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Psychosocial and environmental work factors and their effects on obesity and cardiovascular disease risk among firefighters

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Psychosocial and environmental work factors and their effects on obesity and cardiovascular disease risk among firefighters

DISSERTATION

submitted in partial satisfaction of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

in Public Health

by

Javier Garcia Rivas

Dissertation Committee:
Professor BongKyoo Choi, Chair
Professor Dean Baker
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2019

DEDICATION

To

my lovely wife and children
for their unconditional love, support and patience
during the doctoral program and the writing process of this dissertation.

Things have never been easy for us but they are without a doubt better-off with you three.

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ABSTRACT OF THE DISSERTATION

Psychosocial and environmental work factors and their effects on obesity and cardiovascular disease risk among firefighters

By

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Doctor of Philosophy in Public Health

University of California, Irvine, 2019

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During the last two decades, US firefighters have gradually gotten heavier to become the third heaviest occupational group in the country and workplace has been identified as a salient environmental factor which contributes to the development of obesity among this occupational group. Nevertheless, few studies have studied the impact of the work environment and individual characteristics integrated in a socio-ecological model design.

The long term goal of this investigation is to make a contribution to the research of individual, occupational and environmental factors that play a role in the development of obesity in firefighters. The specific aims of this study were to 1) determine the association between worksite food environmental factors and obesity among male firefighters who work 24-hour shifts. 2) investigate the relationship between health-related (nutrition and physical exercise) self-efficacy and weight outcomes i.e. body mass index, waist circumference and body fat percent. Concurrently, analyze important occupational preceding variables (e.g. institutional, supervisor and coworker support) that facilitate/hamper self-efficacy; and 3) compare four sedentary behavior measures

(number of steps, <100 and <150 counts per minute threshold in actigraphy, sitting time by posture sensor inclinometer and self-reported sedentary work) with regards to obesity and CVD risk factors.

The present study found an indirect association between environmental fast-food density and obesity indicators in male firefighters. The association was mediated by station- and individual-level eating behaviors. Secondly, organizational support was the most important occupational predictor of exercise and nutrition self-efficacy. However, only exercise self-efficacy was directly associated negatively with all three obesity indicators (Waist circumference, BMI and Body Fat Percent). Finally, self-reported sedentary work was identified as the best predictor of CVD risk factors when compared to other physical activity and sedentary behavior measures. Sitting time assessed by inclinometry was also an important predictor of systolic blood pressure and HDL cholesterol. Other measures of occupational inactivity (step count and sedentary behavior assessed by actigraphy) did not perform well as predictive tools.

The present dissertation offers an integral theoretical approach to a public health issue based on an occupational health perspective in order to prevent weight-related diseases and improve the health of firefighters.

INTRODUCTION

Obesity as a relatively modern epidemic is a rising health risk, and antecedent for the majority of modern chronic diseases (World Health Organization, 2017). Important public health efforts have been put in place, however the positive outcomes are still miniscule in comparison to the increase of obesity prevalence and its health effects (Chan & Woo, 2010). Individual-centered intervention studies have also shown small and inconclusive findings on weight change and weight loss maintenance (Teixeira et al., 2015). Addressing socio-environmental conditions that promote weight gain has been understudied and findings in the general population have been inconclusive (Jeffery, French, Raether, & Baxter, 1994; Powell & Chaloupka, 2009; Story, Neumark-Sztainer, & French, 2002). Therefore, focusing on specific populations in relatively controlled environments such as schools and worksites will eventually facilitate the development of more precise models which help investigate explanatory pathways in the development of disease (Choi et al., 2011a; X. Wang, Armstrong, Cairns, Key, & Travis, 2011). An overarching model which offers insight into the individual and occupational/environmental factors that contribute to the development of obesity among firefighters may enable better focused intervention strategies. A model which could allow the analysis and exploration of such pathways between work and obesity is the Socio-ecological Model.

The Socio-ecological Model responds to a systemic approach to reality and represents the set of multi-level elements that have been proposed to maintain an etiological relationship with health (Grzywacz & Fuqua, 2000). The elements within the socio-ecological model are organized into five subsystems (intrapersonal, interpersonal, organizational, community and public policy) in which interrelations are established. The public policy overarching system contemplates the set of organisms, structures and regulations. The community subsystem considers the relationships between organizations. The organizational subsystem refers mainly to dynamics within organizations and institutions. The intrapersonal subsystem addresses issues related to the interaction of the individual with his/her immediate social contacts, i.e. family, friends, and coworkers.

The dynamics established within the subsystems and from one level to the next are essential to the understanding of the mechanisms of behavior change and hence behavior-related health outcomes (Blanchard et al., 2005; Robinson, 2008). The use of a conceptual framework that accounts for the multi-layered complexity of the phenomenon is warranted for a better understanding of its psychosocial mechanisms and subsequently improve intervention strategies (McLeroy, Bibeau, Steckler, & Glanz, 1988).

For instance, Choi et al. (2011a) developed a theoretical framework based on an socio-ecological approach which elucidates the physiological and psychosocial pathways that contribute to the development of obesity in the worksite context among firefighters. The model takes into account the individual, interpersonal and organizational levels, however it does not consider the community level i.e. individual and aggregate weight-related effects of neighborhoods where firehouses are located. This has been acknowledged by the authors in subsequent work (Choi et al., 2017). Moreover, models that help to identify the pathway of work-related obesity risk factors will facilitate improved intervention strategies aimed at diminishing the risk of developing obesity, its associated health consequences and work-related effects (Pandalai, Schulte, & Miller, 2013).

The macro/public policy level conditions that may influence the development of obesity among firefighters are not within the scope of this work.

