IDENTIFYING AND DESCRIBING SEGMENTS OF OFFICE WORKERS BY ACTIVITY PATTERNS: ASSOCIATIONS WITH DEMOGRAPHIC CHARACTERISTICS, LEVELS OF PHYSICAL ACTIVITY, AND BODY MASS INDEX

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ABSTRACT

Michael A. Close: Identifying and Describing Segments of Office Workers by Activity Patterns: Associations with Demographic Characteristics, Levels of Physical Activity, and Body Mass Index
(Under the direction of Leslie A. Lytle)

Sufficient engagement in physical activity is important in reducing the prevalence of activity-linked chronic disease among office workers. The dissertation research, presented through three manuscripts, leverages baseline data from a worksite nutrition intervention study to identify and describe segments of office workers by activity patterns, with the purpose of informing workplace physical activity programming.

In Manuscript One, latent class analysis was used to identify segments of office workers by self-reported types of usual activity behaviors (n = 239). In addition, demographic characteristics and objectively measured levels of physical activity associated with segment membership were examined. A two-class model indicative of "exerciser" (50.2%) and "non-exerciser" (49.8%) segments fit best. Those with a Bachelor's degree or higher (vs. less than Bachelor's degree) were more likely to be a member of the "exerciser" segment, while women (vs. men) were less likely to belong to the "exerciser" segment. In the fully adjusted model, minutes of weekly moderate-vigorous physical activity were more than two times higher for the "exerciser" segment (mean = 209.5 minutes; SE = 13.5) than the "non-exerciser" segment (mean = 77.5; SE = 4.0).

In Manuscript Two, the relationship between segment membership and body mass index was evaluated. In the full model, membership to the "exerciser" segment was associated with

significantly lower mean body mass index (mean = 29.0; SE = 0.6) as compared to the "non-exerciser" segment (mean = 35.1; SE = 0.9).

In Manuscript Three, the predictive validity and test-retest reliability of the self-report physical activity instrument used to collect data for segmentation was evaluated. In the evaluation of predictive validity, the instrument showed reasonably strong overall Spearman correlations in short (rho = 0.35 – 0.40) and long-term (rho = 0.26 – 0.33) timeframes. The overall test-retest reliability of the instrument within an approximate six-month timeframe was also adequate (rho = 0.54 – 0.59). Stratified analyses showed minimal differences in predictive validity and test-retest reliability by age, weight status, and sex.

The overall dissertation findings shed light on the heterogeneity in activity engagement found in the workplace and also contribute to the research examining the psychometric properties of self-reported physical activity instruments.

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CHAPTER 1: INTRODUCTION AND BACKGROUND

1.1 Introduction

An adult's working conditions can contribute to behaviors impacting health both in and outside the workplace (1,2). The physical, psychosocial, and organizational conditions of work affect adults' engagement in protective health behaviors, such as physical activity, and may increase the risk of obesity (2) and other chronic diseases (3). Because of the epidemiological and economic implications of adult overweight and obesity in the United States (4–8), workplace health promotion programs play an important role in encouraging adult engagement in physical activity and other positive weight-related behaviors (9).

A variety of individual-focused and organization-wide workplace health promotion interventions have been shown to improve the physical activity of workers. Individual-focused workplace physical activity interventions often entail supervised physical exercise or physical activity counseling sessions targeting participation of individual workers in one-on-one or group settings. Meanwhile, organization-wide interventions utilize policies and environmental modifications to influence physical activity of employees across the workplace. A comprehensive workplace health promotion program that efficiently integrates both individual-focused and organization-wide approaches may best support physical activity across all workers in a workplace (10).

The selection and integration of individual-focused and organization-wide approaches in a workplace physical activity program may have considerable financial implications for employers. Individual-focused approaches often require paid staff and facilities for programs that are provided at little or no cost to the participant but may incur substantial and on-going cost to employers. In contrast, lower cost organization-wide approaches such as promotion of workplace stair utilization, walking meetings, breaks for physical activity, and other activities such as workplace based clubs or teams, may impact worker physical activity through system-wide changes in the workplace. More expensive environmental changes such as installing treadmill desks, gyms, or walking paths on the grounds are options as well. While an organization-wide approach may modestly increase levels of physical activity among all workers, it may be insufficient for moving those workers who get less than 150 minutes of moderate-vigorous physical activity or 75 minutes of vigorous physical activity per week (11) to levels that meet national guidelines.

Information on patterns of physical activity behavior among workers may support development and targeting of individual-focused and organization-wide approaches to employees. First, employers may use information on the patterning or types of activity behaviors that workers typically engage in to develop interventions in accordance with employees' current activities. Development of interventions that are aligned with existing activity patterns may facilitate employee uptake of interventions and increase the likelihood of employee adherence to greater worksite supported physical activity opportunities. Second, employers may use information on the demographic composition of workers with similar physical activity patterns to target interventions to others with similar patterns. Third, employers may use segment-specific information on body mass index (BMI) and time spent in light and moderate-vigorous physical activity to understand the relationship between activity patterns and objective measures of health, and prioritize employee groups for intervention accordingly. Targeting individual-focused and organization-wide intervention approaches to identified segments of the workforce may be key to ensuring that workplace health programs appropriately engage employees in a cost-efficient manner.

The paucity of research on worker activity patterns limits adequate consideration of segmentation in development of workplace physical activity programs. Much of what we know about worker physical activity is based on simple questionnaires, often obtained from workers as part of an employee health risk assessment. These health risk assessments often rely on a single-item question attempting to assess some aspect of worker activity level (12–14). Obtaining information on worker activity patterns is challenged by the cost and complexity of collecting detailed physical activity information. With limited data on what types of physical activities that employees typically engage in (including activities of daily life as well as exercise behaviors), employers and worksite health promotion programs are limited in their understanding of the types of programming that might be engaging for workers.

The purpose of this dissertation research is to provide actionable insights to workplace health promotion practitioners interested in enhancing levels of physical activity among office workers. The research identifies segments of office workers by types of activity behaviors and examines how those segments may differ by demographic characteristics, amount of objectively measured physical activity, and BMI.

The data in this research are from the Physical Activity Calorie Expenditure (PACE) trial, a worksite health promotion trial testing the effectiveness of PACE food labeling in reducing calorie purchasing and increasing levels of physical activity (15). The study sample consists of office workers employed at three worksites of a major health insurer in North Carolina. Details on the parent study are included in Chapter 2.

Using baseline data from the parent study, we identify and describe segments (i.e., classes or typologies) of office workers based on self-reported usual engagement in activities of daily living (including housework, walking leisurely, gardening, and childcare) and exercise behaviors (including aerobics, bicycle or stationary cycle use, jogging or running, strength training, and stretching/flexibility exercise). We examine the resulting segments and examine if the participants who make up each segment differ by: demographic characteristics, weekly minutes of light and moderate-vigorous activity as assessed using accelerometry, and BMI. Finally, we use the repeated measurement of self-report and objectively measured physical activity conducted in the PACE trial to evaluate the predictive validity and test-retest reliability of the self-report physical activity instrument used in this research, which is largely untested among office workers. The dissertation aims are:

Aim 1: Using latent class analysis, identify segments of office workers based on self-reported activities of daily living and exercise behaviors.

Aim 1a: Using the segments identified in Aim 1, examine how segment membership may differ by demographic characteristics (including age, sex, race/ethnicity, marital status, educational attainment, children in household, and occupation).

Aim 2: Using the segments identified in Aim 1, examine how segment membership may differ by duration and intensity of physical activity, assessed by mean minutes of light and moderate-vigorous physical activity per week via accelerometers and controlling for demographic characteristics.

Aim 3: Using the segments identified in Aim 1, examine how segment membership may differ by mean body mass index (BMI), controlling for demographic characteristics.

Aim 4: Investigate the predictive validity and test-rest reliability of a self-report physical activity instrument among office workers.

The dissertation research extends the literature on workplace physical activity promotion by describing the segmentation of a diverse and obesity-prone sample of office workers in southeastern United States (16,17). Knowledge of patterns of physical activity in the office workplace is important for researchers and practitioners seeking to design workplace physical activity programs that align with workers' existing activity behaviors. This research also adds to the compendium of psychometrically evaluated self-report tools for assessing physical activity and is the first to evaluate a tool in office workers.

Since the dissertation was originally proposed, a small number of meaningful changes to the aims and hypotheses were performed. First, an additional aim (i.e., Aim 4) and corresponding manuscript was added to investigate the validity and reliability of the self-report physical activity instrument used to identify the segments of office workers in Aims 1, 1a, 2, and 3. Second, the hypothesis for Aim 2 was refined to describe in greater detail the expected association between segment membership and objectively measured levels of physical activity. Together, the changes strengthened the contribution of the dissertation research to the literature.

1.2 Background

1.2.1 Aim 1 and 1A

Heterogeneity in workplace preferences and behavior can challenge practitioners seeking to develop chronic disease prevention interventions. Audience segmentation, a principle of social marketing, can aid in the development of targeted public health interventions (18). Though many studies have used person-centered quantitative analyses to segment children and adolescents by modifiable obesity-related behaviors such as physical activity (19), none have identified segments of adult office workers by types of activities in which they engage.

Adult physical activity is comprised of activities of daily living and exercise behaviors. Activities of daily living (e.g., walking, child care, gardening) are typically light-to-moderate intensity activities that individuals commonly perform over the course of a day. In contrast, exercise behaviors (e.g., running, aerobic training) are typically moderate-to-vigorous intensity activities that one intentionally performs to increase time spent in physical activity.

Recent studies show that some office-based occupations, such as office and administrative support workers, have low participation in physical activity that can contribute to the risk of weight gain (16,17). Office workers spend large periods of time in sedentary behavior during the work day, and relatively little time engaged in moderate or vigorous intensity activities in or outside of the workday (20,21). In addition, the reliance on desks for execution of job-related tasks mean that the need for light intensity physical activities, such as standing, is minimal.

Identifying demographic correlates of segment membership could aid development of interventions targeting adverse activity patterns associated with low amounts of objectively-measured time spent in physical activity (Aim 2) and high BMI (Aim 3). Workplace health practitioners may use Aim 1 findings to understand which demographically identified employee subgroups at the workplace may be likely to have an adverse activity pattern. In this way, practitioners targeting similar workplaces may consider physical activity programming that aligns with the activity preferences of potential segment members.

Based on the literature review in this dissertation, membership to physical activity segment is hypothesized to relate to age, sex, race/ethnicity, marital status, educational attainment, and children in the household. In addition to these previously researched characteristics, occupation is also hypothesized to correlate with segment membership. Research on occupation differences in obesity prevalence (16) and adherence to physical activity guidelines (17) suggests that activity patterns may differ across office occupations (e.g., administrative or clerical, customer service or sales). Overall, the aims seek to identify segments of office workers by types of physical activity behaviors (Aim 1), and examine demographic correlates of segment membership (Aim 1a).

1.2.2 Aim 2

Self-report physical activity instruments provide important contextual information on how individuals spend their time engaged in physical activity, which is valuable for intervention development. However, these instruments are also prone to social desirability bias (22) and measurement error that cautions against their use for estimation of absolute levels of physical activity (23,24). Therefore, measurement of absolute levels of physical activity (e.g., to ascertain adherence to physical activity guidelines) should instead be based on more objective and precise accelerometry methods when possible (23).

Aim 2 seeks to investigate differences in mean minutes of light and moderate-vigorous physical activity per week, measured by accelerometers, across the segments identified in Aim 1. Based on the literature review in this dissertation research, no studies have assessed the amount of physical activity engaged in by segments using an objective measure, such as accelerometers. By employing accelerometry data in this way, we can objectively examine whether patterns of physical activity are associated with greater or lesser time spent in light and/or moderate-vigorous physical activity than others. These findings help differentiate between segments that might exhibit similar patterns of behavior, but accrue significantly different time spent in light and/or moderate-vigorous physical activity.

1.2.3 Aim 3

The relationship between physical activity and weight status suggests that patterns of physical activity might be related to BMI (25–27). The literature review conducted for this dissertation found that there was a significant association between activity patterns and BMI in each study that investigated a relationship (28,29). Generally, segments with greater engagement in activities had lower BMI than segments with lesser engagement in activities. The sparse evidence base, however, suggests there is insufficient evidence to conclude that such a relationship is also found among office workers.

Knowledge of mean BMI differences across segments could assist with resource allocation of workplace health interventions. An employer may choose to focus enhanced intervention resources on employee groups with activity patterns associated with increased BMI. Findings from Aim 1a can be used to identify worker subgroups that are likely to have an activity pattern associated with higher BMI, and develop programs that are complementary to their interests.

1.2.4 Aim 4

In research and practice settings, self-report physical activity instruments are commonly used to assess physical activity. These instruments are often applied to populations in settings that are similar but distinct from the initial development sample. In this dissertation research, we examine the psychometric properties of a CHAMPS Physical Activity Questionnaire (30). Information on the predictive validity and test-retest reliability of the CHAMPS instrument among office workers adds to the relatively sparse literature on the psychometric properties of self-report physical activity questionnaires.

CHAPTER 2: LITERATURE REVIEW

2.1 Trends in Workplace Health Efforts: Increasing Focus on Chronic Disease

Physical, psychosocial, and organizational aspects of working conditions may affect workers' risk of chronic disease (3). The worksite may negatively affect employee health through physical job demands as well as through existing social norms of workers and organizational policies that discourage protective behaviors. Conversely, a worksite can foster healthy working conditions that respond to workers' physical, psychosocial, and organizational needs. Occupational safety and health (OSH) and workplace health promotion (i.e., workplace wellness) initiatives have been central to government-, employer-, and employee-led efforts to ameliorate work conditions and reduce incidence of disease.

Traditionally, OSH efforts focused exclusively on protecting workers from injury and illness directly attributable to occupational duties. The starting point of OSH can be traced back to industry efforts to protect against worker injury and illness in the mid-19th century (31). Growing industrialization led to a rapid increase in workers employed in hazardous worksites, often accompanied by few to no pre-existing health services in the surrounding community. The paucity of medical care in the workplace vicinity led to the hiring of company physicians and establishment of company-owned health clinics for care of injured and ill workers (31).

In the late 19th and early 20th century, state and federally mandated workplace safety efforts became more commonplace. During this period, an increasing number of states were legislating enhanced workplace safety protections to prevent occupational injuries among workers (32). The federal government largely played a limited role in workplace safety until the

Occupational Safety and Health Act was passed in 1970 (33). Besides establishing nationwide workplace safety standards and regulations, the Occupational Safety and Health Act of 1970 helped increase awareness of the importance of worker health, and lead to the broader workplace health promotion movement.

Workplace health promotion activities focus on worker health more holistically, with explicit emphasis on health behaviors that are less directly related to job performance such as smoking and diet. The perceived financial benefits of workplace health promotion effects on worker health helped to increase the spread of employer-led efforts in the 1980s and 1990s (31,34–36). Major companies, such as Johnson & Johnson and Du Pont, adopted health promotion strategies targeting lifestyle risk factors beyond the workplace (31,35,37). An emergent literature suggested that workplace health programs were a potentially cost-effective means of reducing health care costs, increasing worker productivity, and enhancing the employer’s image (31,38–40).

Despite the independent evolution of OSH and workplace health promotion efforts, they have become increasingly intertwined over time (1,41,42). Federal government led efforts to formally bridge OSH and workplace health promotion culminated in the Total Worker Health program in 2011 (43). The National Institute of Occupational Safety and Health created the Total Worker Health program to accelerate implementation of policies, programs, and practices that protect workers against occupational health and safety risks while advancing overall health and wellbeing (44). Though limited research is available, emerging evidence suggests that integrated Total Worker Health interventions are associated with beneficial effects on chronic disease risk behaviors (43).

The 2010 Affordable Care Act (ACA) has helped accelerate the implementation of workplace health programs targeting prevention of chronic disease such as obesity (45). ACA regulations offered employers greater latitude to increase employee participation in workplace health programs through financial incentives. Specifically, employers could provide a financial incentive for meeting a biometric-based goal (e.g., lower BMI), participating in an activity (e.g., aerobics classes), and/or completing health risk assessments (31). In particular, the ACA allowed employers to discount up to 30% of workers' health insurance premiums as an outcome-based financial incentive (46). For example, an employer could set a goal of 10% reduction in BMI in order for the employee to reduce their premium by up to 30%.

Despite hypothesized impacts of financial incentives on weight-related behavior, recent evidence suggests that financial incentives alone are insufficient to stimulate uptake of physical activity and other protective health behaviors (46,47). A 2016 analysis of obese participants in a workplace health program found that premium-based financial incentives – lacking any behavioral intervention component – had no effect on weight loss (46). These findings suggest that workplace physical activity programs that actively support employees through activities, policies, and environmental modifications may be more successful than programs that solely rely on financial incentives to induce behavior change (48).

2.2 Obesity Among United States Workers

The alarming prevalence of adult obesity in the United States is a long-standing public health problem (49,50). Obesity-related comorbidities such as type 2 diabetes, hypertension, and cardiovascular disease may adversely impact quality of life and life expectancy while substantially increasing healthcare expenditures over the life course (51–54). Recent epidemiological surveillance data (49) suggest that over one-third of adults were obese in 2011-2014 (36.5%), with significantly more women (38.3%) estimated to be affected than men

(34.3%). The prevalence of obesity appears to particularly burden non-Hispanic black (48.1%) and Hispanic (42.5%) adults compared to non-Hispanic white (34.5%) and non-Hispanic Asian (11.7%) adults. Socioeconomic status, as measured by educational attainment, appears associated with obesity prevalence as well (55).

The alarming burden of adult obesity in the United States is reflected in occupation-specific estimates of obesity prevalence. An analysis of 2010 National Health Interview Survey (NHIS) data classified over one-quarter (27.7%) of United States workers as obese (16). The prevalence of obesity was particularly pronounced in some typically office-based occupations, such as office and administrative support occupations, but lower or average in other office-based sales, science, and business occupations. Specifically, lower-skilled "office and administrative support" workers had increased prevalence of obesity (Prevalence Ratio (PR) = 1.12; 95% CI = 1.02, 1.22) as compared to all other occupation groups. Similarly lower-skilled "sales and related" occupations, however, had decreased prevalence of obesity (PR = 0.86, 95% CI = 0.76, 0.97) as compared to all other occupation groups. Higher-skilled typically office-based "life, physical, and social sciences," "business and financial operations," "computer and mathematical," and "management" were not associated with either increased or decreased prevalence of obesity in fully adjusted models.

