It is unclear why meeting muscle-strengthening guidelines differed from the pattern found from meeting aerobic guidelines or achieving sufficient LTPA in relations to job stability or job control. Future research is needed to understand why workers with less job stability or control gravitated towards muscle-strengthening activities in their leisure time.

Workplace Characteristics.

Based on previous literature, this study examined workplace size and occupational activity as important factors in the relationship with LTPA (Chapters 3 and 4) (Blackwell et al., 2016; Gu et al., 2016). Previous studies found workers who self-reported higher levels of occupational activity in their jobs were more likely to meet aerobic activity guidelines (Kirk & Rhodes, 2011; Kruger et al., 2006). One the other hand, previous studies that measured occupational activity through accelerometer devices found high occupational activity workers were less likely to meet the aerobic physical activity guidelines (Prince et al., 2019; Steeves et al., 2015). Although no statistically significant relationship was found between occupational activity level and sufficient LTPA in this study, results indicated a linear trend with LTPA

decreasing as occupational activity became more strenuous in the general U.S. worker population. This contrast with previous research using self-reported occupational activity measures (Kruger et al., 2006). However, unlike previous studies, this study considered sufficient LTPA as meeting both aerobic and muscle-strengthening guidelines and therefore sufficient LTPA was not overestimated by being calculated from only aerobic activity.

Additionally, this study identified the range of occupational activity levels reported among 23 job categories and also the prevalence of sufficient LTPA among these categories. The prevalence of sufficient LTPA ranged from 22.9% to 48.7%. among the 23 job categories. Occupations typically associated with low occupational activity work, higher education and higher incomes, such as legal, computer/mathematical, management, or business/finance operation occupations, had the highest prevalence rates of sufficient LTPA. Sufficient LTPA was lowest in occupations associated with lower education and income levels: production, health support, and building and ground cleaning maintenance occupations. Additionally, office and administrative support was the only sedentary job category that had a prevalence of sufficient LTPA lower than the overall sample prevalence of sufficient LTPA. Unlike other sedentary job categories, office and administrative support workers had lower education and incomes levels than their counterparts in the other sedentary job categories. These findings showed a trend similar to the trend identified using occupational activity; worker in sedentary job categories were more activity than job categories requiring heavy occupational activity. However, occupational activity may not yield the same health benefits as LPTA (Prince et al., 2019), and therefore it remains important to also encourage LPTA in workers who are in heavy occupational activity jobs. Additionally, the majority of workers in all job categories and all occupational activity levels did not achieve sufficient LTPA. The percentage of workers who did active

sufficient LTPA is below the 2030 target for the U.S. population (Health People 2030, 2018) indicating more attention is needed to increase LTPA in all U.S. adult workers.

Chapter 4 took a closer look at workers with low occupational activity, who were identified by self-report occupational activity. Interestingly, all 23 job categories were present in this sample indicating that workers in all job occupational categories may identify their work as requiring little activity. As expected by the job category name, the most common jobs involving low occupational activity included office and administrative support, management, business and financial operations, sales, and education, training, and library. Similar to the categories identified in Chapter 3, the prevalence of sufficient LTPA was highest in the military specific, life/physical/social science, and protective services job categories in the subpopulation of low occupational activity workers. The lowest prevalence of LTPA was in transportation and material moving, construction and extraction, and farming/fishing and forestry. In this subsample, office and administrative support was the most common job category, and similar to the findings in Chapter 3, these workers had a lower than average prevalence of sufficient LTPA. In both Chapter 3 and Chapter 4, the job categories with the most workers achieving sufficient LTPA also had a higher prevalence of higher education and household incomes. This finding suggests that the workplace, particularly in industries that employ workers of lower education levels or lower incomes, need to develop and provide workplace health promotion programs focused on improving LTPA.

Provision of workplace health promotion programs is well known to be correlated with the size of the workplace (Kaiser Family Foundation, 2019). This was also true in this study. In the subsample of low occupational activity workers, only 42% of workers in worksite with less than 250 had workplace health promotion programs, compared to 76% in 250-499 employee

worksites, 78% in 500-999 employee worksites, and 82% in worksites with greater than 1000 employees. In chapters 3 and 4, this study showed that the odds of sufficient LTPA were highest among workers in medium-sized workplaces (500-999 and 250-499 employees), followed by large workplaces (1000 or more employees) in U.S. workers. This finding identified a need to look closer at why the prevalence of sufficient LTPA dropped in larger worksites, and consider the magnitude of health promotion participation at these worksites.