The present study is aimed at exploring the role of the individual, occupational and environmental factors in the development of obesity in firefighters. To achieve this, we will analyze this issue by addressing the following specific aims:

Aim 1:

a. Explore the relationship between fast-food density around fire stations and obesity among firefighters.

b. Determine whether eating behaviors (e.g. eating out at restaurants or fast-food chains) are a mediator between fast food density and obesity measures among firefighters.

Hypothesis 1a: There is a positive significant association between fast-food density and obesity indicators among firefighters.

Hypothesis 1b: I hypothesize that the association between fast-food density and obesity is mediated by station- and individual-level eating behaviors.

Aim 2:

a. Determine whether health-related self-efficacy (nutrition and physical exercise) is associated with obesity among firefighters.

b. Identify organizational and psychosocial work factors (e.g. institutional, supervisor and peer social support, etc.) that facilitate health-related self-efficacy (nutrition and physical exercise).

Hypothesis 2a: Health-related self-efficacy (nutrition and physical exercise) is negatively associated with obesity among firefighters.

Hypothesis 2b: Health-related self-efficacy (nutrition and physical exercise) is a mediating mechanism between psychosocial work factors (e.g. institutional, supervisor and peer social support, etc.) and obesity indicators.

Aim 3:

Compare three sedentary behavior measures (<100cmp, posture sensor inclinometer and self-reported sedentary work) with regards to obesity and CVD risk factors.

Hypothesis 3: It is plausible that the precision of position in sitting versus standing will be more accurate than self-reported measures and the <100 counts per minute threshold in actigraphy. Thus, posture based sedentary behavior will be more strongly associated with obesity and CVD indicators in firefighters.

Chapter 1

The FORWARD Study

According to the World Health Organization, obesity has doubled worldwide since the 1980s. By 2014, more than 1.9 billion (39%) adults aged 18 and over would be overweight, of whom more than 600 million (13%) were obese (World Health Organization, 2017). Every year, at least 2.8 million people die from diseases associated with obesity or overweightness (World Health Organization, 2017). In the United States more than one third of adults are obese (Centers for Disease Control, 2014). If the trends of obesity maintain the current pace, by 2030 more than half of the population in 39 states could be obese (Levi, Segal, St Laurent, Lang, & Rayburn, 2012). Earlier calculations suggest that obesity may generate costs greater than those attributable to smoking, drinking, and poverty (Strum, 2002). In 2008, the estimated medical cost of obesity was $147 billion per year (Finkelstein, Trogdon, Cohen, & Dietz, 2009). In addition to the societal and public health costs, obesity is associated with work-related expenses manifested in the form of decreased worker productivity and increased need for support services and disability management (Finucane et al., 2011). Obesity-related disabilities cost employers an average of $8,720 per employee every year (Finkelstein, Strombotne, & Popkin, 2010). Furthermore, studies suggest that the indirect cost for employers of obesity-related presenteeism (report to work while sick) is far greater than the direct costs of the medical treatment (Finkelstein, daCosta DiBonaventura, Burgess, & Hale, 2010; Johns, 2010)

In the U.S., there are over 1.2 million voluntary and professional firefighters (USFA, 2017). In a study among 41 occupational groups, Caban et al. (2005) found that firefighters are the third heaviest male occupational group in the United States. In a 5-year follow-up study from 1996 to 2001, Soteriades et al. (2005) reported an increase of obesity prevalence from 35% to 40% among HAZMAT firefighters in Massachusetts. Obesity is a known factor for deaths associated with cardiovascular disease (CVD) (Flegal, Graubard, Williamson, & Gail, 2007). Sudden cardiac arrest accounts for more than half of firefighter deaths (Fahy, LeBlanc, & Molis, 2014). These on-the-job CVD-related deaths are higher than any other occupational group in the country (Kales, Soteriades, Christoudias, & Christiani, 2003). Additionally, obese firefighters have an increased risk of work-related injuries (Jahnke, Poston, Haddock, & Jitnarin, 2013; Poplin, Harris, Pollack, Peate, & Burgess, 2011). In California, the obesity prevalence of firefighters from a south coastal region was lower (between 20% and 25%) than that reported in other studies and lower than the general US population (Choi, Dobson, Schnall, & Garcia-Rivas, 2016). However, the prevalence was similar to that of the region's population (County of Orange Health Care Agency, 2014). This could suggest that the community and neighboring environment surrounding the worksite may have an influence on the organization and its employees.

The identification of individual-level factors associated with weight loss and maintenance have been often explored (Dalle Grave, Centis, Marzocchi, El Ghoch, & Marchesini, 2013). There are empirical studies that address obesity from a perspective that takes into account the impact of the social environment, and analyze the environment of people's homes and their relationship with availability of dietary options (Paeratakul, Ferdinand, Champagne, Ryan, & Bray, 2003; Rundle et al., 2009). Also, there have been efforts which try to integrate genetic and social environmental factors in order to combat obesity (Faith & Kral, 2006). However, the issue has proven to be exceptionally intricate to study by focusing on the general population just as it has been on the individual level (Chan & Woo, 2010). Therefore, it is essential to address this issue with a comprehensive approach that considers the different interrelated layers. Few studies have researched this health issue taking into account the workplace as a central component (Brunner, Chandola, & Marmot, 2007; Chandola, Brunner, & Marmot, 2006; Choi, Dobson, Schnall, & Garcia-Rivas, 2016; Choi, et al., 2011a; Choi et al., 2010; Kouvonen, Kivimäki, Cox, Cox, & Vahtera, 2005). Considering that individuals spend most of their waking hours at work, it is essential to analyze the workplace as the most important institutional system for economically active individuals (Malik, Blake, & Suggs, 2014). At the same time, it is imperative to consider the social and environmental factors that may contribute to the development of obesity in individuals within the workplace. In order to do this, the socio-ecological model offers a suitable approach to integrate the different subsystems, which in interaction can help provide a comprehensive explanation for complex health outcomes such as obesity (Blanchard, et al., 2005; Cassel, 2010; Pratt et al., 2007; Townsend & Foster, 2013).