The increased prevalence of obesity among office and administrative support workers suggests that shared work conditions may foster weight gain. Office and administrative support occupations generally involve prolonged sitting and negligible amounts of physical activity to complete tasks. Because of their low-status, these workers may not have the ability to break for walking or standing unrelated to the task at hand, or otherwise integrate physical activity into their work routine. Over three-quarters of office and administrative support workers in 2010 failed to adhere to national physical activity guidelines, controlling for demographic characteristics and other risk factors (17). Limited occupational physical activity is not exclusive to office and administrative support workers, however, but part of a long-term trend in declining occupational physical activity levels (56).

2.3 Physical Activity Among United States Workers

Over the past century, United States adults have increasingly shifted away from physically demanding occupations (e.g., manufacturing) toward sedentary office-based occupations (57). This shift has been associated with a drastic reduction in occupational physical activity and concomitant increase in the amount of sedentary behavior attributed to one's occupational duties (56). Some research has suggested that workers increase time spent in leisure time physical activity to offset occupational inactivity (58), though more studies suggest there is a positive relationship between low levels of occupational activity and low levels of leisure-time physical activity, or no relationship at all (59–62). According to 1988-2010 Behavioral Risk Factor Surveillance System data, adults' participation in leisure-time physical activity only slightly increased between 1988-2010, while approximately one-quarter of adults reported no leisure-time physical activity at all in 2010 (63).

Time spent in physical activity may accrue from activities of daily living and exercise behaviors of light, moderate, or vigorous intensity. Activities of daily living may involve light- or moderate-intensity behaviors that are not primarily planned for increasing one's physical activity, including tasks involved with gardening, housework, and child care (64). In contrast, exercise behaviors are usually planned with the intention to result in increased physical activity, and involve moderate-vigorous activities such as aerobics, running, and cycling (64). Though the intensity of daily living activities is generally less than that of exercise behaviors, activities of daily living are arguably a greater source of population-wide physical activity.

2.4 Impact of Physical Activity on Adult Weight

A large body of research suggests that time spent in physical activity can spur short-term weight loss and protect against long-term weight gain among adults (25–27,65). The biological plausibility of a relationship between physical activity and weight is best understood through one's energy balance. A population-wide persistent positive energy balance – defined as energy intake exceeding energy expenditure – has been suggested as a key driver of the obesity epidemic (66). Indeed, a small 30 kilojoule imbalance has been said to explain the average population weight gain (67). To maintain energy balance, one's energy expenditure must align with his/her energy intake.

Gradual modification of both energy intake and energy expenditure is recommended to achieve energy balance. However, some might find energy expenditure more easily modifiable than energy intake, and vice-versa. Depending on one's weight status, preferences and other characteristics, increasing one's level of physical activity might be easier than restricting calorie intake (68,69). In these cases, research suggests that increased participation in physical activity may *potentially* compensate for some excess calorie intake (70), though increased calorie intake as a consequence of greater involvement in physical activity is also possible (71). Ultimately, the simultaneous reduction of calorie intake and increase in calorie expenditure is best for achieving and maintaining a healthy weight.

Beyond physical activity effects on weight change, physical activity may confer substantial health benefits that prevent chronic disease. Physical activity has been shown to reduce risk of metabolic syndrome (72) and type 2 diabetes (73), independent of weight loss. Indeed, the beneficial effect of physical activity on levels of total and visceral fat and other weight-related chronic disease risk factors, independent of weight loss, underscores its importance among overweight and obese individuals (74–77).

The research on physical activity and weight has primarily centered on moderate-vigorous intensity activity or total activity, with relatively little focus on light physical activity. Emerging research suggests that light physical activity has meaningful impact on weight gain, though the relationship may depend on whether the activity is low-light "static" (e.g., standing) or high-light "dynamic" (e.g. light house cleaning, food preparation) (78). A recent study of 2003–2004 and 2005–2006 National Health and Nutrition Examination Survey (NHANES) data found that high-light and low-light physical activity were both negatively associated with waist circumference, though only high-light physical activity was inversely associated with BMI (78). A study of older adults found that accelerometer-measured time spent in both high-light and low-light activity were inversely associated with BMI in the minimally adjusted model, though the high-light activity association was null in the fully adjusted model (79). Given the strong inverse correlation between light physical activity and sedentary time (80), light physical activity may supplement moderate-vigorous physical activity as a promising target for weight gain prevention interventions.

2.5 The Role and Effectiveness of Workplace Physical Activity Interventions: Individual-focused and Organization-wide Approaches

2.5.1 Background

In light of the protective effects of physical activity on weight and other health outcomes (26,74), a wide variety of workplace physical activity interventions have been developed. These interventions span from individual-focused intensive aerobic exercise training interventions to organization-wide changes in workplace built environment and employee policies impacting physical activity and sedentary behavior. Individual-focused intervention approaches typically center on individual physical activity counseling (81,82) and exercise programs (83–85) that actively recruit workers for participation in behavior change processes that result in increased physical activity. In contrast, organization-wide approaches may center on worksite policy and environmental changes that more passively encourage increased performance of physical activity (86).

A number of studies have explored the effects of workplace physical activity interventions on levels of physical activity and weight, along with intervention characteristics that moderate intervention-outcome associations. Systematic reviews have found that worksite physical activity interventions are associated with improvement, though modest, in levels of physical activity and weight (87–90). A meta-analysis examining potential moderators of workplace physical activity intervention-outcome associations found that workplace participation in design of the intervention (vs. designed by individuals not employed by the worksite), participation during paid working hours (vs. unpaid working hours), and participation of employee interventionists (vs. outside interventionists) resulted in greater effects on anthropometrics such as BMI (88). Another meta-analysis found that intensive workplace health programs (including physical activity) that actively engage with employees on a weekly basis were four times more effective in changing the targeted behavior than interventions without weekly contacts (84,91). The findings from meta-analyses agree with reviews of physical activity interventions that suggest intensive, tailored individual-focused approaches that actively engage workers in activities are particularly effective in modifying levels of physical activity (92).

2.5.2 Individual-focused Workplace Physical Activity Approaches

Individual-focused workplace physical activity approaches are commonly grouped into exercise training and counseling/support interventions, though many hybrid versions exist as well (93). The exercise training interventions are commonly based on organized aerobics and muscle strengthening sessions that engage workers in physical activity. These interventions help workers actively participating in exercise sessions by overcoming barriers including lack of skills, time, and resource. The counseling/support interventions consist of a variety of counseling, coaching, and motivational interviewing programs that seek to identify and eliminate barriers to physical activity in individual and group settings. These interventions are often explicitly grounded in health behavior theories such as the Social Cognitive Theory and the Transtheoretical Model to encourage behavior change, without necessarily relying on an exercise training component that ensures workers are exercising (93).

Studies suggest that individual-focused exercise training and counseling/support interventions may effectively increase levels of physical activity among workers (93). A review of workplace physical activity interventions identified 6 exercise/training interventions and 13 counseling/support interventions (93). The majority of exercise/training and counseling/support interventions used high-quality randomized controlled trial study designs and targeted workers in largely sedentary workplaces (e.g., university staff, health care workers). The review found that the majority of exercise/training (4 out of 6) and counseling/support (10 out of 13) interventions were associated with meaningful increases in levels of physical activity as measured by steps, minutes of physical activity, and frequency of exercise sessions.

Despite their efficacy, individual-focused interventions face challenges in the recruitment and retention of participants. Research on individual-focused workplace physical activity interventions has found that recruitment rates are often suboptimal (94,95), with one review showing a 44% median recruitment rate (96). Furthermore, those that enroll in workplace physical activity interventions tend to be already active and motivated to exercise (10). Among those enrolled, the retention of participants throughout the program may be difficult. Malik et al. found that the attrition of participants in exercise training and counseling/support interventions ranged 9.2-10% and 1-65%, respectively (93). The varying rates of participant attrition observed in individual-focused physical activity interventions suggest difficulties in maintaining participant engagement (93).

The little research that has explored determinants of participation in individual-focused workplace physical activity interventions suggests higher perceived barriers to physical activity and lower perceived benefits of physical activity are salient factors of non-participation among workers (95). A qualitative study of barriers and enabling factors of participation in worksite physical activity programs identified time constraints, lack of knowledge, lack of instruction, fear, and self-consciousness about physical activity as barriers shared among blue- and white-collar workers (97). Another qualitative study of low physical activity workers in the United Kingdom that refused to participate in a workplace physical activity intervention found that poor self-efficacy for exercise, negative attitudes toward physical activity, time constraints, lack of energy, environmental barriers, and negative perception of the intervention and workplace physical activity culture were primary factors of non-participation (95). The success of individual-focused interventions may therefore hinge on organization-wide interventions that help nurture a workplace culture that is supportive of employee efforts to be physically active.

2.5.3 Organization-wide Workplace Physical Activity Approaches

Organization-wide workplace physical activity approaches complement individual-focused approaches to support worker engagement in physical activity. These interventions may use worksite policies and build infrastructure and support to encourage exercise or activity in and outside the workplace, and nurture positive social norms regarding physical activity. A workplace may utilize one or more components including policies and environmental modifications that encourage adoption of intra-office health communications promoting workplace physical activity (e.g., stair utilization, walking meetings) (93), subsidization of employee gym use, allowance for sit-stand/treadmill desks, and permission of employee breaks for physical activity (86,93,98). By focusing on organizational policy and environmental characteristics influencing employee physical activity, these interventions may succeed in reaching employees that are otherwise unable to participate and adhere to individual-focused interventions.

Organization-wide policy interventions aim to alter employer-driven rules and guidelines that impact physical activity. Common workplace physical activity policies provide employees with protected time (paid or unpaid) to exercise, financial incentives for active commuting to work (e.g., walking, cycling) and gym membership, incorporation of physical activity promotion messages in intra-office communication, and/or encourage walking meetings (98). Through supportive policies, employers modify the unseen structural conditions of work to ease employee incorporation of physical activity in daily life.

Organization-wide environmental interventions modify workplace infrastructure and environmental conditions to facilitate engagement in physical activity. An intervention may decorate common areas (e.g., stairwells) with physical activity promotion materials, build walking paths, provide standing or treadmill desks, and/or offer exercise-related facilities. In tandem with policy interventions, organization-wide environmental interventions influence unintentional and intentional engagement in physical activity, and may particularly benefit workers otherwise reluctant to participate in individual-focused interventions.

The evidence base on organization-wide workplace physical activity interventions is more limited than the evidence base for individual-focused interventions, but overwhelmingly suggests that policy and environmental changes may positively affect physical activity among workers. Cross-sectional studies of workplace physical activity policy and environment interventions in United States metropolitan regions (98), Midwestern communities (99), and North Carolina (100) demonstrate a positive, though inconsistent, effect of organization-wide interventions on employee physical activity. A cross-sectional study of employed adults in three United States metropolitan regions (n = 1313) found that higher number of workplace physical activity policy and environmental strategies implemented was positively associated with higher levels of accelerometer-measured moderate-vigorous physical activity and self-reported recreational physical activity (98). Interestingly, the number of workplace physical activity policy and environment strategies was also positively related to higher total sedentary behavior and negatively related with job-related physical activity. These inconsistent findings may suggest that sedentary workplaces were more likely to institute these changes, or reflect the influence of confounding.

A cross-sectional study of worksite policies and environmental changes in Midwestern communities (n = 977) found positive, linear relationships between the number of workplace policy and environmental interventions and the likelihood of adults meeting national guidelines for physical activity, as measured by self-report (99). The researchers found that associations varied when separately assessing effects of "structured activity policies and environments" (e.g., subsidized health club membership, facilities, sports teams) and "non-structured activity policies and environments" (e.g., resource materials, breaks for physical activity, financial incentives), though no clear pattern favoring structured vs. non-structured interventions emerged.

In contrast to the studies of employed adults in Midwestern and metropolitan settings showing positive effects on total physical activity, a cross-sectional study of employed adults in North Carolina (n = 987) found that workplace physical activity policy and environment interventions were associated with improved physical activity only during work breaks. In adjusted models, the number of policy and environment interventions (including paid time for exercise, onsite exercise facilities, and subsidy of health club membership) was monotonically associated with increased odds of reporting engagement in at least 10 minutes of physical activity during "lunch or other regular work breaks" in a usual week (100). There were no significant effects of workplace physical activity policy and environment interventions on self-reported total leisure-time physical activity (both in and outside the workplace) in the past month.

The few studies of adults that report workplace implementation of physical activity policy and environment interventions suggest that employees may engage in greater physical activity as a consequence. However, there is a paucity of evidence regarding the role of workplace type or occupation in organization-wide intervention effectiveness, and whether related workplace characteristics may moderate the impact of organization-wide interventions on employee physical activity. Regardless, the preponderance of methodologically weak cross-sectional study designs limit our understanding of how organization-wide interventions may impact worker physical activity.

2.5.4 Integrating Individual-focused and Organization-wide Approaches in Comprehensive Workplace Physical Activity Programs

Comprehensive workplace physical activity programs that complement individual-focused interventions with organization-wide policy and environment interventions may optimally address the diversity of worker physical activity needs and preferences (10). While individual-focused interventions require active recruitment and sustained participation of workers, organization-wide interventions change the structural conditions of employment to nudge all employees toward greater physical activity. Individual-focused interventions hinge on worker self-efficacy and attitudes toward physical activity to participate, and may struggle to enroll and maintain workers that require intervention the most. Individual-focused interventions and organizational supports for physical activity in the workplace may act in tandem to maximize intervention effects on employee physical activity.

The disparate reach of individual-focused and organization-wide interventions demonstrates the importance of integrating individual-focused and organization-wide intervention approaches in a comprehensive workplace physical activity program. Organization-wide interventions may act to passively increase physical activity among workers who otherwise would not participate in an individual-focused physical activity intervention, and, at the same time, may positively impact workplace norms regarding physical activity. Tailored individual-focused intervention targeted to workers with adverse patterns of physical activity will help ensure workers most at need are adequately addressed.

Characteristics of employee participation in individual-focused and organization-wide interventions may strongly affect employer return-on-investment from a comprehensive workplace physical activity program. Research suggests that employers may receive a financial return on physical activity interventions through gains in productivity and reductions in medical claims costs (101,102). A review of physical activity intervention cost-effectiveness studies found that environmental approaches may have greater cost-effectiveness than individually targeted behavioral approaches, though only one environmental intervention was considered (103).

The precise targeting of workplace physical activity intervention approaches to employee segments may ensure intervention resources are efficiently deployed. Practitioners may prefer targeting higher cost individual-focused approaches to employee segments that are at greatest risk of inactivity-related morbidity, rather than highly active employees who are more likely to participate but benefit to a lesser extent (10). Lower cost organization-wide approaches may then be used to support highly active employees in sustaining and improving engagement in physical activity. The utility of audience segmentation, a principle of social marketing, in public health interventions is well observed in the literature.

2.6 Use of Audience Segmentation in Public Health Interventions

A social marketing approach is commonly applied to individual-focused public health interventions targeting health behaviors such as physical activity (18,104–106). Definitions of social marketing vary, but key phases of a social marketing intervention include consumer research, audience segmentation, and marketing strategies (104,107) (Figure 2.1). In consumer research (also known as formative research in the social marketing literature), investigators seek to understand the barriers and facilitators that those in the target population might encounter in adopting the behavior. The process of audience segmentation harnesses those data to segment the population into distinct subgroups. Finally, the four Ps of the marketing mix (i.e., price, place, promotion, and product) are used to develop a marketing strategy tailored to one or multiple segments identified.

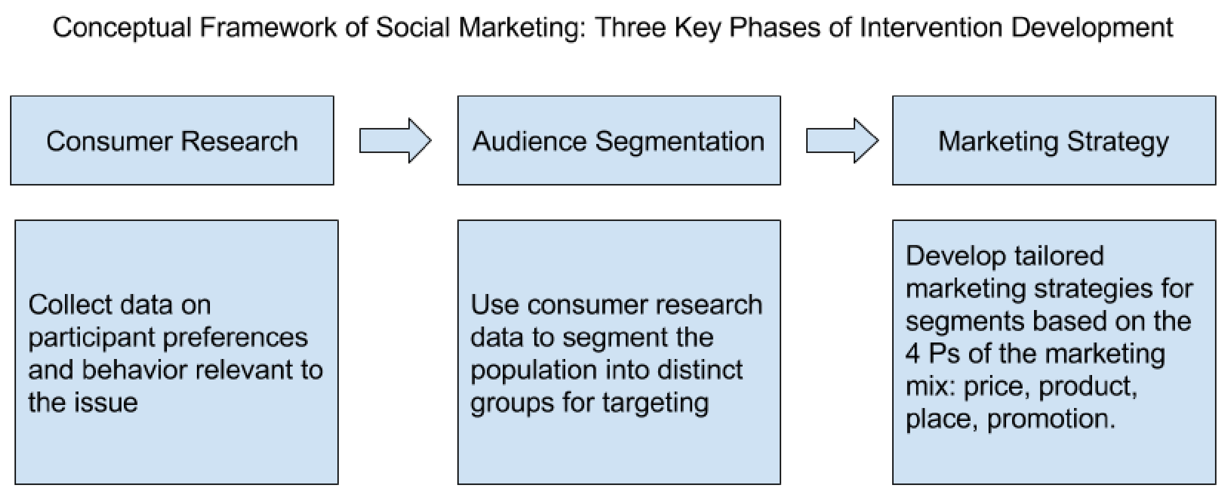

Figure 2.1: Key Phases of Social Marketing Intervention Development: Consumer Research, Audience Segmentation, Marketing Strategy

The methodology used to segment the population can strongly influence the segments identified and the resulting intervention. The segmentation of audience can follow either an a priori or post hoc approach (18). An a priori approach refers to the segmentation of individuals by one or more pre-defined characteristics. For instance, an investigator may choose to segment a population by gender due to behavioral differences found between genders. The intervention would then design separate health communication approaches and messages for females and males. In contrast, post-hoc approaches use quantitative methods to empirically segment populations according to multiple variables of interest in a dataset. Consequently, post-hoc approaches may leverage a host of data sources (e.g., demographics, biometrics, and health questionnaires) to extract population segments that would otherwise be unknown and unconsidered via an a priori segmentation approach.

The analytic methods commonly applied in post-hoc segmentation analyses are finite mixture modeling (e.g., latent class analysis, latent profile analysis) and cluster analysis. In practice, an investigator collects quantitative data on a wide range of demographic and psychosocial variables that are relevant to the behavior of interest, and implements a finite mixture modeling analysis to identify segments (also known as classes, typologies, or latent subgroups). Post-hoc finite mixture modeling approaches are generally favored over a priori approaches because of the ability to make statistical inferences and, importantly, identify the potential for subgroups that are not intuitively obvious.