Strengths and Limitations

One of strengths of this study was its inclusion of both self-reported aerobic and muscle-strengthening activities in the definition of sufficient LTPA. The current body of literature mostly focused on leisure-time aerobic activity as a definition of sufficient activity. This limited definition can lead to an overestimation of the prevalence of meeting the 2018 Physical Activity Guidelines for Americans (U.S. Department of Health and Human Services, 2018). This was evidently found in this study and the prevalence of meeting aerobic activity guidelines was much higher than the prevalence of sufficient LTPA including both aerobic and muscle-strengthening activity guidelines. In addition, this study used the nationally representative sample of U.S. workers and the large diverse sample strengthens the study's generalizability to the U.S. worker population.

Although this study contributed new findings to understanding physical activity in U.S. workers, several limitations need to be acknowledged. First, there were numerous methods used to measure physical activity in the systematic review in chapter 2. Some studies measured only physical activity that occurred at the workplace, some studies measured physical activity all day, and some studies separated occupational activity from LTPA. Additionally, both subjective and objective measures were used to measure the different domains of physical activity. This posed a

challenge in comparing studies between each other and comparing physical activity levels to the studies reported in chapters 3 and 4. In chapters 3 and 4 LTPA was only captured through self-reported measures and may have been overestimated (Fukuoka et al., 2016; Schuna et al., 2013). Additionally, although the guidelines for physical activity refer to all domains of activity, not just LTPA, this study was not able to combine LTPA with occupational activity, household, or transportation physical activity domains to determine if participants met the physical activity guidelines. The NHIS occupational activity questions asked about frequency of lifting, but did not use weight references. This poses a risk of misclassification and limited the ability to directly align with the BLS definition (BLS, 2019b) for occupational activity. Lastly, this study was conducted through secondary data analysis. The extent of variables within each domain of the TWH framework was limited based on the existing variables in the NHIS 2015 dataset that were assigned to each domain.

Implication for Nursing or Practice

Overall, this study found a need to increase physical activity levels in workers. Considering the Total Worker Health framework, this studied identified 4 key recommendations for occupational health nursing practice that target the physical work environment and work policies and culture. First, in regards to the physical work environment, design practices such as prominent stairwells and centralized shared utilities that create opportunities for movement during the workday should be considered by workplaces when designing their office spaces to increase physical activity. Second, in regards to workplace culture, given the strong associations between health promotion programs and workers achieving sufficient LTPA, workplaces should consider offering health promotion activities to their workforce to support worker health and wellbeing. These programs play an important role in building a culture support of health and

positively influencing health behaviors such as LTPA in U.S. workers (CDC, 2016; CDC,2017b). Third, as indicative of the findings showing linkages between increased participation frequency and higher prevalence of sufficient LTPA, occupational health nurses should focus on improving participation frequency to daily to weekly participation to produce the greatest health benefits. Lastly, when developing these programs in larger workplaces, consideration should be given to how well health promotion messaging is received by workers, the level of intervention of these programs, and the effectiveness of the programing reaching the all workers.

Future Research

To further advance the field, all future studies should consider both aerobic and muscle-strengthening activity levels, and include both when defining sufficient LTPA. This reduces the chance of overestimating the prevalence of workers meeting the physical activity guidelines and ensures researchers are capturing all components of physical activity needed to achieve positive health outcomes. Additionally, a more in dept review of the utilization and effectiveness of workplace health promotion programs at larger worksites (>1000 employees) is needed to understand why sufficient LTPA was lower in these workers. Specifically, researchers should consider how messaging about health promotion programs is shared and the populations that participate in the programs. Future research should also consider the relationship between working multiple jobs or working beyond a traditional 40 hours/week and physical activity in U.S. workers. Lastly, future research would benefit from measuring both LTPA and occupational activity objectively to minimize reporting bias and allow for a combined overall level of physical activity measurement.

Conclusion

Sufficient physical activity is an important component of workers' overall health. However, the majority of adult workers in the U.S. do not meet the recommended guidelines for physical activity. In particular, workers who are less active during the workday are at higher risk of negative health effects from insufficient activity. In this study using 2015 NHIS data, the prevalence achieving sufficient LTPA was only 25% in all U.S. workers and 27% in U.S. workers with low occupational activity. The significant factors associated with sufficient LTPA included male gender, having a bachelor's degree or higher, a household income over $75,000, and frequent participation in a workplace health promotion program. The workplace has the opportunity to support efforts to increase the prevalence of workers completing sufficient physical activity by implementing active design practices, health promotion programs, and ensuring workers of all incomes and education levels participate in these programs.

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