In the field of occupational health and obesity, specific working conditions have been identified as factors associated with obesity (Choi et al., 2011b). In general working populations, such factors include: sedentary work (M. Ishizaki et al., 2004; Mummery, Schofield, Steele, Eakin, & Brown, 2005; Ostry, Radi, Louie, & LaMontagne, 2006), shift work (Morikawa et al., 2007; Scheer, Hilton, Mantzoros, & Shea, 2009; van Amelsvoort, Schouten, & Kok, 1999; Yamada, Ishizaki, & Tsuritani, 2002), long work hours (Lakdawalla & Philipson, 2007; Shields, 2002; Solovieva, Lallukka, Virtanen, & Viikari-Juntura, 2013), high job strain (low job control and high work demands) (Masao Ishizaki et al., 2008;

Kivimaki et al., 2006), and isostrain (high job strain and low social support at work) (Brunner, et al., 2007). In firefighters, shift-work, sedentary work, eating behaviors and exercise were identified as contributing factors to work-related obesity (Choi, Dobson, Schnall, & Garcia-Rivas, 2016). Likewise, emergency calls and sleep interruptions are also work factors related to poor eating habits and high caloric snacking (Dobson et al., 2013). Such work characteristics may promote fast food consumption among firefighters. However, none of the previous studies have examined the influence of the neighborhood fast-food density surrounding firehouses and its association with obesity in firefighters. Aims 1a and 1b are designed to bridge this gap in the current literature.

Similarly, in the individual-level sphere, few studies have explored the effects of health-related self-efficacy on obesity in general adult populations (Annesi, Johnson, & McEwen, 2015; Rodriguez, Rodriguez, & Dominguez, 2015). Self-efficacy research in firefighters has mostly focused on stress coping, emotional distress, and post-traumatic stress disorder (Dowdall-Thomae, Gilkey, Larson, & Arend-Hicks, 2012; Heinrichs et al., 2005; Lambert, Benight, Harrison, & Cieslak, 2012; G. Prati, L. Pietrantoni, & E. Cicognani, 2010; C. Regehr, Hill, & Glancy, 2000; Shrira et al., 2015). However, only one pilot study has anecdotally reported associations between obesity and self-efficacy in firefighters (Cheskin et al., 2014). In addition, social support has been widely regarded as an important resource to enhance self-efficacy (Wang, 2005). Therefore, aims 2a and 2b will provide empirical evidence on the effects of health-related self-efficacy and obesity among professional firefighters. In the general population, self-efficacy and the social environment have been shown as important determinants for nutrition and physical activity (McNaughton, Crawford, Ball, & Salmon, 2012). However, this is yet to be explored in firefighters.

Finally, physical activity and sedentary behavior, have been extensively associated with obesity and cardio-metabolic risk biomarkers (Dunstan, Healy, Sugiyama, & Owen, 2010; G. N. Healy, Matthews, Dunstan, Winkler, & Owen, 2011). Among firefighters, physical activity during work and leisure time is also associated with CVD and metabolic risk factors (Durand et al., 2011; Leischik et al., 2015). In addition, sedentary work is associated with obesity indicators (Choi, Dobson, Schnall, & Garcia-Rivas, 2016). Physical activity and sedentary behavior are traditionally assessed by self-report (A. A. Thorp, Owen, Neuhaus, & Dunstan, 2011). Actigraph-based research has recently shown important support for the association between physical activity/sedentary behavior and CVD risk factors, including obesity (Evenson, Buchner, & Morland, 2012; Hagstromer, Oja, & Sjostrom, 2007; G. N. Healy, et al., 2011). In firefighters, actigraphy has helped to characterize 24-hour physical activity during work and leisure time (Kim et al., 2012). Also, it has been used to characterize sedentary, light, moderate, and vigorous physical activity (Keevil et al., 2016). The cut points commonly used are <100 counts per minute (cpm), 100-1950cpm, 1952-5724cpm, and 5725-9498cpm respectively (Jeremey, 2012). However, the sedentary cut-points were originally established in specific study populations e.g. teenage girls in (Treuth et al., 2004) and these do not necessarily reflect the characteristics of sedentary behavior during work hours. It is therefore, indispensable to explore and characterize sedentary behavior in firefighters.

With the addition of new tools for surveillance of sedentary behavior, e.g. posture sensor inclinometer within the same Actigraph device, it is possible to track individual activity patterns (Peterson, Sirard, Kulbok, DeBoer, & Erickson, 2015). However, this tool has not been used to track worksite physical activity/sedentary behavior in firefighters. As a result, our aim 3 is intended to fill this lacuna in the literature by comparing three sedentary behavior measures (<100cmp, posture sensor inclinometer and self-reported sedentary work) and explore their association with obesity and CVD risk factors among firefighters.

The three aims described above will help identify organizational, behavioral and environmental factors that may contribute to the development of obesity and other CVD risks in firefighters. To tackle these aims, analyses were carried out using data collected for the Firefighter Obesity Research: Workplace Assessment to Reduce Disease, also known as the FORWARD Study (Choi, et al., 2011a).

Description of the parent study

As part of Phase I of the CDC/NIOSH funded FORWARD study (Grant Number: 1R21OH009911), conducted between November 2010 and April 2011, researchers in the Center for Occupational and Environmental Health (COEH) at the University of California, Irvine (UCI) developed a firefighter specific questionnaire with the help of four focus groups which included representation from every rank (i.e. firefighters, engineers, captains and chiefs). The questionnaire was designed to assess health behaviors and the work context as a key contributor to the development of obesity in firefighters (Dobson, et al., 2013).