Post-hoc segmentation approaches may identify novel segments that represent better opportunities for intervention than those commonly identified in a priori approaches. The typical usage of pre-defined demographic characteristics for a priori segmentation, such as age and race/ethnicity, treats those within strata as relatively homogeneous in health behavior, disease risk, and other relevant characteristics while much heterogeneity exists. Therefore, interventions that define segments on an a priori basis may develop inadequately tailored interventions of limited effectiveness. Post-hoc segmentation approaches that leverage multiple data sources to reveal segments within populations may clarify intervention targets and support decision-making.

2.7 Segmentation of Physical Activity Behavior Among Adults: Literature Review

The following section reviews epidemiological and intervention research studies that have applied quantitative methods to segment adult populations by physical activity behavior (i.e. identify patterns or typologies). For inclusion, the articles needed to use a person-centered quantitative approach, such as cluster analysis or finite mixture modeling (e.g., latent class analysis and latent profile analysis). Additional inclusion criteria were: more than one indicator variable of a physical activity type (e.g., walking, running), study participants not younger than 18 years of age, and publication before July 6, 2016. This search strategy, while not systematic, is similar to other reviews of segmentation studies (19), and designed to provide a scoping review of the research.

The scholarly research databases searched to identify articles were Google Scholar and PubMed. The references of included articles were also inspected. The search terms and phrases used were: adults, physical activity, exercise, cluster analysis, latent class analysis, latent profile analysis, and finite mixture modeling. The following data were extracted from included studies: authorship and publication year, study design, study sample, sample size, age range, physical activity variables, physical activity assessment method, number of classes (i.e., profiles or clusters) identified, description of classes identified, investigated associations between classes and demographics, investigated associations between classes and anthropometrics, and investigated associations between classes and objectively-measured physical activity levels.

A total of four studies were identified (see Appendix A). All studies employed finite mixture modeling such as latent class analysis and latent profile analysis. The sample sizes were large (n = 3,293–5,362) which suggests that each study had sufficient power to recover the true latent class structure (108). All studies were conducted either in the United States (n = 3) (28,29,109) or United Kingdom (n = 1) (110). The United States studies consisted of older populations, while the United Kingdom study was middle-aged (age range: 31–53). Three of the studies used self-reported measures of physical activity with explicit information on validity and reliability, and measured a similar variety of physical activities spanning activities of daily life and exercise (28,29,110). The remaining study (109) focused on a wider array of social, emotional, and interpersonal activities among older individuals. The following paragraphs summarize key study characteristics and findings of each study.

Mooney et al. sought to identify and characterize activity patterns among older adults to examine associations with health outcomes and inform intervention targeting (28). The probability-based sample consisted of cross-sectional data from 3,497 adults aged 69–75 living in New York City, NY in 2011. To identify activity patterns, an interviewer administered the Physical Activity for the Elderly (PASE) instrument to assess usual engagement in activities of daily living and exercise behaviors. In general, each activity was treated as a separate dichotomous indicator variable (e.g., ever engaged vs. never engaged) or combined with other activities to define activity patterns. Additional self-reported demographic and health status data were collected to describe members of each activity pattern through associations with demographic and health characteristics (e.g., BMI). Using finite mixture modeling, Mooney et al. identified five activity patterns that were labeled as: Least active (i.e., little to no activities reported), Walker, Domestic/gardening, Athletic, Domestic/gardening athletic. Demographic findings suggested that higher income, education, self-rated health status, and single family housing (vs. apartment housing) were associated with membership in more active classes (e.g., Athletic, Domestic/gardening athletic), as compared to less active classes (e.g., Least active, Walker). The typology distributions of BMI followed a pattern where BMI increased as the typology activity level decreased. The investigators concluded that more research was needed to understand compositional differences in activity pattern membership, and how activity patterns relate to health outcomes in this population.

Morrow-Howell et al. sought to identify and describe activity patterns among older adults in the United States (109). The data were from 2008, 2009, and 2010 years of the nationally representative Health and Retirement Study, which measures characteristics of older adults in the United States (n = 4,593). The authors used items from the 2009 Consumption and Activities

Mail Survey module to measure the types and amount of activities that older adults usually perform, ranging from activities of daily living (e.g., walking, house cleaning), exercise, and a more broad set of socio-emotional and interpersonal behaviors (e.g. managing medical conditions, showing affection, phone/letter/email, helping others). The activity responses were then grouped into activity domains (e.g., personal leisure, physical exercise, interpersonal exchange/helping others) and used as trichotomous indicator variables to define the activity patterns (i.e., classifying variables). Data from 2008 and 2010 years were used to assess antecedents (e.g., demographic, behavioral, health) and wellbeing outcomes (e.g., self-rated health status and depressive symptoms) of activity patterns. Using finite mixture modeling, the authors identified five activity patterns that were labeled as: Low Activity, Moderate Activity, High Activity, Working, and Physically Active. Non-white individuals were less likely to belong to more active typologies than the least active typology, compared to white individuals. Age was negatively associated with membership to more active typologies, compared to the least active typology. Income and education were positively associated with membership to more active typologies than the least active typology. The authors concluded that the Low Activity pattern reflected older adults that were more vulnerable on socioeconomic and health characteristics than High Activity members that reflect socioeconomically fortunate busy retirees.

Cheung et al. sought to identify and describe activity patterns to develop information that could support health care providers in counseling patients regarding physical activity (29). Data were from the probability-based Northern Manhattan Study, a prospective cohort study representative of adults located in the Northern Manhattan region of New York City, NY. The authors used baseline data on physical activity collected from adapted National Health Interview Survey items. The items measured the type and frequency of activities of daily living and exercise behaviors usually performed. Additional demographic and health status information were collected to evaluate activity pattern associations with demographic characteristics and cardiovascular disease risk factors. In contrast to the analytical approach shared by Mooney et al. and Morrow-Howell et al. of using individual or grouped activity measures as indicator variables defining the activity pattern, Cheung et al. used the items to generate four composite variables that described characteristics of overall physical activity: average minutes per physical activity session, frequency of physical activity per week, total calorie expenditure of physical activity per week, and number of activity types. Cheung et al. identified and labeled six classes: No Activity, Rare Activity, Active Weekly, Active Every Other Day, Active Daily, Highly Active. The lower activity classes were characterized by high proportions of females, Hispanic individuals, and non-high school graduates. Meanwhile, the composition of higher activity classes was less markedly influenced by gender and race/ethnicity. The influence of smoking status, moderate alcohol consumption, and social support varied across classes. Prevalence of obesity significantly differed across classes; those in the two most physically active classes had reduced odds of obesity, compared to the least physically active class. The investigators concluded that frequency of activities and number of activity types were the primary factors differentiating activity patterns, and relevant demographic findings could help inform patient counseling.

Silverwood et al. sought to identify and describe longitudinal patterns of physical activity in mid-adulthood (110). Data were from the probability-based birth cohort study, 1946 National Survey of Health and Development, in the United Kingdom. At multiple time points between 31 and 53 years of age, participants reported usual physical activity using various measures of physical activity, including the Minnesota Leisure Time Physical Activity Questionnaire. Information on the other measures was not provided. The investigators used cross-sectional and longitudinal data to conduct separate sex-specific latent class analyses for walking, cycling, and leisure-time physical activity. The walking and cycling analyses revealed two activity patterns corresponding to high and low levels, while the leisure-time physical activity analysis revealed three activity patterns labeled: Low Activity, Sports and Leisure Activity, and Gardening and Do-it-yourself Activities. No associations of activity patterns with sociodemographic or health characteristics were explored. The investigators concluded that multiple longitudinal patterns of physical activity are evident, and further research is needed to link patterns with health outcomes.

In conclusion, the literature review findings highlight the gaps filled by the dissertation research. The majority of studies were focused on older individuals rather than younger and middle-aged individuals that primarily constitute the full-time worker population in the United States. Of the two studies that examined associations with BMI (28,29), both found statistically significant results. No studies examined associations between activity pattern membership and objectively measured levels of physical activity, thereby limiting knowledge of the validity and uniqueness of activity patterns.

The dissertation research was designed to fill identified gaps in the evidence base to characterize activity patterns among office workers and inform cost-efficient resource allocation of workplace physical activity programs. Using a valid and reliable measure of self-reported physical activity, office workers are segmented by types of activity behaviors usually engaged in, encompassing activities of daily living and exercise behaviors. Knowledge of worker activity patterns will inform development of workplace physical activity interventions that complement existing behavior.

Accelerometer-measured physical activity and BMI are used to examine the relationship of segment membership with objective health measures. Demographic characteristics associated with segment membership are examined to understand potential correlates of segment membership in an office workplace.

CHAPTER 3: DISSERTATION CONCEPTUAL MODEL AND STUDY SAMPLE

3.1 Conceptual Model

The dissertation research seeks to identify and describe segments of office workers by types of physical activity. Figure 3.1 depicts the overall conceptual model of the dissertation research. For Aim 1, we use activities of daily living and exercise behaviors to identify segments of office workers. For Aim 1a, we investigate whether segment membership is associated with demographic characteristics: age, sex, race/ethnicity, marital status, educational attainment, children in household, and occupation. For Aim 2, we examine whether segments differ in mean minutes of light and moderate-vigorous physical activity per week as assessed by accelerometry. For Aim 3, we assess whether segments by mean BMI. For Aim 4, we examine the predictive validity and test-retest reliability of the self-report physical activity instrument used to define the segments of office worker by activity patterns.

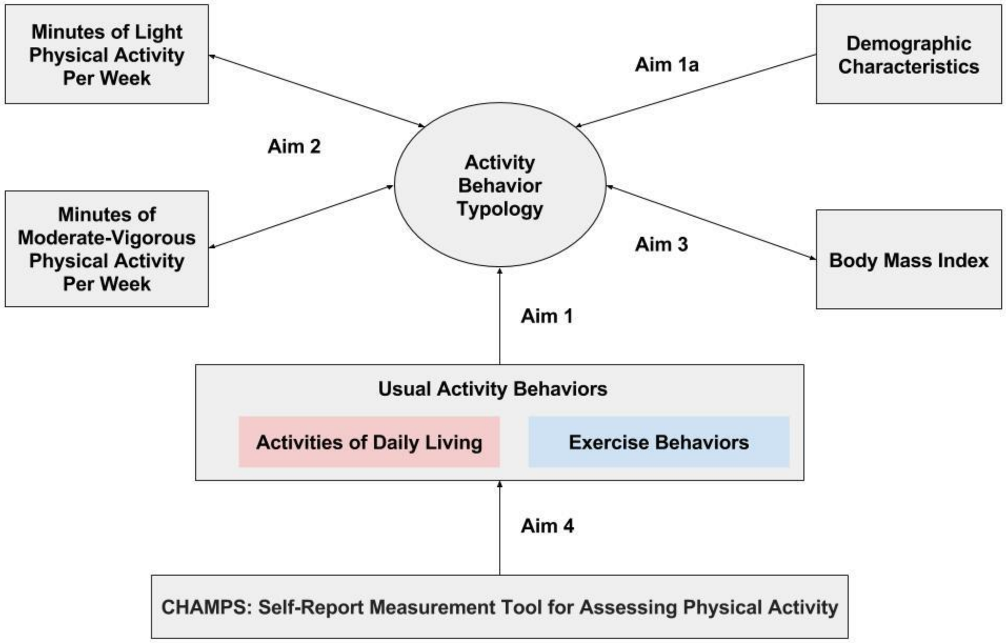

Figure 3.1: Overall Conceptual Model of Dissertation Research

3.2 Overview of Aims and Hypotheses

Aim 1:

Identify segments of office workers by activities of daily living and exercise behaviors performed. Latent class analysis is used to identify segments (i.e., latent classes or typologies) of office workers according to self-reported activities of daily living and exercise behaviors.

H1: Consistent with previous person-centered analyses of physical activity among adults, we hypothesize that there will be 2–4 unique segments of office workers differentiated by engagement in activities of daily living and exercise behaviors.

Aim 1a:

Examine demographic correlates of segment membership. Logistic regression is used to examine correlates of segment membership including age, sex, race/ethnicity, marital status, educational attainment, children in household, and occupation.

H1a: We hypothesize that segments will differ by age, sex, race/ethnicity, marital status, educational attainment, children in household, and occupation.

Aim 2:

Examine whether segments of office workers differ in mean minutes of light and moderate-vigorous physical activity per week. A latent class distal outcome approach is used to determine whether segments differ in accelerometer-measured mean minutes of light and moderate-vigorous physical activity per week, controlling for demographic characteristics.

H2: We hypothesize that segments self-reporting a greater number of activities of daily living and exercise behaviors usually engaged will be associated with more objectively measured weekly minutes of light and moderate-vigorous physical activity, on average, than segments reporting lesser number of activities of daily living and exercise behaviors usually engaged.

Aim 3:

Examine whether segments of office workers differ in mean BMI. A latent class distal outcome approach is used to determine whether segments differ in mean BMI, controlling for demographic characteristics.

H3: We hypothesize that segments will differ in mean BMI.

Aim 4:

Investigate the predictive validity and test-rest reliability of a self-report physical activity instrument among office workers. Overall and demographic subgroup-specific Spearman correlations are calculated to assess the magnitude of correlations.

H4a: For overall predictive validity, we hypothesize that levels of physical activity estimated by CHAMPS, expressed as number of moderate-vigorous activities and weekly minutes of moderate-vigorous activity, will predict accelerometer-measured minutes of weekly moderate-vigorous activity in both short- and long-term periods.

H4b: For overall test-retest reliability, we hypothesize that levels of physical activity as assessed by CHAMPS at two timepoints will be significantly correlated.

H4c: For stratified analyses, we hypothesize that predictive validity and test-retest correlations will be stronger among younger (vs. older), men (vs. women), and obese (vs. normal and overweight) adults, as shown in similar research (111,112).

3.3 Parent Study

Data are from the 12-month baseline phase of the National Cancer Institute R01 trial, *Effects of Physical Activity Calorie Expenditure (PACE) Food Labeling* (5R01CA184473), in 2015 (15). The study evaluated the effectiveness of PACE food labeling on meal calorie purchasing and physical activity levels among worksite cafeteria patrons at a major health insurer in North Carolina. The aims of the PACE trial are fourfold and are to examine the effect of the PACE labels on:

1) average purchased calories per meal among regular worksite cafeteria patrons;

2) accelerometer-measured minutes of moderate and vigorous physical activity and gym use frequency among regular worksite cafeteria patrons;

3) self-reported physical activity and caloric intake, and biometric outcomes among regular worksite cafeteria patrons;

4) average weekly calories from selected high popularity, high calorie foods purchased in cafeterias and overall gym use frequency.

The PACE trial was conducted over a 24-month period, including a 12-month baseline phase and 12-month intervention phase, using a two-arm study design. During the 12-month baseline phase, participant data on calorie purchasing and physical activity were collected at regular intervals across three worksite cafeterias. At the conclusion of the baseline phase, a 12-month intervention phase immediately began, in which measurements continued on a similar schedule. The PACE labeling was assigned to “intervention” cafeteria menus and calorie labeling assigned to “control” cafeteria menus for the yearlong period.

During the baseline phase, the study was conducted in three worksites of a major health insurer in North Carolina located in Durham, Chapel Hill, and Winston-Salem. The company employed approximately 3600 workers across these locations at the time of recruitment. A cohort was recruited from each worksite through email, company newsletter, cafeteria signage, and in-person recruitment tables. Full-time employees and contract workers were eligible for the PACE study if they were at least 18 years of age and reported eating lunch or were willing to eat lunch from the cafeteria at least three times per week. The study population was comprised of workers in administrative/clerical, customer service/sales, financial/technical, environmental/food services and management occupations.

3.4 Data Collection

The dissertation research uses baseline data collected prior to intervention exposure over a 12-month period between March 2015 and March 2016 (Table 3.1). The parent study collected data from a demographics questionnaire, self-reported physical activity questionnaire, hip-worn accelerometers, employer's biometric screening program (e.g., weight and height), and other instruments. Measures were administered at enrollment and four timepoints. Each timepoint was spaced approximately three months apart. The data collection schedule is described below, with further measurement details included in chapters where such measures were employed.

At enrollment, participants completed self-administered demographic questionnaire. The demographics questionnaire collected information on a range of variables including age, race/ethnicity, sex, educational attainment, and marital status.

At timepoints 1 and 3, all participants were invited to complete a version of the Community Health Activity Model Program for Seniors (CHAMPS) physical activity questionnaire (30,113). No financial incentives were provided for completing the questionnaires, though financial incentives were available for other study measurements (i.e., food photo taking and accelerometry). The CHAMPS questionnaire is described further in the Measures section.

At timepoints 2 and 4, all participants were invited to wear an accelerometer for seven consecutive days. An Actigraph wGT3X-BT accelerometer was provided for participants to wear over the right side of the hip throughout the day and night except for showering. A pencil-and-paper log was provided for participants to record the dates, bed times, and wake times. In addition, participants were invited to record the date, start time, end time, and intensity level of activities that are not captured accurately by the accelerometer (e.g., bicycling, swimming, yoga). The participants were offered $10 in cash to wear the accelerometer for the weeklong period.

Biometric data were collected independent from the study. During January 2015 – September 2015, a trained technician from the employer's health screening contractor measured employee weight, height, triglycerides, blood pressure, cholesterol, and presence of cotinine. The employer routinely collects annual biometric measurements from permanent employees that participate in the employer’s health screening program. However, contract workers, non-consenting permanent employees, and those employed after the annual biometric exam period are ineligible for participation, and therefore data on these employees are missing.

Table 3.1: Data Collection Timeline of Measures in Dissertation Research (March 2015 – March 2016)

	Enrollment*	Baseline Year			
Timepoint		1	2	3	4
Approximate month of measurement		3 mo	6 mo	9 mo	12 mo
Demographics and Medical History					
Self-Report Physical Activity Questionnaire					
Accelerometer Measurement					
*Enrollment was open and rolling throughout baseline year. The majority of participants enrolled prior to baseline, however, some participants were not enrolled at early measurement time points.					
Note: Biometrics (e.g., weight, height) collected independently from study during January 2015 – September 2015.					

CHAPTER 4: IDENTIFYING AND DESCRIBING SEGMENTS OF OFFICE WORKERS BY ACTIVITY PATTERNS: ASSOCIATIONS WITH DEMOGRAPHIC CHARACTERISTICS AND OBJECTIVELY MEASURED PHYSICAL ACTIVITY

4.1 Introduction

Promotion of physical activity is a key public health strategy for prevention of chronic disease (75). The health benefits of physical activity accrue over time to reduce incidence of obesity, type 2 diabetes, and other activity-related chronic disease (26). Despite the various protective effects of physical activity, many adults in the United States fail to engage in recommended levels of physical activity (114,115). The 2008 Physical Activity Guidelines for Americans recommend that adults engage in 150 minutes per week of moderate-intensity, 75 minutes of vigorous intensity, or a combination of moderate-vigorous physical activity for 150 minutes per week (11). However, recent self-reported data from the National Health Interview Study (NHIS) in 2016 suggests that only about half of adults meet aerobic guidelines (114,116), and accelerometer-based estimates suggest that the prevalence of adherence to aerobic guidelines might be as low as 9.6% nationally (115).