Phase II ran between May 2011 and December 2012. During the two years, data was obtained from a representative sample of 365 firefighters working for the Orange County Fire Authority (OCFA).

OCFA firefighters participated in an ongoing wellness and fitness program (WEFIT) in collaboration with the COEH at UCI. Firefighters were encouraged to participate in a voluntary annual physical evaluation. Complete fire crews, usually made up of 3 to 5 members, visited the clinic located at OCFA headquarters. During the WEFIT visit, height and weight were collected by an experienced exercise physiologist who recorded data to the nearest 1/8 of an inch. Weight was measured using a Detecto D1130 mechanical weight scale and height with a Seca 216 clinical stadiometer. BMI was obtained with the following formula: weight in pounds/(height in inches)2 * 703. Waist circumference was recorded with non-stretchable tape. The FORWARD Study questionnaire was administered (with a participation rate of 84%) during the WEFIT visit, and clinical data was obtained through an extraction form filled out by the COEH physicians. Study participants were asked to sign Health Insurance Portability and Accountability Act (HIPAA) disclosure forms indicating the measures that would be extracted from their clinical record. The study was approved by the University of California Irvine, Institutional Review Board (IRB), HS#: 2010-7823.

The inclusion criteria required firefighters to be over 21 years old, to have worked at OCFA for at least one year, to visit the COEH clinic for their biennial WEFIT screening, and to agree to complete the work-specific questionnaire developed by Choi et al. (2011b). The questionnaire collected demographics and worksite information (firehouse number, size of fire crew, number of shifts worked per month), fast food consumption and self-reported physical activity data (see appendix 1). Data for the present study has been de-identified.

During Phase II of the FORWARD study, I collaborated with the research team as project manager. In this role, I was in charge of approaching firefighters to explain the study, get verbal and written informed consent, and administer the questionnaire in accordance with IRB requirements. I was also in charge of recruiting firefighters for the substudy (see description below). In addition to data collection, I was responsible for data entry and management and for keeping recruitment records.

Substudy

Between September 2011 and July 2012, a subsample of 83 firefighters was randomly selected to participate in a follow-up sub-study. The participation rate for this subsample was 50%. Firefighters who agreed to participate in this stage were asked to wear a physical activity monitor (ActiGraph GT3X+) and record their food intake in a diary for 1 on-duty day (24 hr) and 1 off-duty day (24 hr). Information about on-duty day activities was obtained from a call record provided by the participants with the approval of their captain. There were no substantial differences between participants in the main survey (N=365) and those of the sub-study (N=83) (Choi, Ko, et al., 2014).

Research strategy

The three specific aims are conceived within a socio-ecological theoretical framework which is intended to contribute to the understanding of the worksite food environment, organizational, and individual factors that contribute to the development of obesity among firefighters. In order to achieve this, aims 1-3 were designed to 1) analyze the influence of the neighborhood fast food density surrounding the firehouses; 2) determine whether health-related self-efficacy is associated with obesity measures in firefighters; and identify work psychosocial factors that facilitate health-related self-efficacy (nutrition and physical exercise); 3) determine whether the <100cpm sedentary threshold in accelerometry (intensity) is an optimal predictor of obesity and cardiovascular disease risk factors in firefighters and compare three sedentary work measures (<100cmp, position sensor inclinometer and self-reported sedentary work) with regards to obesity and CVD risk factors.

Statistical analyses for the three aims were carried out using the SPSS software package.

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Chapter 2

(Aims 1a and 1b)

1. Background

Even though the general US population has maintained stable physical activity patterns in the last 20 years, the US spending on fast-food has increased from $6 billion to $110 billion during the past 30 years (Block, Scribner, & DeSalvo, 2004). Fast-food outlets have increased from about 30,000 in 1970 to more than 233,000 in 2004 and have been classified as the most rapidly expanding sector of the US food distribution center.

The recommendations of the WHO (World Health Organization) establish a caloric intake of 2000 to 2500 Kcal/day for an adult male and from 1500 to 2000 kcal/day for women. The caloric value and fat content in fast-food may play an important role in the overall diet and health of individuals (Paeratakul, et al., 2003). One single fast-food meal could account for a total day's worth of calories (Barro, Griggs, Leonhardt, & Cain Miller, 2014), which coupled with poor human adaptation to recognize foods with high caloric content could be major contributors to the development of obesity (Brunstrom, Drake, Forde, & Rogers, 2018). High caloric content (i.e. total kcal intake) is generally higher among people who report eating at fast-food restaurants (Paeratakul, et al., 2003). Similarly, an association exists between fast-food intake and increased body mass index (BMI), weight gain (French et al., 2010) and obesity (Maddock, 2004). Orange County ranks number four among 100 of the largest metropolitan areas in the country with the fastest growing wage gaps (Waheed, Romero, & Sarmiento, 2014) and fast-food density is known to be higher in black and low-income communities (Block, et al., 2004). OCFA firehouses are evenly geographically distributed across the county, which locates firehouses in communities with diverse racial/ethnical composition and socioeconomic conditions. Furthermore, firefighters are required to work 24 hour shifts, including consecutive 42, 72, and 96 hour shifts (Choi, Dobson, Schnall, & Garcia-Rivas, 2016; Choi, Schnall, et al., 2014; Dobson, et al., 2013). This means firefighters virtually live part-time in their worksites. Furthermore, in data obtained from the FORWARD Study (Choi, et al., 2011b), 85% of them report sometimes or always eating out in restaurants or fast-food while on-duty. Therefore, I expect that the diet and obesity indicators of firefighters will be influenced by the food environment of the communities they serve.