Because physical activity encompasses activities of daily living (e.g., housework, child care) as well as exercise behavior (e.g., cycling, running), there are numerous ways that adults can achieve recommended levels of physical activity (11). Occupational physical activity also counts toward meeting physical activity guidelines, however, adults are increasingly employed in largely sedentary office-based occupations that require minimal physical activity. Indeed, the proportion of adults in the United States employed in a median moderate-intensity occupation (defined as a median intensity level of 3.0–5.9 METs) declined from 48% in 1960 to 20% in 2008 (56).

Office workers in largely sedentary occupations spend long, uninterrupted periods of time sitting while engaged in deskbound activities (20,21). Reliance on desks for execution of job-related tasks means that the opportunity for engaging in light (e.g., standing) and moderate-vigorous (e.g., brisk walking) intensity physical activity is usually minimal. In addition, research suggests that individuals employed in sedentary occupations may also opt for more sedentary activities in their leisure time (20). Approximately three-quarters of adults in office and administrative support occupations are estimated to engage in insufficient physical activity during leisure-time to meet federal guidelines (17).

Given the burden of insufficient physical activity, a variety of workplace physical activity interventions have been developed to enhance levels of physical activity and prevent chronic disease (3,87,88,93,117). These interventions span from individual-focused intensive aerobic exercise training interventions to organization-wide changes in built environment (e.g., walking paths) and policies (e.g., protected time for physical activity). Systematic reviews have found that worksite physical activity interventions are associated with improvement, though modest, in levels of physical activity and weight (87,88,93).

While there has been a rapid proliferation of workplace physical activity programs among mid-to-large size employers (118), substandard levels of recruitment and participation limit the effectiveness of workplace interventions (96). Those efforts may be more successful in enrollment and impact if programs are designed to meet the needs of workers, with particular attention paid to the activity preferences of underlying worker segments (10). Audience segmentation is a principle of social marketing that posits that populations are made up of underlying segments of people sharing similar preferences and behaviors (18). A few studies have utilized audience segmentation to identify patterns of physical activity behavior in adult populations (28,29,109,110), though none of these studies have examined segments of physical activity behavior among office workers.

The purpose of this study is to identify segments of office workers by examining their patterns of self-reported engagement in activities of daily living and exercise behavior. In addition, we examine if segments differ by demographic characteristics and weekly minutes of accelerometer-measured light and moderate-vigorous physical activity. The sample is composed of office workers in mostly sedentary occupations employed at a health insurer in North Carolina.

We set hypotheses with regard to number of segments and associations with demographic characteristics and accelerometer-measured physical activity. We hypothesized that the number of activity behavior segments would range between two and four. A two-segment solution would primarily be differentiated by those who are highly active and highly inactive: 1) usually engaged in both categories of activity (i.e., activities of daily living and exercise behavior), 2) usually engaged in neither category of activity. A four-segment solution would suggest that, in addition to highly active and highly inactive segments, there are also segments who usually engage in a certain category of activity but not the other: 1) usually engaged in both categories of activity, 2) usually engaged in neither category of activity, 3) usually engaged in activities of daily living but not exercise behaviors, 4) usually engaged in exercise behaviors but not activities of daily living. Additionally, we hypothesize that segments with a greater number of activities reported usually engaged will be associated with greater weekly minutes of light and moderate-vigorous physical activity than segments with lesser number of activities usually engaged.

Finally, we hypothesized that segment membership would differ by age, sex, race/ethnicity, marital status, educational attainment, children in household, and occupation.

4.2 Methods

4.2.1 Parent Study

The present study is a secondary analysis of data collected from participants enrolled during the 12-month baseline phase (March 2015 – March 2016) of the *Effects of Physical Activity Calorie Expenditure (PACE) Food Labeling* (5R01CA184473) study. The study evaluated the effectiveness of PACE food labeling on meal calorie purchasing and physical activity levels among worksite cafeteria patrons at a major health insurer in North Carolina. PACE food labeling displays the number of miles of walking necessary for a prototypical adult (e.g., 160 lb. adult walking at a 30 minute/mile pace) to burn off the calories contained in the labeled food. All ethical aspects were approved by the Institutional Review Board of the University of North Carolina at Chapel Hill. The present study uses data from the baseline phase of the trial before PACE food labeling was implemented; no intervention phase data are studied. Details on the parent study can be found elsewhere (15).

The study was conducted in three worksites of a major health insurer in North Carolina employing approximately 3600 workers. A cohort was recruited from each worksite through email, company newsletter, cafeteria signage, and in-person recruitment tables. Full-time employees and contract workers were eligible for the PACE study if they were at least 18 years of age and reported eating lunch or were willing to eat lunch from the cafeteria at least three times per week. The study population was comprised of workers who self-reported an occupation in administrative/clerical, customer service/sales, financial/technical, environmental/food services and management categories. The sample that participated in this research consists of 414 participants that were enrolled into the parent study and invited to complete a variety of study-related questionnaires and measurements.

4.2.2 Measures

Activities of Daily Living and Exercise Behaviors

During April 2015 – June 2015, all participants were invited to complete the Community Health Activity Model Program for Seniors (CHAMPS) physical activity questionnaire. The CHAMPS questionnaire measured employees' participation in activities of daily living and exercise behaviors in the past week. The CHAMPS questionnaire was originally designed to assess the types, frequency, and duration of activity behaviors in which adults usually engage (113). We used a modified version of CHAMPS originally developed by Resnicow and colleagues (30) which better matches the age and race/ethnicity composition of our sample. Because of measurement error in self-reported physical activity instruments (23,119), we did not use CHAMPS to estimate time spent in physical activity intensity levels or energy expenditure. Rather, CHAMPS was solely used to assess the types of activity behaviors that one usually performs. Of 414 participants in the baseline sample, 310 completed the CHAMPS questionnaire (74.9% response rate).

CHAMPS data examining the frequency of activity behavior engagement in the past week were dichotomized for analysis, an approach consistent with previous finite mixture modeling of self-reported adult physical activity data (28,109). The indicator variables were dichotomized by those who engaged in the behavior at least once in the past week (vs. no engagement in the past week), except for frequently reported activities or behaviors with relatively high variance (e.g., leisure walking, light housework), which were dichotomized at the median. To ensure model parsimony, only CHAMPS activities that have been reported by at least 20% of the analytic sample were included. In the case of similar but separately measured activities (e.g., aerobics vs. aerobic machine, light gardening vs. heavy gardening), variables were combined and included if either sub-activity was endorsed by less than 20% of the sample, but exceeded 20% in combination (see Appendix B). Of the 22 CHAMPS indicator variables considered (including those combined), a total of five activities of daily living and seven exercise behaviors (n = 12; 55%) met inclusion criteria.

Demographic Characteristics and Objectively Measured Physical Activity

Demographic characteristics and objectively measured physical activity data were collected and used to compare the segments informed by the CHAMPS data. At enrollment, participants completed an in-person self-administered "Demographics and Brief Medical History" questionnaire on a mobile tablet (iPad; Apple Inc., Cupertino, CA). A study staff member was available to assist participants and provide a paper-based questionnaire in the event of any technological issues.

During July 2015 – September 2015, all participants were invited to wear an accelerometer for objective measurement of light, moderate, and vigorous physical activity over seven consecutive days. Participants were provided an accelerometer (wGT3X-BT; Actigraph, LLC, Pensacola, FL) to wear over the right side of the hip throughout the day and night except for showering. Participants also received a pencil-and-paper log to record the date, bed times, and wake times. A $10 cash incentive was given to participants to encourage wearing the accelerometer for a week.

Accelerometers capture movement in the form of "counts" which are then processed into minutes of light physical activity and moderate-vigorous physical activity based on pre-specified cutpoints. Cutpoints originally developed for NHANES were used to define light (100–2020 counts/minute) and moderate-vigorous (≥2020 counts/minute) physical activity (120,121). Valid accelerometer data were defined as at least four days and approximately 8 hours of wear time per day (≥7.5 hours/day) (122,123). The minutes of physical activity per day were averaged and multiplied by 7 to create minutes per week variables for light and moderate-vigorous physical activity (124). Of 414 participants in the baseline sample, 240 contributed valid accelerometer-measured data for calculation of BMI (58.0% response rate). Most participants in the analytic sample provided valid accelerometer wear data (n = 177; 74.1%).

Body Mass Index (BMI)

Between January 2015 and September 2015, a trained technician in the employer's biometric screening program used a portable stadiometer (213; Seca Ltd, Hamburg, Germany) and digital scale (WB-110A; Tanita Corp., Arlington Heights, IL) to take a single measurement of workers' height and weight, respectively. A continuous BMI variable was derived and rounded to the nearest tenth decimal place. Of 414 participants in the baseline sample, 284 had weight and height measurements for calculation of BMI (68.6% response rate). BMI was used as a covariate in analyses examining differences by segments.

4.2.3 Data Analysis

All data management and analyses were performed with Stata (version 14; Stata Corp., College Station, TX) and Mplus (version 7.4; Muthén & Muthén, Los Angeles, CA). Variables were inspected for missingness, outliers, and distributional assumptions. A two-sided alpha of 0.05 was set for statistical significance.

To identify segments of office workers, we used the 12 selected activity behaviors as indicator variables in a latent class analysis. Latent class analysis is a person-centered quantitative approach to revealing underlying classes (or segments) of individuals based on patterns of individual responses. In contrast to algorithm-based cluster analysis methods (e.g., signal detection analysis), it is based on a formal statistical model that allows the estimation of probabilities of membership in each class per individual, rather than assigning each individual to one class according to pre-defined criteria (as done in applications of cluster analysis). In this way, we account for the inherent uncertainty of classifying individuals into a single latent subgroup. For each class, conditional probabilities are estimated to show the likelihood that each class member engages in each activity behavior as dichotomized (i.e., engages in the behavior at least once per week).

To determine the true number (and patterning) of activity behavior classes, information criteria and statistical tests are used. In the present study, we used the Bayesian Information Criterion (BIC) and bootstrap likelihood ratio test (BLRT) to select the latent class solution. The BIC and BLRT have been shown to perform consistently well in selecting the true number of classes in sample sizes ranging 200–1000 (108,125). In addition to the BIC and BLRT, the entropy index value was calculated to describe the classification quality (i.e., extent of certainty that individuals are accurately classified) in each class solution. The preferred class solution has a low BIC value, significant BLRT statistic ($p < 0.05$), high entropy index value, and is interpretable (i.e., each class indicates a cogent pattern of activity behavior).

Once the class solution was selected, we used the Vermunt 3-step approach to assess how class membership was associated with demographic characteristics and accelerometer-measured weekly minutes of physical activity (126). The Vermunt 3-step approach is used to adjust for the uncertainty of assigning each individual to a class when estimating class associations with covariates. The Vermunt 3-step approach improves upon traditional classify-analyze approaches, which risks bias due to lack of adjustment for classification uncertainty (126,127). Applications of the Vermunt 3-step approach were used to examine demographic correlates and estimate class-specific means of weekly minutes of accelerometer-measured light and moderate-vigorous physical activity.

Demographic correlates of segment membership were evaluated using the automated R3STEP application of the Vermunt 3-step approach in Mplus. Multinomial logistic regression models were estimated to evaluate the odds of class membership versus a referent class by age, sex, race/ethnicity, marital status, educational attainment, children in household, and occupation.

Segment differences in mean accelerometer-measured minutes of light and moderate-vigorous physical activity per week were assessed using the manual Vermunt 3-step continuous distal outcome application. To account for departures from normality in the outcome distributions, we freely estimated class-specific variances in the distal outcomes (128). Wald tests of equality were performed to examine whether the class-specific mean estimates were significantly different. We estimated three types of models to assess potential influence of confounding: M1) crude, M2) demographics-adjusted, M3) demographics and BMI-adjusted.

In the analytic sample, there were no missing activity behavior indicator variable data. However, roughly one-quarter of included participants did not provide valid accelerometer data (n = 62; 25.94%) and were handled through the expectation-maximization algorithm (129). Due to missingness of demographic covariates, only two participants were deleted from analyses. Fixed effects were used to control for the clustering of workers in the three worksites.

4.3 Results

The analytic sample is comprised of baseline data from participants that were enrolled in the study (n = 414), including those that later withdrew from the PACE study. Of 414 participants, we excluded those that did not complete the self-reported physical activity questionnaire (n = 104) or have weight and height measured for BMI calculation (n = 130).

Fifty-nine participants were missing both self-reported physical activity and BMI data. Therefore, the analytic sample size is 239. The included participants were more likely to be older ($p = 0.003$), female ($p = 0.017$), and married or in domestic partnership ($p = 0.040$) than excluded participants.

Table 4.1 shows descriptive characteristics of the analytic sample. A majority of the sample was female (n = 196; 82.01%), earned at least a Bachelor's degree (n = 154; 64.44%), and was married or in a domestic partnership (n = 129; 53.97%). About one-third of participants reported a financial or technical occupation (n = 80; 33.61%) while the rest were in a management (n = 65; 27.31%), customer service or sales (n = 48; 20.17%), or administrative or clerical occupation (n = 45; 18.91%). More than 80% of the sample was overweight or obese. Mean minutes of objectively measured moderate-vigorous physical activity per week were slightly lower than federal guidelines of 150 minutes per week (mean = 144.30 minutes; SD = 111.10). The prevalence of engagement in each selected activity behavior is shown in Table 4.2.

Table 4.1: Descriptive Characteristics of Analytic Sample (N = 239)

	N [mean]	% [SD]
Age (years)	[43.44]	[9.76]
Sex		
Male	43	17.99
Female	196	82.01
Race		
White	115	48.12
Black or African American	102	42.68
Asian	10	4.18
More than one race	7	2.93
Other	5	2.09
Hispanic		
No	228	95.40
Yes	11	4.60
Education		
Less than high school	0	0.00
High school	30	12.55
Some college	0	0.00
Technical or trade school	18	7.53
Associate’s degree	37	15.48
Bachelor’s degree	89	37.24
Master’s or other advanced degree	65	27.20
Occupation[a]		
Administrative or clerical	45	18.91
Customer service or sales	48	20.17
Financial or technical	80	33.61
Environmental or food services	0	0.00
Management	65	27.31
Marital Status		
Single, never married	60	25.10
Married or domestic partnership	129	53.97
Widowed	4	1.67
Divorced or separated	46	19.25
Number of children in household (<18 yr)[b]	[0.88]	[1.05]
Body mass index (BMI)	[31.91]	[8.05]
Weight Status		
Underweight (<18.50)	1	0.42
Normal weight (18.50–24.99)	46	19.25
Overweight (25.00–29.99)	65	27.20
Obese (≥30.00)	127	53.14
Accelerometry[c]		
Moderate-vigorous physical activity per week (minutes)	[144.30]	[111.10]
Light physical activity per week (minutes)	[1,514.32]	[389.42]

Worksite		
A	88	36.82
B	89	37.24
C	62	25.94
Note: Missing values not included in calculation of percentages.		
[a] 1 participant missing occupation information.		
[b] 1 participant missing number of children information.		
[c] 62 participants missing accelerometry information.		

Table 4.2: Frequencies of Activities of Daily Living and Exercise Behavior Indicator Variables (N = 239)

	N	%
Activities of Daily Living		
Walk leisurely	101	42.26
Care for children	56	23.43
Light housework	94	39.33
Heavy housework	85	35.56
Light or heavy gardening[a]	95	39.75
Exercise Behaviors		
Bicycle or stationary cycle using legs only	56	23.43
Aerobics or aerobic machine use[b]	72	30.13
Fast or brisk walking	83	34.73
Jogging or running	51	21.34
Light strength training	78	32.64
Moderate to heavy strength training	58	24.27
Stretching or flexibility exercises	89	37.24
[a] Combined light and heavy gardening		
[b] Combined aerobics/aerobic dancing and aerobic machine		
Note: Activity behaviors are dichotomized by engagement at least once in the past week, except for walking leisurely and light housework, which were dichotomized at the median. Included activities were reported by at least 20% of the sample		

Table 4.3 displays the BIC and BLRT results for each class (i.e., segment) solution examined: 2-class, 3-class, and 4-class. As the number of classes fit increased, the BIC value increased. The BLRT test statistic comparing k versus k-1 classes was statistically significant ($p < 0.0001$) for each model fitted, thereby indicating improved model fit for each class added. We

selected the 2-class model as the preferred solution. The BIC value (3502.46) was lowest of the three models, and the pattern of physical activity behavior suggested by each class was plausible. The entropy index value of the 2-class model (0.75) indicated that the model was sufficiently capable of classifying individuals into classes.

Table 4.3: Class Enumeration Fit Statistics (N = 239)

Classes	**N**	**LL**	**BIC**	**E**	**BLRT LL**	**BLRT *P***	**C1**	**C2**	**C3**	**C4**
1	239	-2072.44	4232.49	NA	NA	NA	239	—	—	—
2	239	-1677.30	3502.46	0.746	-1765.03	<0.0001	120	119	—	—
3	239	-1652.83	3535.67	0.809	-1677.30	<0.0001	104	25	110	—
4	239	-1630.80	3573.76	0.826	-1652.83	<0.0001	28	111	72	28

Note: The 2-class solution was selected as the preferred model representing the true class structure among office workers in the sample. BIC: Bayesian Information Criterion; LL: Log likelihood; BIC: Bayesian Information Criterion; E: Entropy; BLRT: Bootstrap Likelihood Ratio Test. C: Number of participants in each class of solution. NA: Not applicable for single-class model.

Table 4.4 displays the prevalence of latent class membership by modal assignment (i.e., most likely class) and class-specific conditional probabilities of engaging in each activity behavior. The sample was roughly evenly divided with 50.2% of the sample belonging to the class deemed as representing “exercisers” and 49.8% belonging to the class labeled as representing “non-exercisers.”