Fast-food density refers to the number of businesses in a determined radius that is identified by its accessibility via walking or driving (Burns & Inglis, 2007). There is no consensus as to the amount of miles considered within walking/driving distance. However, some studies use national census data and zip codes to delimit geographical areas (Fleischhacker, Evenson, Rodriguez, & Ammerman, 2011; Maddock, 2004). Other studies exploring fast-food restaurant density in databases containing spatial data of businesses have used 0.5, 1, 2 and 5 mile radii (Reitzel et al., 2014). A major drawback in measuring fast-food density is the elemental definition of fast-food, but it can be generally defined as convenience food purchased in self-service or carry-out eating venues without wait service (Pereira et al., 2005). In a systematic review of fast-food density studies, Fleischhacker et al (2011) found that almost half of the studies used their own set of characteristics to define fast-food. It is therefore essential to clearly define the study variable and its operationalization in order to facilitate replicability of future studies. Available tools like the North American Industry Classification System, which is used for classifying businesses based on the processes used to produce goods or services, is the standard for Federal statistical agencies (Dalziel, 2007). Using the appropriate code for all business searches can offer a sample of fast-food outlets (e.g. NAICS Code 722513 used for categorizing "Limited-Service Restaurants") when using databases like ReferenceUSA. This same code has been used previously to measure fast-food density (Reitzel, et al., 2014). This commercial database was also field validated and used to identify tobacco outlet distribution (D'Angelo, Fleischhacker, Rose, & Ribisl, 2014). ReferenceUSA is a promising tool for identifying environmental food characteristics surrounding worksites.

Evidence shows that the local environment plays an important role in the food consumption of individuals (L. Moore, Diez Roux, Nettleton, Jacobs, & Franco, 2009). Nevertheless, no studies exist to analyze the local environment of work location among firefighters. The availability of both restaurants and supermarkets is crucial to the decision-making of neighboring communities. For instance, a study in urban New York found that local density of healthy food was associated with lower prevalence of obesity (Rundle, et al., 2009). Conversely, Reitzel et al. (2014) found an association between fast-food density proximity and BMI. The present study intends to explore whether there is a similar association between fast-food density and obesity among firefighters. In comparison with other occupations with high obesity prevalence, firefighting is one of the most physically demanding occupations (Phillips et al., 2012; Von Heimburg, Rasmussen, & Medbø, 2006). This could suggest that there are other work-related conditions that may have an effect on the development of obesity and weight related diseases. The workplace has been identified as a salient environmental factor which contributes to the development of obesity among firefighters (Choi, et al., 2011a; Choi, et al., 2010). In addition, the workplace has been regarded as an important intervention site to control and reverse obesity among shift workers (Morgan et al., 2011). However, little is known about the effects of the neighborhood food environment in worksite based studies exploring the contributing factors of obesity.

Because firefighters can be regarded as living part-time at home and part-time at work, it is imperative to consider the home and working environmental conditions that may influence the behaviors contributing to obesity among firefighters.

The proposed theoretical model (see figure 1) takes into account the neighborhood environmental factors which may contribute to the development of obesity among firefighters. In addition, the model includes organizational and individual characteristics that may explain the pathway of the association.

Other covariates have been identified as salient factors associated with obesity. Age and sex are well-established in the literature as contributors to overweight and obesity in the general population (Y. Wang & Beydoun, 2007). In working populations, sedentary work and shift work are other known occupational confounders (Kubo et al., 2010; Macagnan et al., 2012; Mummery, et al., 2005). Specifically in firefighters, a previous study identified sedentary work and shift work as important contributors to obesity (Choi, Dobson, Schnall, & Garcia-Rivas, 2016).

Exercise has been used as part of worksite interventions to prevent and reduce obesity and other CVD risk factors, including diet and weight loss (Blair, Piserchia, Wilbur,

& Crowder, 1986; Thorndike, 2011). Also, exercise is known to affect the dietary intake and energy balance of individuals (Södergren, McNaughton, Salmon, Ball, & Crawford, 2012). Furthermore, exercise coupled with diet yield improved sustained weight loss (Curioni & Lourenco, 2005).

Based on current research literature in the general population and in specific working populations, including firefighters, the following aims are proposed for exploring the association between the occupational food environment and obesity in firefighters:

Aim 1 (a and b)

a. Explore the relationship between area fast-food density and obesity among firefighters.

b. Determine whether station- and individual-level eating behaviors are mediators between area fast-food density and obesity among firefighters using path analysis.