Table 4.4: Prevalence of Classes and Conditional Probabilities of Activity Behavior Engagement (N = 239)

	Total Sample	**Exercisers**	**Non-Exercisers**
N	239	120	119
Class Prevalence (%)		50.21	49.79
Activities of Daily Living			
Walking leisurely	0.42	0.43	0.41
Care for children	0.23	0.23	0.24
Light housework	0.39	0.38	0.41
Heavy housework	0.36	0.43	0.28
Light or heavy gardening	0.40	0.44	0.35
Exercise Behaviors			
Bicycle or stationary cycle use	0.23	0.39	0.07
Aerobics or aerobic machine use	0.30	0.46	0.14
Fast or brisk walking	0.35	0.49	0.19
Jogging or running	0.21	0.41	0.01
Light strength training	0.33	0.60	0.03
Moderate to heavy strength training	0.24	0.47	0.00
Stretching or flexibility exercises	0.37	0.58	0.15

Note: Class N and prevalence based on most likely latent class membership of each observation (i.e., individuals assigned into class that she/he has highest probability of belonging). Activity behaviors are dichotomized by engagement at least once in the past week, except for walking leisurely and light housework, which were dichotomized at the median. Fixed effects for three worksites in all models.

In the “exerciser” class, members were distinguished by a moderate probability of engagement in an array of exercise behaviors (0.39–0.60). Of all exercise behaviors, the “exerciser” class had the highest probability of engaging in light strength training (0.60) and stretching or flexibility exercises (0.58), while they were least likely to use a bicycle or stationary cycle (0.39). Of all activities of daily living, “exercisers” were most likely to engage in heavy housework (0.43) and light or heavy gardening (0.44), while least likely to engage in childcare (0.23) and light housework (0.38).

In the “non-exerciser” class, there was low probability of engaging in any exercise behaviors (0.00–0.19). Of all exercise behaviors, “non-exercisers” were most likely to engage in fast or brisk walking (0.19) and least likely to engage in moderate to heavy strength training (0.00). Of activities of daily living, “non-exercisers” were most likely to engage in light housework (0.41) and walking leisurely (0.41), while least likely to engage in childcare (0.24). Notably, the probability of engaging in leisure walking, childcare, and light housework, were roughly similar across classes.

Table 4.5 presents the odds of belonging to “exerciser” as compared to “non-exerciser” class for each demographic characteristic. Of all characteristics evaluated, educational attainment and sex were identified as key correlates of segment membership. Earning at least a Bachelor’s degree (vs. educational attainment below a Bachelor’s degree) was associated with twice the odds of being in the “exerciser” class, as compared to the “non-exerciser” class (OR = 2.12; 95% CI = 1.02, 4.40). Meanwhile, being a female (vs. male) was associated with significantly reduced odds of membership in the “exerciser” class (OR = 0.18; 95% CI = 0.06, 0.52) as compared to the “non-exerciser” class. Age, children in the household, occupation, race/ethnicity, and marital status were not statistically related to class membership.

Table 4.5: Correlates of Membership to Exerciser vs. Non-Exerciser Class (N = 237)

	"Exercisers" vs. "Non-Exercisers"				
	Coef.	SE	OR	95% CI	*P*
Age	-0.02	0.02	0.98	(0.94, 1.02)	0.275
Educational Attainment[a]					
Bachelor's degree or Above	0.75	0.37	2.12	(1.02, 4.40)	0.043
Sex[b]					
Female	-1.72	0.54	0.18	(0.06, 0.52)	0.002
Children in the household	0.34	0.40	1.40	(0.64, 3.05)	0.398
Occupation[c]					
Administrative or clerical	-0.54	0.53	0.58	(0.21, 1.64)	0.303
Customer service or sales	-0.11	0.54	0.90	(0.31, 2.57)	0.845
Financial or technical	-0.10	0.44	0.90	(0.38, 2.13)	0.814
Race/ethnicity[d]					
Non-Hispanic White	-0.06	0.38	0.94	(0.45, 2.00)	0.877
Marital Status[e]					
Married or domestic partnership	-0.46	0.47	0.63	(0.25, 1.60)	0.333
Widowed, divorced, or separated	0.64	0.54	1.89	(0.65, 5.48)	0.239

[a] Referent was below Bachelor's degree (high school, technical or trade school, Associate's degree).
[b] Referent was male.
[c] Referent was management.
[d] Referent was Hispanic, Black or African American, Asian, more than one race, or other.
[e] Referent was single, never married.
Note: Fixed effects for three worksites in all models.

Table 4.6 shows how the two classes differed by levels of light and moderate physical activity objectively measured by accelerometer in three analytic models. With regard to light physical activity, the total mean minutes of light physical activity ranged from about 1486 to 1542 minutes between classes and across analytic models. There were no statistically significant differences in light physical activity between the two classes in any of the models. For minutes of moderate-vigorous activity, the "exercisers" class had in excess of 200 minutes of moderate-vigorous physical activity per week, on average, while the "non-exercisers" had less than 78 minutes of moderate-vigorous physical activity per week. Regardless of the adjustments used, "exercisers" had significantly more weekly minutes of accelerometer-measured moderate-vigorous physical activity than "non-exercisers."

Table 4.6: Minutes of Accelerometer-Measured Physical Activity Per Week, Per Class (N = 237)

	Light Physical Activity			**Moderate-Vigorous Physical Activity**		
	M1[a]	**M2[b]**	**M3[c]**	**M1[a]**	**M2[b]**	**M3[c]**
Log Likelihood	-1470.64	-1454.31	-1447.86	-1196.05	-1173.08	-1163.59
Exercisers						
Mean	1501.12	1485.96	1488.99	205.72	208.69	209.46
SE	41.66	42.47	41.51	13.42	13.48	13.52
Non-Exercisers						
Mean	1527.59	1542.06	1539.52	77.36	76.75	77.49
SE	47.91	48.38	47.35	4.31	4.16	4.04
P	0.70	0.42	0.45	<0.001	<0.001	<0.001

[a] Crude Model: adjusted by worksite.

[b] Demographics-Adjusted Model: adjusted by worksite, age, education, sex, children in household, occupation, race/ethnicity, and marital status.

[c] Demographics- and BMI-Adjusted Model: adjusted by worksite, age, education, sex, children in household, occupation, race/ethnicity, marital status, and BMI.

4.4 Discussion

In the present research, we found two distinct segments of office workers based on their self-reported activities of daily living and exercise behaviors. Our findings are consistent with previous research identifying unique segments of adults that differ by their physical activity behavior (28,29,109). These studies suggest that population segments are primarily differentiated by the average intensity level of activities engaged (i.e., segments are primarily characterized by the extent to which moderate-vigorous activities are engaged), rather than the clustering of particular light and moderate-vigorous activities (e.g., segments are primarily characterized by permutations of engagement in specific light and moderate-vigorous activities).

Our research diverges from previous segmentation analyses in that only two segments were identified, rather than the five-to-six segments identified in studies of other adult populations (28,29,109). For example, a latent class analysis of adults in the Northern Manhattan Study identified six classes distinguished by the frequency of engagement in physical activity: no activity, rare activity, active weekly, active every other day, active daily, and highly active (29). Notably, these studies utilize large samples without exclusive focus on office workers. The fewer number of classes identified in the present study may be attributed to the homogeneity of the sample which included only sedentary office workers who were primarily overweight or obese. In addition, our smaller sample size may have restricted us from identifying additional segments.

We found that sex was significantly associated with segment membership. Female office workers were less likely to be in the "exerciser" class as compared to the "non-exerciser" class. Previous physical activity behavior segmentation research has found sex to be a significant correlate of segment membership, though the nature of the relationship is unclear. Nationally representative segmentation studies of adults in the United Kingdom and United States indicated that female sex was generally associated with membership in more active segments (109,110). However, the relationship between sex and segment membership was less clear in segmentation studies of adults in New York City (28,29). These conflicting findings suggest the relationship between sex and segment membership potentially varies across adult subpopulations. Consequently, our findings might reflect barriers to physical activity that female office workers in sedentary occupations may experience more often than male peers in their daily life.

Aside from sex, educational attainment was the only other demographic characteristic significantly associated with segment membership. The association of educational attainment with activity behavior segment membership is consistent with previous segmentation research in the United States. Both Morrow-Howell et al. and Cheung et al. found that educational attainment was consistently related to membership in a more active segment (29,109).

The assessment of class-specific differences in accelerometer-measured weekly minutes of light and moderate-vigorous physical activity reflects how each behavioral pattern may result in different amounts of time spent in physical activity, and subsequent ability to meet physical activity guidelines. The "exerciser" class was associated with significantly greater minutes of moderate-vigorous physical activity per week than the "non-exerciser" class, exceeding national guidelines of 150 minutes of moderate-vigorous physical activity per week. Meanwhile, estimates of weekly minutes of light physical activity were largely identical, thereby reflecting the roughly equivalent engagement in light intensity sources of physical activity across classes (e.g., walking leisurely).

4.4.1 Limitations

Our findings must be considered along with their limitations. External validity is an important limitation. Our non-probability sample is composed of office workers employed by one health insurer across three North Carolina worksites, and primarily engaged in sedentary occupations: administrative/clerical, customer service/sales, or financial/technical. The prevalence of overweight and obesity in the analytic sample was higher than recent national and state-level adult prevalence estimates (130,131), and limited data were available to draw inferences for normal weight or underweight individuals.

Participants that met inclusion criteria for this study were more likely to be older, female, and married or in a domestic partnership than those excluded. Therefore, the external validity of this research is additionally limited among the younger, male, and unmarried (or not in domestic partnership) individuals that provided insufficient data for inclusion in this study. Overall, these individuals composed a small proportion of the parent study in which this sample is drawn, and an even smaller proportion of the total workforce at these three worksites, indicating the need for robust recruitment strategies that enroll and retain young adults, men, and others that are consistently under-represented in workplace health interventions (96).

Self-report physical activity (April – June 2015) and accelerometry (July – September 2015) were not measured simultaneously. Though objectively measured physical activity was collected slightly after self-report physical activity, research shows that absolute levels of physical activity are largely stable throughout the year and only minimally affected by seasonal change (132–135). Therefore, we do not expect levels of physical activity engagement to meaningfully differ across the two periods of measurement.

An existing workplace health program may have affected the segments found and may impact generalizability. The employer has a comprehensive workplace physical activity program offering multiple components including an individual-focused Weight Watchers program and organization-wide interventions, such as policies (e.g., sneakers allowed at work) and environmental supports (e.g., on-campus gym facility). Therefore, our findings may be interpreted as identifying employee activity behavior segments that persist amidst prevailing comprehensive workplace physical activity programs.

4.4.2 Policy and Practical Implications

Our findings suggest that the promotion of activities that are accessible and enjoyable to the least active workers might be the best use of worksite resources, particularly when resources are limited. Specifically, worksite activity programs that support engagement in light activities of daily living may appeal to "non-exercisers" at the worksite, who may lack interest in moderate-vigorous exercise-type behaviors commonly targeted in workplace health promotion. For instance, walking was a commonly engaged activity across segments that is highly modifiable and associated with various health benefits (136,137). Systematic reviews show that walking group interventions are associated with a medium-size positive effect on levels of physical activity and various beneficial health outcomes, including body mass index, total cholesterol, blood pressure, and resting heart rate (136,137). Changes in workplace policies or built environment that support greater engagement in walking may therefore benefit workers that are otherwise uninterested in intensive moderate-vigorous exercise programs.

4.5 Conclusion

As more adults are employed in largely sedentary office occupations (56), information on the segmentation of office workers in sedentary occupations by activity patterns may become increasingly important in helping to design effective workplace physical activity programs. Our study found two segments of office workers suggesting differential likelihood of engagement in activity behaviors and levels of moderate-vigorous physical activity. Information on physical activity segments in the studied workplace provides valuable insight for researchers and practitioners targeting activity-linked chronic disease among sedentary office workers. The study fills a gap in the literature regarding patterns of physical activity among office workers in sedentary occupations, contributing evidence that office workers in sedentary occupations may be broadly distinguished by whether exercise behaviors are engaged in. Future research should explore how workplace wellness programs may effectively encourage “non-exercisers” to become more active, and therefore achieve greater impact.

CHAPTER 5: PATTERNS OF PHYSICAL ACTIVITY BEHAVIOR AMONG OFFICE WORKERS: THE ROLE OF BODY MASS INDEX

5.1 Introduction

Approximately 71% of adults in the United States were estimated to be overweight or obese in 2013–2014 (131). There are myriad physical and mental health implications related to excess weight, including increased risk of cardiovascular disease, cancers, type II diabetes, and depression (138). The societal impact of obesity is evident in the workplace, where employers often bear significant medical care and productivity costs (139). Among full-time employees in the United States, an estimated $30.3 billion per year in medical expenditures, $12.8 billion per year in absenteeism, and $30.0 billion per year in presenteeism (i.e., decreased productivity when working while sick) are attributed to obesity (139).

Engaging in sufficient physical activity is a key to attaining and maintaining a healthy weight (11,140). However, adults increasingly work in sedentary office-based occupations that involve prolonged sitting and little to no moderate-vigorous physical activity (56,141). The growing dominance of deskbound work means that adults have fewer opportunities to integrate physical activity in their daily life, and engage in recommended levels of physical activity. Indeed, most employed adults do not engage in enough moderate-vigorous physical activity during their leisure-time to meet federal guidelines (17). Because employed adults spend a large proportion of their day at work, increased availability of opportunities to engage in physical activity at work may play an important role in improving adult workers' adherence to physical activity guidelines (142), especially for office workers (117).

Workplace physical activity interventions have been shown to be an effective type of obesity prevention program (9,88,143,144). These interventions often incorporate exercise training and/or counseling to promote physical activity in and outside the workplace (93). Getting employees to enroll and stay engaged in physical activity programs is a persistent challenge faced by worksite health promotion programs, and is even more challenging for those employees with the greatest need (9,10,96). While myriad factors ranging from individual-level factors (e.g., beliefs about physical activity) to structural factors (e.g., workplace polices constraining activity options during the work day) may partially explain this gap (95,145), program-specific characteristics, such as lack of program attractiveness in terms of perceived interest and accessibility, may also impede participation (146,147). Finally, enjoyment in physical activity plays an important role in overcoming internal and external barriers to participation (148,149).

To maximize participation and effectiveness of workplace physical activity programs, it is important to understand how weight status is associated with workers' engagement in physical activity (150,151). Weight status may influence physical activity-related cognitions and behaviors, and moderate the effect of programming on health outcomes. For instance, relationships between levels of physical activity and both perceived self-efficacy and social support are significantly weaker for obese individuals than healthy and overweight individuals (152,153). Therefore, workplace program developers may need to pay particular attention to ensure that program offerings account for the disparate needs and preferences of overweight and obese workers.

Overweight (25.00-29.99 BMI) and obese (≥30.00 BMI) adults have been found to engage in differential amounts of moderate-vigorous physical activity (154,155) and kinds of activity behavior (154–157). Activities of daily living (e.g., household cleaning) and exercise behaviors (e.g., running, strength training) that one may engage in on a given day constitute general patterns of activity. Assessment of a relationship between activity patterns and BMI may help workplace activity programmers understand the weight-related needs of workers in each segment.

The present study investigates how patterns of activity and BMI are related in a sample of office workers in urban North Carolina worksites. Typologies of office workers based on their activity patterns and validated in previous research are used to estimate typology-specific mean BMI, a commonly used measure of weight status. In addition, differences in BMI across typologies are examined. Workplace health practitioners may find these results useful in understanding how weight status may relate to activity patterns, and subsequently affect uptake of program offerings.

5.2 Methods

5.2.1 Sample

Data are from the *Effects of Physical Activity Calorie Expenditure (PACE) Food Labeling* study (March 2015 – March 2016). The study tested the effects of routine exposure to PACE food labeling (vs. conventional calorie labeling) on eating and physical activity behaviors among patrons of a worksite cafeteria. PACE food labeling translates calories in food products sold in the worksite cafeterias into the amount of miles a prototypical adult would need to walk in order to burn off the calories, with the aim of helping cafeteria customers make informed purchasing decisions. The study was conducted in three worksites of a health insurer located in three different urban localities in central and western North Carolina, employing approximately 3600 workers. Details can be found elsewhere (15). The current study uses baseline data from the PACE study, prior to any intervention exposure. The inclusion criteria for the parent study were: 1) full-time company employee or contract worker, 2) at least 18 years of age, and 3) reported eating lunch or were willing to eat lunch from the cafeteria at least three times per week. The Institutional Review Board of the University of North Carolina at Chapel Hill approved the study.

The analytic sample was drawn from baseline data of all participants that had enrolled in the study (n = 414). Participants were excluded from the analytic sample if missing either self-reported physical activity data (n = 104) or BMI data (n = 130). Fifty-nine participants were missing both self-reported physical activity and BMI data (n = 59). The resulting analytic sample size was 239 (Table 5.1). Study participants were more likely to be older (p = 0.003), female (p = 0.017), and married or in domestic partnership (p = 0.040) than participants excluded (n = 175).

5.2.2 Measures

Self-reported physical activity was assessed between April 2015 and June 2015. To measure recent engagement in physical activity, we used a modified version of the Community Healthy Activities Model Program for Seniors (CHAMPS) physical activity questionnaire (113), which was shown to be valid and reliable in a younger population similar to that of the present study (30). The instrument asks participants to report engagement in 25 different activities (as well as two “Other” options) in the past week, categorized as: 1) general household activities, 2) conditioning or exercise-type activities, 3) walking/jogging/running, and 4) sports and other recreational activities.

BMI was derived from weight and height measurements taken as part of the employer’s annual biometric screening conducted between January 2015 and September 2015. A trained technician for the employer’s biometric screening program used a portable stadiometer (213;

Seca Ltd, Hamburg, Germany) and digital scale (WB-110A; Tanita Corp., Arlington Heights, IL) to take a single measurement of workers' height and weight. The derived variable was rounded to the nearest tenth decimal place.

Other measures were also administered in the baseline phase and used to characterize the segments of office workers in previous research (158). At enrollment, a questionnaire was administered on a mobile tablet (iPad; Apple Inc., Cupertino, CA) to collect information on demographic characteristics. During July 2015 and September 2015, objective physical activity was measured using accelerometers at (wGT3X-BT; Actigraph, LLC, Pensacola, FL), Details on data collection in main study can be found elsewhere (15).

5.2.3 Latent Class Analysis Derived Patterns of Physical Activity Behavior

The present study is based on previous research that identified and described segments of office workers by activity patterns in this sample (158). We conducted a latent class analysis to identify activity patterns using self-reported engagement in activities of daily living and exercise behavior. A brief description of the latent class analysis follows.

The latent class analysis used a set of 12 indicator variables to represent common activity behaviors, and define segments of office workers by activity patterns. Item responses were dichotomized by those who engaged in the behavior at least once in the past week (vs. no engagement in the past week), except for leisure walking and light housework, which were dichotomized at the median due to relatively high variance and frequency in engagement. Based on the distribution of item responses, activity behaviors were selected for inclusion in the LCA if at least 20% of the sample engaged in the behavior at least once per week, with exceptions for activities of similar nature (e.g., aerobics and aerobic machine use) or identical activities that differ by intensity (e.g., light gardening and heavy gardening), which were considered in combination. Of 22 CHAMPS activity behaviors (including those combined), the 12 used as indicator variables represented five activities of daily living and seven exercise behaviors (Table 5.1).