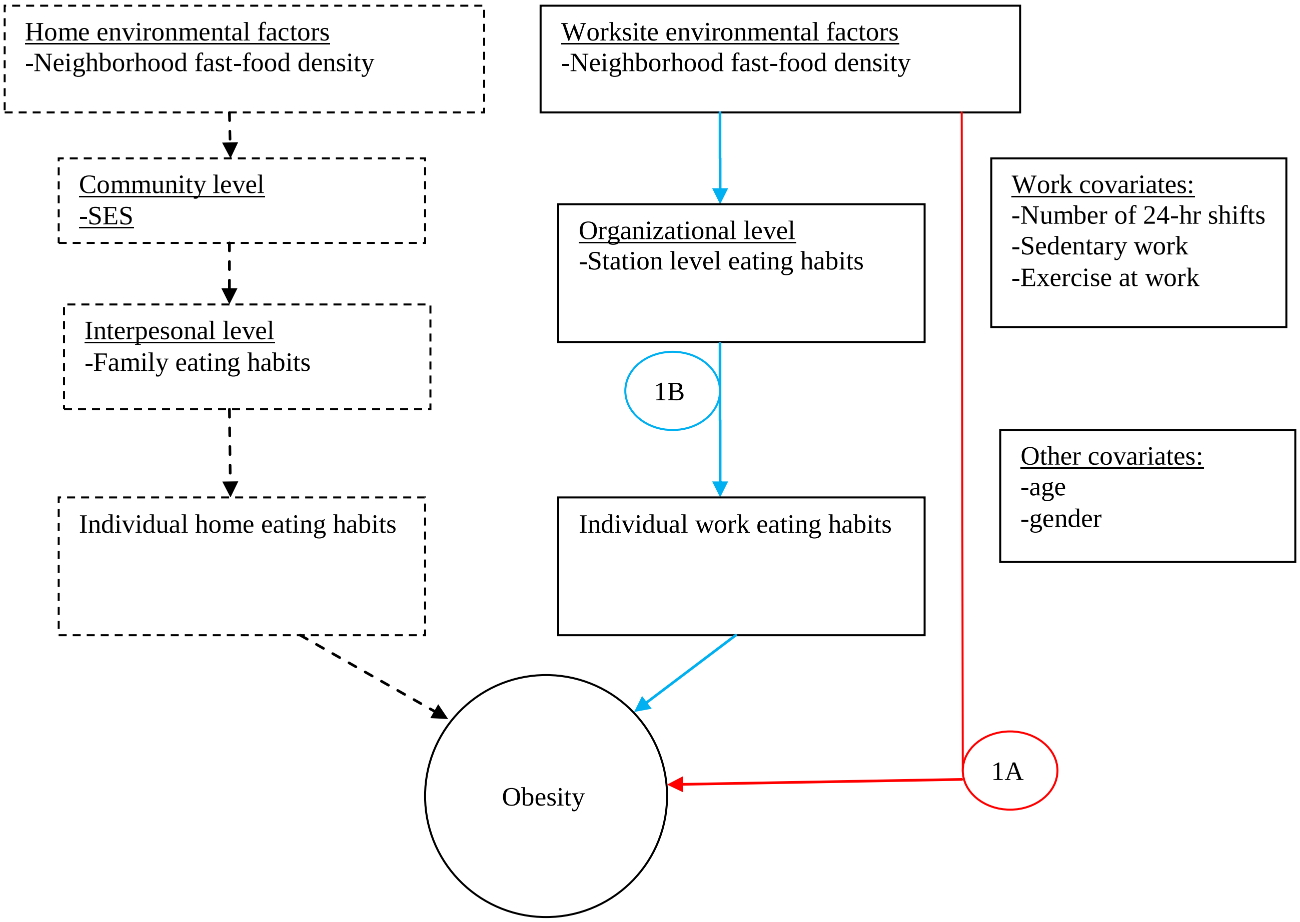

Figure 1. Socio-ecological model on worksite environmental factors, organizational and individual determinants of obesity.

2. Methods

1. Aim 1a

In order to address aim 1a shown in pathway 1A in figure 1, the relationship between geographical fast-food density and work-related obesity was explored. Data on the number of businesses within a 0.5, 1, 2 and 3 mile radius of each fire station was used to assess fast-food density using Reference USA. Other studies have used these same distance radii when studying area fast-food density as a risk factor of obesity (Jeffery, Baxter, McGuire, & Linde, 2006; L. V. Moore, Roux, Nettleton, Jacobs, & Franco, 2009).

a. Sample

The distribution of firefighters in Orange County may be biased by self selection into firehouses which are the farthest from inner cities and have fewer fire calls. Nevertheless, firefighters are also known to choose firehouses with frequent fire calls in search of action. Firefighters with higher ranks and more seniority tend to be heavier than their opposites (Choi, Dobson, Schnall, & Garcia-Rivas, 2016). However, firefighters with the highest rank and seniority also have the option to select their firehouse of preference. The choice can be for a number of reasons (e.g. wanting to work at a slower house, the desire for action and fighting fires - and thus selecting busier houses, wanting to be closer to home, preference for newer and better equipped houses, etc.). Younger and newer recruits do not have as many chances to select a fire station; they are generally assigned to one. Therefore, based on the numerous reasons considered for selecting into a specific house, I do not expect self selection to critically bias the study sample from the general OCFA firefighter population.

Due to the cross-sectional nature of the fast-food density measure, a time effect from exposure to the environment cannot be assumed although the sample was restricted to firefighters who had worked at their current fire station (at time of survey) for at least 1 year. Office workers (headquarters) were also excluded from the sample since their work is primarily on a 9am to 5pm schedule.

The FORWARD survey data includes information on how long firefighters have worked in the current firehouse (e.g. "When did you begin your current position: Year:") and the firehouse in which they worked before (e.g. "Have you changed work location during the past 5 years?" and " If Yes, when was the latest change? Year:"). It is hence possible to identify firefighters who have worked at their fire station for at least a year at the time of the study. 232 firefighters were considered for the analyses after excluding office workers and firefighters that had not worked for at least a year in their current fire station. Additionally, female firefighters made up only 2% of the sample (N=5) so they were excluded from the final sample (N=227). Nevertheless, the basic information on work and obesity of the female firefighters was reported in previous studies (Choi et al., 2016).

b. Measures

i. IV: environmental fast food density

Fast-food density data was collected in both 2011 and 2012. In order to assess the reliability of the data, an interrater correlation reliability test was performed. The average measures for the number of outlets in these two years had an ICC of 0.955. Also, the average number of outlets in 2012 (10.1) was slightly higher than in 2011 (8.1) although the difference was not statistically significant based on a one-sample t-test, suggesting that the 2011 fast-food density might be more conservative when attributing the environmental exposure of fast-food outlets to firefighters of a determined fire station.