Table 5.1: Frequencies of Activities of Daily Living and Exercise Behavior Indicator Variables (N=239)

	N	%
Activities of Daily Living		
Light housework (median)		
0 = At or below the median in engagement (times/week)	145	60.67
1 = Above the median in engagement (times/week)	94	39.33
Heavy housework		
0 = No engagement during past week	154	64.44
1 = Engaged in at least once during past week	85	35.56
Total gardening*		
0 = No engagement during past week	144	60.25
1 = Engaged in at least once during past week	95	39.75
Care for children		
0 = No engagement during past week	183	76.57
1 = Engaged in at least once during past week	56	23.43
Walk leisurely (median)		
0 = At or below the median in engagement (times/week)	138	57.74
1 = Above the median in engagement (times/week)	101	42.26
Exercise Behaviors		
Ride a bicycle or stationary cycle using legs only		
0 = No engagement during past week	183	76.57
1 = Engaged in at least once during past week	56	23.43
Light strength training		
0 = No engagement during past week	161	67.36
1 = Engaged in at least once during past week	78	32.64
Moderate to heavy strength training		
0 = No engagement during past week	181	75.73
1 = Engaged in at least once during past week	58	24.27
Stretching or flexibility		
0 = No engagement during past week	150	62.76
1 = Engaged in at least once during past week	89	37.24
Total aerobics**		
0 = No engagement during past week	167	69.87
1 = Engaged in at least once during past week	72	30.13
Walk fast or briskly		

0 = No engagement during past week	156	65.27
1 = Engaged in at least once during past week	83	34.73
Jogging or running		
0 = No engagement during past week	188	78.66
1 = Engaged in at least once during past week	51	21.34
§ Reported by at least 20% of the sample		
* Combined light and heavy gardening		
** Combined aerobics/aerobic dancing and aerobic machine		

A 2-class solution was determined to best represent the activity-related typologies or segments of the participating sample. Compared to 3- and 4-class solutions, the 2-class solution had relatively low BIC value (BIC = 3502.46), satisfactory entropy (Entropy = 0.75), and reflected a cogent pattern of behavior. The classes were roughly evenly divided between an "exerciser" class (50.21%) and "non-exerciser" class (49.79%) (Table 5.2). While the "exerciser" class exhibited higher probabilities in engagement in more intense activities of daily living (e.g., heavy housework) and exercise behaviors (e.g., running) than the other class, both typologies shared a roughly equivalent, moderate probability of walking leisurely.

Table 5.2: Prevalence of Latent Classes and Conditional Probabilities of Activity Behavior Engagement (N = 239)

Class	Total Sample	Exerciser	Non-Exerciser
Prevalence (%)		50.21	49.79
n	239	120	119
Activities of Daily Living			
Engaged in walking leisurely	0.42	0.43	0.41
Engaged in childcare	0.23	0.23	0.24
Engaged in light housework	0.39	0.38	0.41
Engaged in heavy housework	0.36	0.43	0.28
Engaged in light or heavy gardening	0.40	0.44	0.35
Exercise Behaviors			
Engaged in bicycle or stationary cycle use	0.23	0.39	0.07
Engaged in aerobics or aerobic machine use	0.30	0.46	0.14
Engaged in fast or brisk walking	0.35	0.49	0.19
Engaged in jogging or running	0.21	0.41	0.01
Engaged in light strength training	0.33	0.60	0.03
Engaged in moderate to heavy strength training	0.24	0.47	0.00
Engaged in stretching or flexibility exercises	0.37	0.58	0.15
Note: Class prevalence based on most likely latent class membership of each observation.			
Note: Walking leisurely and light housework were dichotomized at the median. All other variables were dichotomized by engagement at least once in the past week vs. never in the past week.			
Note: Fixed effects for three worksites in all models.			

Segment membership was differentially associated with select demographic characteristics and objectively measured weekly minutes of moderate-vigorous physical activity. Female workers were less likely to be in the “exerciser” segment, as compared to the “non-exerciser” segment (OR = 0.18, 95% CI = 0.06, 0.52). Those with at least a Bachelor’s degree had higher odds of being in the “exerciser” segment, as compared to the “non-exerciser” class (OR = 2.12, 95% CI = 1.02, 4.40). Mean minutes of moderate-vigorous physical activity per week were greater for the “exerciser” segment (mean = 209.46 minutes; SE = 13.52) than the “non-exerciser” segment (mean = 77.49; SE = 4.04).

5.2.4 Data Analysis

In order to compare the BMI of the typologies that emerged from the data, a Vermunt 3-step approach was used, adjusting for classification uncertainty (126,128,159). We applied a Wald test of equality to assess whether class-specific BMI means were significantly different. Class-specific variances in BMI were allowed to be unequal across classes to account for departure from normality that may bias mean estimates (128).

A crude model (i.e., only adjusted for worksite clustering) and full model (i.e., demographics-adjusted) were estimated. The full model controlled for age (continuous), sex (1 = Female, 0 = Male), race/ethnicity (1= "non-Hispanic white," 0 = "Black or African American," "Asian," "More than one race," or "Other"), marital status (1 = Single, never married, 2 = Married or domestic partnership, 3 = Widowed, Divorced or separated), educational attainment (1 = Bachelor's Degree or above, 0 = below Bachelor's Degree), children in household under 18 years of age (1 = at least one child; 0 = no children), and occupation (1 = Administrative or clerical, 2 = Customer service or sales, 3 = Financial or technical, 4 = Environmental or food service, 5 = Management).

Statistical analyses were conducted with Stata (version 14; Stata Corp., College Station, TX) and Mplus (version 7.4; Muthén & Muthén, Los Angeles, CA). Univariate statistics of variables were examined. A two-sided alpha of 0.05 was set for statistical significance. Fixed effects were used to account for worksite clustering in all models. Two participants were deleted from analyses because of missing information on a demographic covariate.

5.3 Results

The descriptive characteristics of the analytic sample are described in Table 5.3. The analytic sample was mainly female (n = 196; 82.01%), college educated (i.e., had earned at least Bachelor's degree) (n = 154; 64.44%), and married or in a domestic partnership (n = 129;

53.97%). Occupations reported by the participants included: financial or technical (n = 80; 33.61%), management (n = 65; 27.31%), customer service or sales (n = 48; 20.17%), and administrative or clerical (n = 45; 18.91%). More than half of the sample was obese (n = 127; 53.14%) and more than a quarter were overweight (n = 65; 27.20%).

Table 5.3: Descriptive Characteristics of Analytic Sample (N = 239)

	N [mean]	**% [SD]**
Age in years	[43.44]	[9.76]
Female	196	82.01
Non-Hispanic White	110	46.03
Education		
Bachelor's degree or above	154	64.44
Occupation[a]		
Administrative or clerical	45	18.91
Customer service or sales	48	20.17
Financial or technical	80	33.61
Environmental or food services	0	0.00
Management	65	27.31
Marital Status		
Single, never married	60	25.10
Married or domestic partnership	129	53.97
Widowed, divorced, or separated	50	20.92
Number of children in household (<18 yr)[b]	[0.88]	[1.05]
Weight Status		
Underweight (<18.50)	1	0.42
Normal weight (18.50–24.99)	46	19.25
Overweight (25.00–29.99)	65	27.20
Obese (≥30.00)	127	53.14
Accelerometry[c]		
Moderate-vigorous physical activity per week (minutes)	[144.30]	[111.10]
Light physical activity per week (minutes)	[1,514.32]	[389.42]
Worksite		
A	88	36.82
B	89	37.24
C	62	25.94
Note: Missing values not included in calculation of percentages.		
[a] 1 participant missing occupation information.		
[b] 1 participant missing number of children information.		
[c] 62 participants missing accelerometry information.		

Table 5.4 displays BMI results. In the crude model, the estimated mean BMI for the "exerciser" class (mean = 28.93; 95% CI = 27.74, 30.13) was significantly lower ($p < 0.001$) than that of the "non-exerciser" class (mean = 35.09; 95% CI = 33.39, 36.78). After controlling for demographic covariates, we found that differences in BMI by typology remained highly significant ($p < 0.001$).

Table 5.4: Class-Specific Mean Estimates of Body Mass Index (BMI) (N = 237)

	Crude Model	**Full Model***
Number of Free Parameters	7	17
Log Likelihood	-986.75	-963.22
Exerciser		
Mean	28.93	28.99
SE	0.61	0.61
95% Confidence Interval	(27.74, 30.13)	(27.80, 30.18)
Non-exerciser		
Mean	35.09	35.08
SE	0.86	0.85
95% Confidence Interval	(33.39, 36.78)	(33.41, 36.74)
Wald Test of Parameter Constraints (*P*)	<0.001	<0.001

*Controlling for age, sex, race/ethnicity, marital status, educational attainment, children in household under 18 years of age, and occupation.

5.4 Discussion

We found that two activity pattern typology segments present in an office workplace differed by mean BMI. Notably, those participants who were in the segment named "exerciser" had a mean BMI of 28.99, corresponding to an overweight status (25.00–29.99 BMI) while those in the "non-exerciser" segment had a mean BMI of 35.08, placing them in an obese weight status (≥30.00 BMI) (160). These findings suggest that overweight and obese individuals in this sample of North Carolina office workers may engage in distinctly different patterns of physical activity behavior. However, the cross-sectional nature of our study underscores our lack of knowledge regarding the causal relationship between segment membership and weight status.

Our findings that activity patterns differ by BMI are consistent with previous research. To our knowledge, only two latent class analyses of self-reported adult physical activity have examined segment differences by BMI (28,29). Both analyses studied samples of adults in New York City and identified 5-6 segments, which were significantly different by BMI. Though our study identified fewer segments, our findings are consistent in that the less active the segment, the greater the mean BMI. Notably, our study setting in small-to-medium sized urban centers of North Carolina substantially differs from that of New York City, where atypically robust infrastructure is present to support common engagement in active forms of commuting (e.g., walking and cycling) that may subsequently affect activity behavior patterns (161). Therefore, activity patterns found in New York City samples may have limited generalizability to populations in urban areas without similar infrastructure. Therefore, the activity patterns herein may be more representative of urban office worker populations prevalent in the United States than current evidence.

Our findings suggest that higher BMI office workers are less likely to exhibit an "exerciser" activity pattern as compared to lower BMI office workers. Our research does not help explain why this may be so. It may be that obesity makes it more difficult or uncomfortable for people to exercise (148,162). Or it may be that obese individuals are adversely affected by body image concerns that weaken exercise motivation in or outside the workplace (163). In either case, these findings suggest that the more vigorous exercise training programs commonplace in the workplace wellness field might be less appealing to obese workers.

The epidemiological research on moderate-vigorous physical activity and BMI suggests that the incremental effects of a physical activity intervention on BMI may depend on the individual's baseline physical activity level (164). Specifically, research shows that moderate-vigorous physical activity and BMI appear curvilinearly related, whereby the incremental effect of increased physical activity on BMI is strongest at low levels of baseline moderate-vigorous physical activity and attenuates to non-significance at baseline high levels of moderate-vigorous physical activity (165). Therefore, the benefits of workplace activity programming on BMI might be greatest among "non-exerciser" workers who engage in modest levels of moderate-vigorous physical activity, as compared to more active "exerciser" workers. Providing worksite activity programs that are attractive to obese workers, who may benefit the most from increased physical activity, is paramount to gaining their participation and commitment to a program. In addition, workplace weight control programs that target both facets of energy balance – physical activity (i.e., energy expenditure) and nutrition (i.e., energy intake) – may particularly attract obese workers interested in sustaining weight loss as an outcome of program participation.

Programs that focus on an active lifestyle rather than on exercise might be more appealing to many workers, particularly those that are obese (153,166,167). There is a large evidence base demonstrating the effectiveness of walking interventions in positively influencing weight gain and related cardiometabolic outcomes, as well as their acceptability and feasibility in office settings (136,137,168–170). Interventions to promote routine stair use at the workplace have also been associated with increased stair ascent and descent – both physically intense activities that can result in significant calorie expenditure and beneficial cardiovascular outcomes (171,172). Other such activity-based worksite programs should be explored.

5.4.1 Limitations

There are limitations to our study. First, our sample is drawn from a larger study of adults enrolled in a nutrition intervention study. Therefore, participants might be more interested in weight-related behaviors than typical office workers, and may already engage in a greater amount and diversity of physical activity behaviors than the norm. Second, the employer of study participants has an ongoing comprehensive workplace wellness program, including aerobic exercise programs and on-site gym facility. Therefore, these findings may not be generalizable to office workers that do not have such programs available. Third, height and weight data were extracted from the records of the employer's biometric program contractor. Therefore, we cannot attest to the accuracy and fidelity to protocol of technicians measuring participant weight and height. Finally, our small sample size of mostly overweight and obese individuals at baseline (80.34%) restricted identification of a physical activity pattern significantly associated with a mean BMI within a healthy weight range.

5.5 Conclusion

The segmentation of office workers by weight-related patterns of physical activity provides important insight for workplace health practitioners. Understanding of activities that are commonly engaged by both segments may inform selection of intervention components that are of interest to all workers. Further research to understand the complex determinants of physical activity among office workers is needed to aid the development of efficacious and scalable interventions that mitigate the rise of obesity prevalence attributed to sedentary employment.

CHAPTER 6: PREDICTIVE VALIDITY AND TEST-RETEST RELIABILITY OF A SELF-REPORT PHYSICAL ACTIVITY INSTRUMENT AMONG OFFICE WORKERS

6.1 Background

The role of physical activity in the prevention of chronic disease is well established (26,173,174). Valid and reliable methods to assess levels of physical activity are required for both surveillance and intervention studies (173,175). While objective methods such as accelerometers have important advantages over self-report methods, the information provided by accelerometry is largely limited to an assessment of minutes of activity and estimates of energy expenditure; contextual information on the types of behaviors engaged in is not available from accelerometry. In addition, researchers often lack the resources and capacity to collect and analyze accelerometry data (113,176). In light of these limitations, myriad self-report physical activity questionnaires have been developed to meet specific research objectives.

The Community Healthy Activities Model Program for Seniors (CHAMPS) physical activity questionnaire is commonly used to assess levels and types of physical activity engagement among adults (113). The original CHAMPS physical activity questionnaire was designed to measure physical activity of older adults, with prompts for the participant to enter information on the frequency and duration of engagement in common activity behaviors in the past week (30). Researchers can use these data to express recent physical activity in a number of ways including weekly minutes of moderate-vigorous physical activity (MVPA). Though CHAMPS was designed for older populations in the United States, original and modified versions are frequently applied to younger populations (177–184).

Evaluating a measurement tool's validity and reliability, including predictive validity and test-reliability, is an important step in confirming the utility and precision of an instrument's ability to answer important public health questions. Predictive validity evaluates the ability of a measure to predict an outcome measured using a criterion or more objective measure at a later time point (185). Test-retest reliability examines whether a measure used twice within a timeframe where change is not expected is consistent across time. In addition, investigation of differences in the measurement tool's psychometric properties by age, sex, and weight status are key to ensuring that validity and reliability holds across subgroups examined (111). Verifying the validity and reliability is an essential step during instrument development and also when instruments are adapted or used with unique populations.

The predictive validity and test-retest reliability of self-report physical activity instruments such as CHAMPS are seldom examined when used with different population groups, potentially weakening the robustness of physical activity estimates (186,187). To our knowledge, a study of CHAMPS predictive validity has never been published in the literature, though other studies have examined concurrent validity against measures of accelerometry and physical fitness (23,30,113,188–190). Test-retest reliability studies of CHAMPS, however, have been published in the literature (23,113,188–190), though not with the modified version used in this study (30).

The present study seeks to investigate the predictive validity and test-retest reliability of CHAMPS in a sample of office workers in southeastern United States across measurement timepoints in a 12-month timeframe. Implementation of valid and reliable physical activity assessment methods is especially important for workers that have largely sedentary office-based occupations. Indeed, 80.7% of office and administrative support workers are estimated to not engage in sufficient physical activity at leisure-time to meet national physical activity guidelines that recommend weekly engagement in 150 minutes of moderate physical activity, 75 minutes of vigorous physical activity, or a combination of both totaling 150 minutes, as well as muscle strengthening activities on at least two days a week (11,17). For predictive validity, we hypothesize that levels of physical activity estimated by CHAMPS, expressed as number of moderate-vigorous activities and weekly minutes of moderate-vigorous activity, will predict accelerometer-measured minutes of weekly moderate-vigorous activity in both short- (e.g., within a few months) and long-term (e.g., outside 6 months) periods. For test-retest reliability, we hypothesize that levels of physical activity as assessed by CHAMPS at two timepoints will be significantly correlated. In addition, we hypothesize that predictive validity and test-retest correlations will be stronger among younger (vs. older), men (vs. women), and obese (vs. normal and overweight) adults, as shown in similar research (111,112).

6.2 Methods

6.2.1 Sample

Data were from the baseline phase of the Effects of Physical Activity Calorie Expenditure (PACE) Food Labeling study (March 2015 – March 2016) (15). The study investigated the effects of PACE food labeling on nutrition and physical activity outcomes among employee patrons of a worksite cafeteria. In contrast to calorie menu labeling, PACE food labeling displays calories as the number of miles a prototypical adult would need to walk in order to expend the calories contained in a food offering. The primary goal of PACE food labeling is to increase consumer understanding of calorie content of food offerings, and thereby lead to reduction in calories purchased. The inclusion criteria for the participation in the parent study were: 1) full-time company employee or contract worker, 2) 18 years of age or older, and 3) reported eating lunch or were willing to eat lunch from the worksite cafeteria at least three times per week. The study setting comprised three worksites of a major health insurer located in three different urban localities in central and western North Carolina. The insurer employed approximately 3600 workers total.

The baseline sample (n = 414) was predominantly middle-aged (mean years of age = 42.2), racially diverse (white: 45.4%, black: 44.7%), female (77.8%), overweight or obese (mean BMI = 31.0), with a college (38.4%) or graduate degree (25.9%) (15). Further details on the baseline sample composition and PACE study can be found elsewhere (15).