Because the 0.5, 1, and 2 mile radii are nested within the 3 mile radius in the fast-food density data, each level was analyzed separately to explore the association with each obesity measure (Waist circumference, Body mass index, and Body fat percent). Other studies have used a 5 mile radius, but because of the plausibility of a large overlap in the FF density geographical surroundings within each fire house, the 3 mile radius was selected as the largest area limit for this study. The data shows that the 3 mile radius level has a more normal distribution of fast-food outlets compared to all other levels (0.5, 1, and 2 mile). Also, as the fast-food density area is reduced, the number of fast-food outlets shows less variability. For example, the number of fast-food outlets under the half-mile radius ranges between 0-2 with a mean of 0.63 (SD 0.6), and the 1 mile radius ranges between 0 and 7 fast-food outlets with a mean of 1.54 (SD 1.2). The 2 and 3 mile radius had a mean of 4.5 (SD 3.1) and 10.1 (SD 5.5), respectively.

ii. DV: waist circumference, BMI, percent body fat

As described in Chapter 1, body weight and height were obtained (BMI), body fat percent was measured with a skin-fold caliper and waist circumference was recorded with non-stretchable tape. All measures were collected by a trained exercise physiologist.

iii. Covariates

Age was entered into statistical analyses as continuous variable.

Shift work was self-reported as the total number of 24-hour shifts firefighters worked during the past month.

Sedentary work was measured with a single item "My job often requires sitting for long periods of time" and a 4 point Likert scale response set (1 = Strongly disagree, 2 = Disagree, 3 = Agree, 4 = Strongly agree) drawn from the MIDUS II study (Choi, et al., 2010; Ryff et al., 2007). Choi et al. (2016) have also reported test-retest reliability of this item.

Exercise at work was assessed with a single item asking "On average during the past year, how many days a week have your aerobic or cardio EXERCISE (work outs) met the following two criteria: •30 minutes or more in duration and •Medium (work up a sweat and slight heart rate increase) to vigorous intensity (work up a good sweat and rapid heart rate increase) at the fire station" with a four point response set (0 days/week; 1 day/week; 2 days/week; and 3 or more days/week.

Station level eating habits were assessed with two validated items (Thompson et al., 2002): "Estimate the % of firefighters in my station eating more than 5 servings of fruits (1 serving =1 medium fruit) and vegetables (1 serving = 1/2 cup) each day" and "Estimate the % of firefighters in my station eating foods that are high in cholesterol or fat". These items are recorded via a multiple choice percentage estimate of the number of firefighters that consume fruit/vegetables and foods high in fat/cholesterol i.e. 0%, 20%, 40%, 60%, 80%, 100%.

Individual eating habits was assessed in a four point Likert scale 1=5-6 servings a day; 2=3-4 servings a day; 3=1-2 servings a day; and 4=never/rarely when asked "How many servings of food do you eat (per day) that are high in fiber, such as whole grain bread, high fiber cereal, fresh fruits or vegetables? (a serving size: 1 slice bread, ½ cup vegetables, 1 medium fruit, ¾ cup cereal)". The same response set was used for a second item "How many servings of food do you eat (per day) that are high in cholesterol or fat such as fatty meat, cheese, fried foods or eggs? (a serving size: 3 ½ oz meat, 1 egg, 1 oz/slice cheese)". The fatty foods item was inverted and added to the fruit and vegetable item, the item response range is 2-8 (see table 4), with higher values indicating unhealthier eating habits.

Both, the station-level and individual-level items have been validated in previous studies with firefighters (Elliot et al., 2007). As suggested by Finney and DiStefano (2006) items were grouped into single measured variables: station level eating and individual eating behaviors. In both cases, station-level and individual eating behaviors were obtained by averaging the individual measures. In both cases, the fatty food items were reversed to reflect unhealthy eating behaviors. Additionally, for the station-level eating behaviors variable, the average of each station was used to reflect the aggregate calculation of the station-level behaviors.

c. Analyses

i. Multilevel model testing

Based on the structure of the data, in which firefighters are inherently nested within each firehouse, a multilevel (2 level) model was initially contemplated. Multilevel models consider the presence of data hierarchies by taking into account "residual components at each level and at the same time allow for the examination of the effects of group level and individual level variables on individual level outcomes while controlling for the non-independence of observations within groups" (Goldstein, 1995). Multilevel logistic regression analysis accounts for non-independence of observations within groups, and groups are seen as part of a larger population of groups (Diez-Roux, 2000). For a two-level (multilevel) analysis, the model is conceptualized as a two-stage system of equations where one equation is used to explain individual variation within each group and another equation is used to explain variations across groups (Diez-Roux, 2000).

However, after examining the intraclass correlation coefficients (ICC) to determine if multilevel data analyses were warranted, no station level clustering effect was found. ICCs were calculated to compare the clustering effect of the station level on the outcome of firefighters (BMI, waist circumference, and body fat percent) (Killip, Mahfoud, & Pearce, 2004). ICC is usually obtained with the following formula in order to determine the degree of covariance in the error terms of firefighters sharing the same fire station:

$\rho = \sigma^2_{u0j} / \sigma^2_{u0j} + \sigma^2_{eij}$, where

σ^2_{eij} = variance at level 1 – firefighters (for each outcome BMI, WC, BFP)

σ^2_{u0j} = variance at level 2 – fire stations

In SPSS this same results are obtained by using the F-statistic in the one-way analysis of variance (Hox, Moerbeek, & van de Schoot, 2017):

ρ= F-1 / F+ñ-1, where

ñ = the mean sample size

For instance, after running an ANOVA analysis for BMI, WC and BFP by station number, the following F-statistic values are obtained:

Table 1. Output from SPSS ANOVA table (N=230), df(52,178)

	F	p
Body mass index	1.39	0.060
Waist circumference	1.35	0.078
Body fat percent	1.30	0.110

The ICC for BMI is 1.390-1/1.390+4.4-1 = 0.087, where ñ is the total population 232 divided by the number of stations 52. The 95% confidence interval is obtained from the standard error based on the formula by Snijders and Bosker (2012, p. 21). This means that about 9% of the variance in BMI would be explained by the group (fire station) to which the firefighter belongs, however this is non-significant based on the 95% CI, values for other outcome measures and 95% confidence intervals are shown in table 2.