6.2.2 Data Collection

To measure year-round physical activity (and assess time-dependent intervention effects), four measurement timepoints occurred approximately every three months in which self-report and objectively measured physical activity were assessed on an alternating basis. The timepoints corresponded to: T1) CHAMPS (spring/summer 2015), T2) accelerometry (summer 2015), T3) CHAMPS (fall 2015), and T4) accelerometry (winter 2016) (see Appendix C). Because timespans of varying lengths have been used to measure predictive validity, we paired timepoints to reflect short- and long-term periods of predictive validity. Short-term predictive validity was assessed by examining the ability for the physical activity assessment from T1 CHAMPS questionnaire to predict T2 physical activity assessment using accelerometers. Long-term predictive ability was assessed by examining the ability for the physical activity assessment from T1 CHAMPS questionnaire to predict T4 physical activity assessment using accelerometers. Test-retest reliability for the CHAMPS questionnaire was assessed by examining T1 and T3 CHAMPS measures. Accelerometry measures of PA have been found to be stable over time in the past unless an intervention is being evaluated (133–135), and are not examined as a research question here.

Each timepoint represented an approximate three-month measurement window in which self-reported and objectively measured physical activity could be assessed. Therefore, the gap between participants taking the measurements varied. The average gap in days between each CHAMPS and accelerometer measurement for short-term (T1 to T2) and long-term (T1 to T4) predictive validity was 106 days (SD = 7.7) and 276 days (SD = 8.6), respectively. Because the variation in time gap between T3 and T4 measurements was roughly twice that of other predictive validity periods (mean = 113 days, SD = 15.6), we did not consider this interval as robust for evaluation of short-term predictive validity and, therefore, did not assess it. The average number of days separating the two accelerometry periods (T2 to T4) was 165 days (SD = 7.2). The average number of days between participants taking the two CHAMPS measures (T1 to T3) was 157 days (SD = 15.4).

6.2.3 Measures

CHAMPS Questionnaire

At timepoints 1 and 3, participants were invited to complete the Community Health Activity Model Program for Seniors (CHAMPS) physical activity questionnaire. No financial incentive was provided for completion of the questionnaire. We used a modified version of CHAMPS originally developed by Resnicow and colleagues for a younger population that reflects our office worker sample (30). Participants were asked to recall engagement in 25 different activities (along with two “Other” options) within four categories in the past week: 1) general household activities, 2) conditioning or exercise-type activities, 3) walking/jogging/running, and 4) sports and other recreational activities. For each reported activity, participants were asked to report the frequency per week, total minutes per week, and usual intensity. Number of moderate-vigorous activities was computed as a count of all moderate-vigorous activities (n = 19) the participant engaged in at least once in the past week. Number of light, moderate, and vigorous activities was computed as the count of all activities engaged in at least once in the past week. To estimate weekly moderate-vigorous and total minutes of physical activity, we computed total minutes spent in moderate-vigorous and all activities, respectively, as classified by the metabolic equivalent of task (MET) intensity level of each activity behavior (see Appendix D) (64,113).

Accelerometry

Participants were invited to wear an accelerometer (wGT3X-BT; Actigraph, LLC, Pensacola, FL) for seven consecutive days. The accelerometers were to be worn over the right side of the hip during the day and night, except for showering. A pencil-and-paper log was provided to record date and bed/wake times to assist with data processing. A $10 cash incentive was given to participants to encourage wearing the accelerometer for a week. Accelerometer data were considered valid if the participant wore the accelerometer at least four days and approximately 8 hours of wear time each of those days (122,123). We used cutpoints from NHANES to define light (100–2020 counts/minute) and moderate-vigorous (≥2020 counts/minute) physical activity (120,121). We averaged minutes of MVPA across valid days and multiplied by 7 to create a measure of weekly minutes of MVPA.

Biometrics

Weight and height were measured independently from the study as part of an employer-provided biometric screening offered to employees on a voluntary basis annually. The measurements were collected between January 2015 and September 2015. A trained technician used a portable stadiometer (213; Seca Ltd, Hamburg, Germany) and digital scale (WB-110A; Tanita Corp., Arlington Heights, IL) to take a single measurement of workers' height and weight.

BMI was derived from weight and height measurements and rounded to the nearest tenth decimal place.

Demographic Characteristics

At study enrollment, participants were invited to complete a questionnaire that collected information on a range of demographic characteristics, including age and sex. Most participants enrolled – and therefore completed this questionnaire – shortly before initiation of the baseline phase, though some participants enrolled during the baseline phase as well.

6.2.4 Data Analysis

We paired measurement timepoints to evaluate the predictive validity and test-retest reliability of CHAMPS. We compared CHAMPS and accelerometer measurements from timepoints to evaluate short-term (T1 to T2) and long-term (T1 to T4) predictive validity. We paired CHAMPS timepoints (T1 to T3) to evaluate test-retest reliability. We compared accelerometry measurements at timepoints T2 and T4 to evaluate the stability of accelerometry over time, and indicate whether levels of physical activity are stable enough for CHAMPS to have predictive validity and test-retest reliability in the timeframes evaluated. In the present study, we excluded participants that completed the CHAMPS outside the pre-identified time frame (T1: n = 2; T3: n = 38) or provided insufficient CHAMPS data to allow estimation of weekly moderate-vigorous minutes (i.e., no information about duration of single moderate-vigorous activity engaged) (T1: n = 1) (see Appendix E).

To evaluate predictive validity, we computed the non-parametric Spearman's rho correlation (for non-normal data) of CHAMPS and accelerometer measurements for short-term (T1 and T2) and long-term (T1 and T4) periods. The CHAMPS measures were expressed as the self-reported: 1) number of moderate-vigorous activities per week, and 2) minutes of MVPA per week. Accelerometry was expressed as minutes of MVPA per week.

To evaluate test-retest reliability, we computed Spearman correlations of CHAMPS measurements between T1 and T3. The CHAMPS measures were expressed as the self-reported: 1) number of light, moderate, and vigorous activities per week, 2) number of moderate-vigorous activities per week 3) minutes of total physical activity per week, 4) minutes of MVPA per week.

We conducted stratified analyses of predictive validity and test-retest reliability to identify potential differences in how the instrument performs based on age, sex, and weight status. We dichotomized age at 50 years to assess differences between older and younger workers, a cutpoint used by similar research (191). For sex, categories were: female, male. For weight status, we used World Health Organization criteria to categorize healthy weight (18.50–24.99), overweight (25.00–29.99), and obese (≥30.00) (160).

All analyses were conducted in Stata 15.0 (College Station, TX, USA). The Institutional Review Board of the University of North Carolina at Chapel Hill approved the study.

6.3 Results

Summary statistics for CHAMPS and accelerometer measurements are presented in Table 1. The mean minutes of MVPA were assessed to be greater using CHAMPS at T1 (mean = 226.1; SD = 253.5) and T3 (mean = 195.5; SD = 218.6) as compared to accelerometry at T2 (mean = 143.2; SD = 115.1) and T4 (mean = 128.7; SD = 124.6). CHAMPS data also show between 2.7 and 2.3 moderate-vigorous activities and 5.4 and 4.8 light, moderate and vigorous activities reported at T1 and T3, respectively. As expected, the overall correlation of accelerometer-measured minutes of weekly MVPA at T2 and T4 was found to be moderate-high (rho = 0.66; $p < 0.05$), thereby indicating a great degree of stability in MVPA despite seasonal change (data not shown).

Table 6.1: Summary Statistics of CHAMPS and Accelerometry Variables

Variable	n	Mean	SD	Min	Max
CHAMPS					
T1 Minutes of MVPA per week	307	226.1	253.5	0	1455
T3 Minutes of MVPA per week	217	195.5	218.6	0	1080
T1 Number of MV activities	307	2.7	2.2	0	11
T3 Number of MV activities	217	2.3	2.0	0	11
T1 Number of light and MV activities	307	5.4	2.8	0	15
T3 Number of light and MV activities	217	4.8	2.7	0	16
Accelerometry					
T2 Minutes of MVPA per week	247	143.2	115.1	17	584
T4 Minutes of MVPA per week	118	128.7	124.6	15	784

Note: CHAMPS: Community Healthy Activities Model Program for Seniors Questionnaire. MV: moderate-vigorous. MVPA: moderate-vigorous physical activity. T1: CHAMPS timepoint (spring/summer 2015). T2: accelerometry timepoint (summer 2015), T3) CHAMPS timepoint (fall 2015), and T4) accelerometry timepoint (winter 2016).

Table 6.2 shows the association of CHAMPS-measured number of moderate-vigorous activities and minutes of MVPA per week with accelerometer-measured minutes of MVPA in short- and long-term periods. Both CHAMPS estimates were moderately correlated with accelerometer-measured minutes of MVPA in the short-term period, though the overall correlation was slightly stronger for CHAMPS number of moderate-vigorous activities (rho = 0.40; $p < 0.0001$) than CHAMPS minutes of MVPA per week (rho = 0.35; $p < 0.0001$). In the evaluation of long-term predictive validity, the correlations of both CHAMPS estimates with accelerometry were slightly attenuated though statistically significant as compared to those in the short-term period. In contrast to results from short-term predictive validity, the CHAMPS number of moderate-vigorous physical activities was slightly less correlated with accelerometer-measured minutes of weekly MVPA (rho = 0.26, $p = 0.01$) than CHAMPS weekly minutes of MVPA (rho = 0.33; $p = 0.001$).

Table 6.2: Overall Predictive Validity and Test-Retest Reliability of CHAMPS: Spearman Correlations

CHAMPS Variable	**rho**
Predictive Validity	
Short-term (T1 to T2) (n = 223)	
Number of MV activities	0.40*
Minutes of MVPA per week	0.35*
Long-term (T1 to T4) (n = 95)	
Number of MV activities	0.26*
Minutes of MVPA per week	0.33*
Test-Retest Reliability (T1 to T3) (n = 217)	
Number of light, moderate, and vigorous activities per week	0.58*
Number of MV activities per week	0.59*
Minutes of total physical activity per week	0.54*
Minutes of MVPA per week	0.56*

Note: CHAMPS: Community Healthy Activities Model Program for Seniors Questionnaire. rho: Spearman correlation. MV: moderate-vigorous. MVPA: moderate-vigorous physical activity. rho: Spearman correlation. Predictive validity is the Spearman correlation of CHAMPS variables with accelerometer-measured minutes of weekly moderate-vigorous physical activity. * $p<0.05$.

Stratified analyses of predictive validity demonstrated that CHAMPS estimates were largely predictive of later accelerometer-measured activity across demographic groups, though the magnitude differed to some extent (Table 6.3). With regard to age, the CHAMPS variables assessing number of moderate-vigorous activities as well as minutes of MVPA per week were significantly related to accelerometer-measured weekly minutes of MVPA in both age groups in the short-term period. However, for long-term predictive validity, the only significant association was of CHAMPS-measured weekly minutes of MVPA predicting accelerometer-measured MVPA in the older age group. Interestingly, the long-term association between the two assessments of minutes of MVPA (rho = 0.45) was larger than the short-term associations between the two measures (rho = 0.29) for those who were 50 and older. When stratified by sex, correlations between the CHAMPS variables and accelerometer-measured minutes of MVPA were, for the most part, stronger for women in the sample as compared with men. With the exception of the long-term association between CHAMPS-measured number of moderate-vigorous activities and accelerometer-measured minutes of MVPA, CHAMPS was more predictive of accelerometer-measured minutes of MVPA in women as compared to men. With regard to weight status, the only significant associations were seen in the short term and with those who were at a healthy or obese weight status. In general, patterning of correlations by age, sex, or weight status was less apparent for long-term predictive validity, potentially due to a smaller sample (n = 95) than in the short-term period (n = 223).

Table 6.3: Stratified Analyses of Predictive Validity and Test-Retest Reliability of CHAMPS-Derived Physical Activity Assessments

	Age				**Sex**				**Weight Status**					
CHAMPS Variable	**<50**		**≥50**		**Male**		**Female**		**Healthy (18.50–24.99 BMI)**		**Overweight (25.00–29.99 BMI)**		**Obese (≥30.00 BMI)**	
	n	rho	n	rho	n	rho	n	rho	n	rho	n	rho	n	rho
Predictive Validity														
Short-term (T1 to T2)														
Number of MV activities	156	0.43*	67	0.31*	46	0.10	177	0.34*	36	0.37*	47	0.27	96	0.41*
Minutes of MV activity per week	156	0.35*	67	0.29*	46	0.07	177	0.29*	36	0.50*	47	0.23	96	0.39*
Long-term (T1 to T4)														
Number of MV activities	65	0.22	30	0.25	19	0.27	76	0.13	16	0.28	25	0.18	40	0.14
Minutes of MV activity per week	65	0.22	30	0.45*	19	0.15	76	0.25*	16	0.39	25	0.35	40	0.26
Test-Retest Reliability (T1 to T3)														
Number of light and MV activities per week	149	0.64*	68	0.45*	43	0.70*	174	0.53*	37	0.62*	51	0.40*	93	0.61*
Number of MV activities per week	149	0.61*	68	0.56*	43	0.62*	174	0.56*	37	0.66*	51	0.46*	93	0.65*
Minutes of total activity per week	149	0.58*	68	0.45*	43	0.61*	174	0.49*	37	0.64*	51	0.52*	93	0.51*
Minutes of MV activity per week	149	0.55*	68	0.58*	43	0.57*	174	0.51*	37	0.65*	51	0.54*	93	0.57*

Note: CHAMPS: Community Healthy Activities Model Program for Seniors Questionnaire. MV: moderate-vigorous. BMI: body mass index. rho: Spearman correlation. * $p<0.05$.

Test-retest reliability of the CHAMPS instrument was good for both assessment of the number of activities as well as estimated minutes of MVPA per week; associations over time were statistically significant and correlations all above 0.50 (Table 6.2). Stratified analyses of test-retest reliability indicated good reliability across demographic groups (Table 6.3). Consistent with predictive validity stratified analyses, test-retest correlations were stronger among obese individuals than overweight individuals for number of light, moderate, and vigorous activities engaged per week (rho = 0.61 vs. 0.40), number of moderate-vigorous activities per week (rho = 0.65 vs. 0.46), and weekly minutes of MVPA (rho = 0.57 vs. 0.54). In contrast with sex-specific predictive validity analyses, test-retest correlations were stronger for men than women across all four CHAMPS measures. The test-retest correlation was stronger among younger workers (vs. those 50 years or older) across all measures, except for minutes of MVPA per week.

6.4 Discussion

The purpose of our study was to evaluate the predictive validity and test-retest reliability of a self-report physical activity questionnaire in a sample of office workers in southeastern United States. Our findings indicate that the CHAMPS questionnaire demonstrates adequate predictive validity and test-retest reliability in our sample, as evidenced by Spearman correlations of moderate-to-high magnitude. The evaluation of short- and long-term predictive validity and sample size of our study constitute a meaningful contribution to the literature.

Overall, the moderate-to-high predictive validity correlations suggest that CHAMPS is a useful and practical instrument to utilize for assessment of usual physical activity. When compared to other self-report instruments, the correlation of CHAMPS estimates with accelerometer-measured MVPA were within range of tools of similar or longer length, including the International Physical Activity Questionnaire (IPAQ), Global Physical Activity Questionnaire (GPAQ) and Minnesota Leisure Time Physical Activity Questionnaire (men: r = -

0.15–0.43; women: r = -0.36–0.52) (111). The magnitude of correlations found in our study are consistent with those previously found with CHAMPS, which found a Spearman correlation for MVPA (rho = 0.37) measured concurrently using accelerometers among older adults (23). Notably, this study along with all others in the systematic review examined concurrent validity rather than predictive validity.

The association of CHAMPS with later measurements of accelerometer-measured physical activity was considered strong. A high level of association between measures is not expected given that physical activity behaviors may change over time, and certain moderate-vigorous activities are poorly measured by accelerometry (e.g., bicycle riding and strength training). Indeed, the explicit measurement of such activities may partially explain why CHAMPS estimates for minutes of weekly MVPA are higher than accelerometer-measured estimates, though over-reporting of moderate-vigorous physical activities in self-reported physical activity questionnaires is equally plausible and prevalent (22). Because we evaluated predictive validity and not concurrent validity, we cannot determine the source of the discrepancy in estimates.

The test-retest correlations compare favorably to those found for other self-report physical activity questionnaires with shorter reliability timeframes, including long form versions such as the International Physical Activity Questionnaire (IPAQ) and Global Physical Activity Questionnaire (GPAQ) (192–194). The test-retest correlations were moderate but slightly lower than those found in studies of CHAMPS test-retest reliability in 2-week and 6-month periods. Previous research on test-retest reliability of CHAMPS estimates found a two-week Pearson's correlation of 0.62 for all activities and 0.76 for moderate-intensity activities (190). A two-week test-retest reliability study by Stewart and colleagues found Pearson's correlations ranging from

0.58 to 0.67 (113). A study of 6-month test-retest reliability found intra-class correlation coefficient of minutes of MVPA of 0.66 (23). In sum, the magnitude of overall test-retest reliability found in our sample (rho = 0.54–0.59) is relatively close to that of previous CHAMPS findings, despite the relatively long 5-month time gap (mean = 157 days) between measurements.

Stratified analyses indicated that the CHAMPS was valid and reliable across age, sex, and weight status. The short-term predictive validity was good for both older and younger groups, while better for women (vs. men) and non-overweight individuals. Correlations of long-term predictive validity were generally weaker than short-term predictive validity. Test-retest reliability was largely similar across all demographic groups evaluated. The stronger predictive validity correlations among healthy weight and obese adults, as compared to overweight adults, potentially suggests that healthy weight and obese adults may pay more attention to their activity levels as compared to overweight adults. Paying attention to activity levels may be part of a healthy lifestyle adopted by healthy weight people, while those who are obese may be more concerned about their health and self-monitor physical activity as a strategy to lose weight (153). Those who are overweight might not be as motivated to pay attention to their activity levels and are, therefore, less accurately able to answer self-report questionnaires regarding their activity. While previous research concurs that healthy weight individuals tend to report physical activity with a high degree of accuracy, studies have found differentially poorer agreement between self-report and objective measures of physical activity among overweight and obese individuals – thereby conflicting with our findings on obesity (195–197). Overall, our findings suggest that self-report physical activity questionnaire findings must be cautiously interpreted in accordance with the weight profile of the sample.

Despite the changing of seasons, we found that the correlation of CHAMPS with a later measurement of objectively measured physical activity was moderately strong. This suggests that one's level of physical activity is relatively consistent throughout the year, despite the changing of seasons. This finding is consistent with recent studies that have found that objectively measured levels of adult physical activity are largely stable throughout the year (132–135) or minimally influenced by season (198). The lack of relationship between season and physical activity may relate to the prevalence of MVPA engagement in indoor settings (e.g., gyms) or occupational and transit sources of physical activity that are static throughout the year (133). However, seasons with unusually high frequency of adverse weather events may impact engagement in physical activity, as meteorological conditions (e.g., rain, wind chill) have been shown to affect day-to-day engagement in physical activity within seasons (133,199,200). In addition, seasonal differences in physical activity have been found in some populations (199).

6.4.1 Limitations

Our study must be considered along with its limitations. We used an accelerometer as the criterion measure to which predictive validity was evaluated for CHAMPS. However, hip worn accelerometers are known to lack precise measurement of light physical activity (e.g., standing) and strength training. Therefore, our criterion measure may perform worse than other accepted criterion measures of physical activity, such as doubly labeled water, which is considered the "gold standard" in construct validation though vulnerable to other sources of error (e.g., variation in metabolic rate) (22,176,185). Regardless, accelerometers are a commonly accepted criterion for validation of questionnaires in the literature (111). Because not all participants completed all measurements, there may be selection bias in which participants composed the analytic samples. For example, highly active or healthier individuals may have been more likely to participate in all measurements than less active or healthy individuals. The study results are based on a convenience sample of office workers in a health insurer in North Carolina, and generalizability is accordingly limited.

6.5 Conclusion

Application of valid and reliable self-reported physical activity questionnaires is key to determining prevalence of insufficient physical activity and evaluating the effectiveness of physical activity interventions among office workers. We found that assessments of physical activity from the CHAMPS instrument, expressed as a count of activities and minutes of activity, show a reasonable degree of predictive validity and test-retest reliability for application to office workers in sedentary occupations. These results suggest that a simple count of different activities that participants report to engage in may adequately distinguish physical activity levels in this population, thereby indicating an avenue for researchers to reduce participant response burden in study applications.

Our overall findings suggest that researchers may consider using CHAMPS as a relatively short and comprehensive assessment method of measuring the qualitative (i.e., behavioral domains) and quantitative (i.e., frequency, duration, and intensity) dimensions of recent physical activity. Greater psychometric evaluation of commonly applied self-report physical activity questionnaires is needed to aid appropriate selection of assessment tools in workplace settings.

CHAPTER 7: SYNTHESIS

The dissertation research, using the social marketing principle of audience segmentation, harnessed unique data sources to reveal and describe segments of office workers based on activities of daily living and exercise behaviors. The three dissertation manuscripts herein have been prepared for publication in the peer-reviewed literature.

As prevalence of activity-linked obesity and other chronic disease rises, information on prevailing activity patterns may be helpful in developing intervention approaches to successfully engage the broadest audience of office workers. Systematic reviews show that workplace physical activity interventions are associated with improved levels of physical activity and beneficial activity-related health outcomes (87,88,93). A literature review of studies that have identified and described segments of adults by self-reported physical activity behavior was conducted as part of this dissertation research and found only four studies that met inclusion criteria, none of which focused on office worker populations. Demographic and anthropometric characteristics of segments were largely unexplored. Of the few identified studies, two investigated associations with anthropometrics and none assessed differences in objectively measured physical activity.

The aims were designed to fill the gaps highlighted by the literature review. A latent class analysis approach was used to segment the population by self-reported activities of daily living and exercise behavior (Aim 1). Demographic correlates of segments were then explored to understand the probability of segment membership according to selected worker characteristics (Aim 1a). Investigation of segment associations with mean accelerometer-measured light and moderate-vigorous physical activity (Aim 2) and BMI (Aim 3) was conducted to investigate the potential health impact of segment membership. Finally, we investigated the predictive validity and test-retest reliability of the self-report physical activity instrument utilized in the research as a means of evaluating the robustness of our segmentation results, while adding to literature on the psychometric properties of self-report physical activity instruments which are commonly used in research and practice settings (Aim 4).

Aim 1, Aim 1a, and Aim 2 were investigated in the first manuscript. Using a sample of office workers enrolled in worksite nutrition study, latent class analysis was used to determine the segmentation of office workers by activity patterns (Aim 1). The sample was roughly equally divided into two segments representing “exercisers” and “non-exercisers.” Men (vs. women) and those with at least a Bachelor’s degree were more likely to be a member of the “exerciser” segment, as compared to the “non-exerciser” segment (Aim 1a). In adjusted models, the mean minutes spent in objectively measured weekly moderate-vigorous physical activity was significantly greater among “exerciser” members than “non-exerciser” members, whereas no significant difference was found in weekly minutes of objectively measured light physical activity (Aim 2).

Aim 3 was investigated in Manuscript 2. Technician-measured weight and height from the employer’s biometric screening program was used to describe the mean BMI of each segment. The mean BMI value was significantly greater among “non-exercisers” than “exercisers.” These results suggest a relationship between segment membership and adiposity, though the cross-sectional nature of the data precludes causality.

Aim 4 was investigated in Manuscript 3. The predictive validity and test-retest reliability of the self-report physical activity instrument used to identify the segments were evaluated.

Using data from the 12-month baseline phase, we found significant Spearman correlations between a self-report tool and accelerometers suggesting adequate levels of short- and long-term predictive validity, as well as test-retest reliability. The confirmation of the psychometric properties of the self-report CHAMPS questionnaire used in this research adds credence to the findings of this dissertation research and contributes a psychometrically-tested measurement tool to the field.

The dissertation findings contribute to the evidence base on workplace physical activity and inform program development in several ways, and highlights areas where further research is needed. First, greater research on the segmentation of workers by activity patterns across different types of workplaces is needed to aid targeting of segments. Second, innovation in tailored workplace physical activity programs is needed to complement approaches that target segments. Finally, organization-wide interventions that are capable of rapid proliferation are needed to nurture physical activity across segments through policy and environmental modifications.

The targeting of interventions to segments defined by single or multiple group-level variables (e.g., age, gender, and occupation) is typically used in social marketing interventions to ensure that intervention content is adequately designed to address the specific preferences and needs of a specific subgroup (201). For example, a workplace practitioner may choose to develop an intervention targeting women based on national epidemiological surveys showing that female workers are at higher risk of insufficient physical activity as compared to male workers. However, this a priori method of segmentation may ignore other characteristics of the population including behavioral preferences and psychosocial factors that may be predictive of activity preferences (18). As an example, this dissertation research showed that the workforce participating was segmented by the types of activities behaviors that they engaged in; one segment showed that activity patterns were fairly restricted to activities of daily life while the other segment appeared to engage in specific activities related to getting exercise. This information is important to worksite health promotion directors because it suggests that programs and resources that enhance opportunities for individuals to get more exercise (for example, a worksite aerobic course, a softball team, or a new gym) will likely only appeal to those workers who are already exercising. For those workers who are not already engaging in exercise behaviors, incentivizing participation in these exercise-focused programs would be essential, but may still fall short in their ability to engage workers who are not predisposed to exercising. For the segment of workers who are primarily doing activities of daily living, worksite programs that focus on walking groups, stress reduction, or yoga for flexibility and balance might hold more of an appeal. A more robust evidence base on activity patterns across workplaces would help practitioners and researchers identify and characterize segments in need of greater physical activity in their workplace of interest, and develop appropriately targeted interventions.

Beyond targeted approaches, there is a need for continued innovation in individually tailored evidence-based behavior change strategies that meet workers' needs and preferences for increased engagement in physical activity. Tailored intervention approaches often work alongside and complement targeted approaches; delivering behavior change strategies designed for one specific person in response to an assessment (201). For example, just-in-time adaptive interventions are a novel type of intervention methodology that leverage the ubiquity of smartphones to provide tailored behavior change assistance in response to data collected in real-time (202). The sparse yet promising evidence base on just-in-time adaptive interventions and other individually tailored mHealth and eHealth physical activity interventions indicates the direction in which tailored workplace physical activity interventions should innovate in the future (203,204). This research did not investigate the use of tailored interventions but the identification of two segments (exercisers and non-exercisers) suggest that the measures collected in real time would need to vary based on segment. As an example, a tailored intervention for the segment of non-exercisers might be based on a prompt to get up and move every 30 minutes while the measure used to prompt exercisers might be based on heart rate or getting into one's cardio zone. Sensitivity to what are appropriate measures to tailor on reflects the importance of self-efficacy; tailoring should be based on a goal that the individual believes is both achievable and important enough to engage in.

Development of organization-wide interventions that are capable of broad dissemination and implementation are also needed. The current diffusion of workplace policies and environmental supports for physical activity is positive, but adoption of these interventions remains far from satisfactory (205). These organization-wide interventions may provide greatest flexibility for workers to engage in physical activity in whichever way they see fit, and are key to nurturing a culture of health. This dissertation research suggests that as an organization plans for worksite health promotion programming and allocation of resources they should consider the needs of all of the workers; or if limited resources preclude this holistic approach, be conscious about what group of workers they are most interested in reaching. Aerobics classes or "Biggest Loser" competitions may attract very different segments of workers; adding a walking path around the work campus and paid time to use it may benefit more workers and in ways that extend beyond increasing physical activity. Ideally, a wide variety of options to increase worker health would be considered.

In conclusion, promotion of physical activity in the workplace may be strengthened by greater understanding of activity patterns and innovation in individual-focused and organization-wide physical activity interventions. A comprehensive workplace physical activity program, informed by segmentation and utilizing evidence-based strategies, may optimally impact workers' levels of physical activity and have other physical, social and emotional health benefits as well.

APPENDIX A: PHYSICAL ACTIVITY SEGMENTATION STUDIES AMONG ADULTS

Authorship	Data Analysis	Study Sample	Country	Sample Size	Age Range	Measured Physical Activity Variables	Physical Activity Assessment Method	Number of Classes	Description of Classes	Investigated Class Associations with Demographics	Investigated Class Associations with Anthropometrics	Investigated Class Associations with Objectively-Measured Physical Activity Levels
Mooney et al., 2015	Finite mixture modeling	A longitudinal cohort study, the NYC Neighborhood and Mental Health in the Elderly Study II (NYCNAMES-II).	United States	3,497	65-75	Sports, exercise, walking, light housework, heavy housework, home repairs, lawn work or yard care, outdoor gardening, caring for others	Physical Activity Scale for the Elderly (PASE)	5	Least Active, Walker, Domestic/gardening, Athletic, Domestic/gardening athletic.	Borough of residence, Home type, Sex, Age, Education Race/ethnicity, Health, Household income	Body mass index	No
Silverwood et al., 2011	Finite mixture modeling	Population-based birth cohort study, the Medical Research Council's 1946 National Survey of Health and Development.	United Kingdom	5,362	31-53	Walking, cycling, gardening, do-it-yourself activity, sport or leisure activity, vigorous housework, heavy gardening, heavy building or do-it-yourself, sport or vigorous leisure activity, leisure-time physical activity	Minnesota Leisure Time Physical Activity Questionnaire	Separate latent class analyses for walking (2), cycling (2), and leisure-time physical activity (3).	Two walking latent classes were identified representing low and high levels of activity. Two cycling latent classes were identified representing low and high levels of activity. Three latent classes were identified for leisure-time physical	Sex	No	No

									activity: ‘‘low a ctivity", ‘‘sports and l eisure activity’’, and ‘‘gardening and do-it-yourself activities’’.			
Morrow-Howell et al., 2014	Finite mixture modeling	Subsample from 2008-2010 Health and Retirement Study	United States	4,593	Mean = 69.45, SD = 8.91	Personal leisure, civic/religious, physical exercise, interior household chores, exterior household chores, managing medical conditions, employment/computer use, interpersonal exchange/ helping others, community leisure.	Activity-related items from 2009 Health and Retirement Survey - Consumption and Activities Mail Survey	5	Low Activity, Moderate Activity, High Activity, Working, and Physically Active	Age, Sex, Education, Number of people in household, Number of living child, Race, Marital status, Family assets, Family income, Social support , Number of close friends, Urban/rural, Neighborhood safety, Neighborhood cohesion, Health, CES-D, Mobility/ADL	No	No

Cheung et al., 2015	Finite mixture modeling	A population-based cohort study, Northern Manhattan Study (NOMAS)	United States	3,293	Not reported for analytic sample. The mean age for cohort at baseline is 69.	Walking, jogging or running, hiking, gardening or yard work, aerobics or aerobic dancing, other dancing, calisthenics or general exercise, golf, tennis, bowling, bicycle riding, swimming or water exercise, horseback riding, handball, racquetball, squash, other.	Adapted items from National Health Interview Survey	6	No Activity, Rare Activity, Active Weekly, Active Every Other Day, Active Daily, Highly Active	Age, Sex, Race or ethnicity, Education, Smoking status, Moderate alcohol consumption, Social support	Body mass index, Waist circumference	No

APPENDIX B: SELECTION OF ACTIVITIES OF DAILY LIVING AND EXERCISE BEHAVIOR INDICATOR VARIABLES (N = 239)

	N	**%**	Included in analysis §
Light housework (median)			Yes
0 = At or below the median in engagement (times/week)	145	60.67	
1 = Above the median in engagement (times/week)	94	39.33	
Heavy housework			Yes
0 = No engagement during past week	154	64.44	
1 = Engaged in at least once during past week	85	35.56	
Light gardening			No^
0 = No engagement during past week	150	62.76	
1 = Engaged in at least once during past week	89	37.24	
Heavy gardening			No
0 = No engagement during past week	197	82.43	
1 = Engaged in at least once during past week	42	17.57	
Total gardening*			Yes
0 = No engagement during past week	144	60.25	
1 = Engaged in at least once during past week	95	39.75	
Machinery work			No
0 = No engagement during past week	220	92.05	
1 = Engaged in at least once during past week	19	7.95	
Care for elderly or disabled			No
0 = No engagement during past week	225	94.14	
1 = Engaged in at least once during past week	14	5.86	
Care for children			Yes
0 = No engagement during past week	183	76.57	
1 = Engaged in at least once during past week	56	23.43	
Ride a bicycle or stationary cycle using legs only			Yes
0 = No engagement during past week	183	76.57	
1 = Engaged in at least once during past week	56	23.43	
Light strength training			Yes
0 = No engagement during past week	161	67.36	
1 = Engaged in at least once during past week	78	32.64	
Moderate to heavy strength training			Yes
0 = No engagement during past week	181	75.73	
1 = Engaged in at least once during past week	58	24.27	
Stretching or flexibility			Yes
0 = No engagement during past week	150	62.76	
1 = Engaged in at least once during past week	89	37.24	

Aerobics or aerobic dancing			No
0 = No engagement during past week	195	81.59	
1 = Engaged in at least once during past week	44	18.41	
Aerobic machines involving arms and legs			No
0 = No engagement during past week	199	83.26	
1 = Engaged in at least once during past week	40	16.74	
Total aerobics**			Yes
0 = No engagement during past week	167	69.87	
1 = Engaged in at least once during past week	72	30.13	
Stair or step machine			No
0 = No engagement during past week	203	84.94	
1 = Engaged in at least once during past week	36	15.06	
Swim (laps)			No
0 = No engagement during past week	231	96.65	
1 = Engaged in at least once during past week	8	3.35	
Martial arts, boxing, wrestling			No
0 = No engagement during past week	237	99.16	
1 = Engaged in at least once during past week	2	0.84	
Walk leisurely (median)			Yes
0 = At or below the median in engagement (times/week)	138	57.74	
1 = Above the median in engagement (times/week)	101	42.26	
Walk fast or briskly			Yes
0 = No engagement during past week	156	65.27	
1 = Engaged in at least once during past week	83	34.73	
Jogging or running			Yes
0 = No engagement during past week	188	78.66	
1 = Engaged in at least once during past week	51	21.34	
Total sports and recreational activities***			No
0 = No engagement during past week	204	85.36	
1 = Engaged in at least once during past week	35	14.64	
§ Reported by at least 20% of the sample			
^ Combined with heavy gardening			
* Combined light and heavy gardening			
** Combined aerobics/aerobic dancing and aerobic machine			
*** Combined tennis, baseball/softball, basketball, golf, bowling, and dancing			

APPENDIX C: TIMELINE OF TIMEPOINT MEASUREMENTS USED IN MANUSCRIPT 3

Measure	**PACE Baseline Year**												
	2015										**2016**		
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
CHAMPS		T1					T3						
Accelerometry					T2						T4		

APPENDIX D: LIST OF MET VALUES ASSIGNED TO EACH ACTIVITY ON CHAMPS QUESTIONNAIRE

Item	**MET Weight**
Light Intensity	
Light housework (such as general upkeep, sweeping, vacuuming, laundry)	2.5
Light gardening (such as watering plants)	2.3
Care for elderly or disabled (lifting, pushing a wheelchair)	2.5
Care for children (lifting, carrying, pushing a stroller)	2.5
Stretching or flexibility (do not count yoga or Tai-chi)	2.5
Walk leisurely (such as for transportation, for exercise, on a treadmill, or with dog)	2.5
Moderate-Vigorous Intensity	
Heavy housework (such as washing windows, cleaning gutters. Mowing the lawn)	4.5
Heavy gardening (such as spading, raking)	4.4
Machinery work (such as your car, truck, or lawn mower)	3.0
Ride a bicycle or stationary cycle using legs only	5.0
Light strength training (such as hand held weights of 5 pounds or less or elastic bands)	3.0
Moderate to heavy strength training (such as hand-held weights of more than 5 pounds, weight machines or push-ups)	7.0
Aerobics or aerobic dancing (step aerobics, hi-low impact aerobic videos)	5.0
Aerobic machines involving arms and legs (such as rowing, cross country ski machines or elliptical machines)	7.0
Stair or step machine	7.0
Swim (laps)	7.0
Martial arts, boxing, wrestling	7.5
Walk fast or briskly (such as hiking, for exercise, transportation, on treadmill, or with dog)	3.5
Jogging or running (outside or on treadmill)	7.0
Play tennis	8.0
Play baseball/softball	5.0
Play basketball (do not count time on the sidelines)	7.0
Play golf - (count walking time only)	4.0
Bowl	3.8
Dance (African, modern, tap, hip-hop, break, during church)	4.5
Note: MET = metabolic equivalent. Scored according to Stewart et al. (2001) and Ainsworth et al. (2011). "Other" responses scored according to activity.	

APPENDIX E: DESCRIPTION OF MEASUREMENT TIMEPOINTS IN MANUSCRIPT 3

Timepoint	Instrument	Dates of measurements during timepoint	Notes
T1 (N=307)	CHAMPS	4/27/2015 – 6/4/2015	Excludes 2 observations with outlying CHAMPS measurement dates at 8/4/2015 and 10/15/2015. Excludes 1 observation with missing MVPA MET minutes estimate (insufficient data).
T2 (N=247)	Accelerometry	7/22/2015 – 9/27/2015	
T3 (N=217)	CHAMPS	9/28/2015 – 11/19/2015	Excludes 38 outlying CHAMPS measurement dates between 3/23/2016 – 4/5/2016
T4 (N=118)	Accelerometry	1/19/2016 – 3/17/2016	

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