Table 2. ANOVA by station number for each obesity measure and ICC from F-statistic				
Obesity measure	F-statistic	ICC	95% confidence interval	
BMI	1.390	0.087	-0.032	0.206
Waist circumference	1.349	0.078	-0.039	0.195
Body fat percent	1.300	0.068	-0.047	0.183

The disadvantage with the formula above is that ñ considers that each of the fire stations have the same number of firefighters (i.e. data completely balanced), which is not the case in our sample. Therefore a more precise approach is to use an unconditional mixed model: Obesityij = $\gamma 00$ + $u0j$ + eij, where $u0j$ is the variance of the mean for each fire station around the overall mean Obesity score (Snijders & Bosker, 2012). Note that Obesity in the formula stands for all three obesity indicators (BMI, Waist circumference and Body fat percent). Each outcome was analyzed individually with their own mixed model as suggested by (Peugh & Enders, 2005). Based on the SPSS output, the variance of Obesity by station number is 0.765 with a residual of 8.99. So the ICC for BMI in this model is equal to: ρ = $\sigma 2u0j$ / $\sigma 2u0j$ + $\sigma 2eij$ = .765 / 8.99 + .765 = 0.078, which tells us that about 8 percent of the total variation in body mass index can be accounted for by which station in which each firefighter works.

Thus, it is evident that the calculation above using the ANOVA output overestimates the intraclass correlation coefficients. The calculation of the ICC for each obesity measure was done in this same way and results are shown in table 3 below.

Table 3. ICC obtained from unconditional mixed models.	
Obesity measure	ICC from mixed model method
BMI	0.078
Waist circumference	0.034
Body fat percent	0.027

As noted by Snijders and Bosker (2012), if the intraclass correlation coefficient shows no evidence of a nesting structure in the data set, it is best to proceed with the analysis of the data by single-level methods like ordinary least squares (OLS) regression analysis. Therefore, in order to explore the association between fast-food density and obesity, such regression analyses were performed for all three obesity indicators in order to address aim 1a.

ii. OLS models

Univariate regression analyses were conducted using each fast-food density radius as independent variables and each obesity indicator as outcome (Waist Circumference, Body Mass Index, and Body Fat Percent).

Model 1: $y = b_0 + b_1x_1 + e$

Model 2: $y = b_0 + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5 + e$

Model 3: $y = b_0 + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5 + b_6x_6 + b_7x_7 + e$

$$\text{Where } y = \begin{cases} \text{Waist Circumference} \\ \text{Body Mass index} \\ \text{Body Fat Percent} \end{cases}$$

, $x_1 = \begin{cases} 0.5 \\ 1 \\ 2 \\ 3 \end{cases}$ mile radius for area fast-food density

, x_2 = age
, x_3 = shift work
, x_4 = sedentary work
, x_5 = exercise at work
, x_6 = station-level eating habits
, x_7 = individual-level eating habits

2. Aim 1b

Finally, path analysis was used to test the association described in aim 1b, including the mediation effect of station- and individual-level eating habits. This pathway is illustrated by the label "1B" in figure 1. Path analysis is a multivariate method that allows the verification of causal models and the identification of direct and indirect contribution of independent variables that explain the variability of dependent variables. It is often regarded as an extension of multiple regression, where not only the direct effect of a set of exogenous (independent) variables on an endogenous (dependent) one is explored, but also the association between the predictor variables and the indirect influence of the variables on the dependent variables (Aron & Aron, 2001). It should be noted that this method does not prove causation but helps to make inferences from a theoretical causal hypotheses (Denis & Legerski, 2006).

The objective of the proposed path analysis is to explore the indirect association between environmental fast-food density and obesity among firefighters. This association is grounded on the Socio-Ecological Model, which in this case contemplates the organizational setting and individual behavioral factors as a potential cascade mechanism leading to obesity.

a. Sample

The sample for the SEM analyses was the same one used in Aim 1 (N=227 male firefighters).

b. Measures

i. IV: environmental fast food density

The 3-mile radius fast food density was used in the analyses of aim 1b.

ii. DV: waist circumference, BMI, percent body fat

The three obesity measures were also the same used in aim 1a (Waist Circumference, Body Mass Index and Body Fat Percent). As described in chapter 1, data was collected by trained a professional.

iii. Mediators: individual and station-level eating

Individual and station –level eating behaviors were the same variables used for aim 1a analyses. Additionally, age was included as a covariate in the path analysis models.

c. Analyses – Path analyses

i. Specification

A path diagram using SPSS AMOS 18 was elaborated to examine the mediating pathway between fast-food density and obesity. This procedure obeys the logic presented on path 1B in the conceptual model framed in figure 1.

Path analysis is a type of structural equation modeling, which is family of multivariate statistical models and essentially an extension of regression models (Hox & Bechger, 1998). These allow estimating the effect and relationships between multiple latent and/or observed variables. The purpose of the pathway proposed in this study is to predict the effect of station- and individual- level eating behaviors within a determined fast-food density environment on the obesity of firefighters as shown in figure 2. Note that eating behaviors in this study is understood as negative eating behaviors i.e. high fat and cholesterol rich food, and low fruit and vegetable consumption. The model suggests a pathway from a socio-ecological theoretical standpoint and its effect on the individual obesity of firefighters.

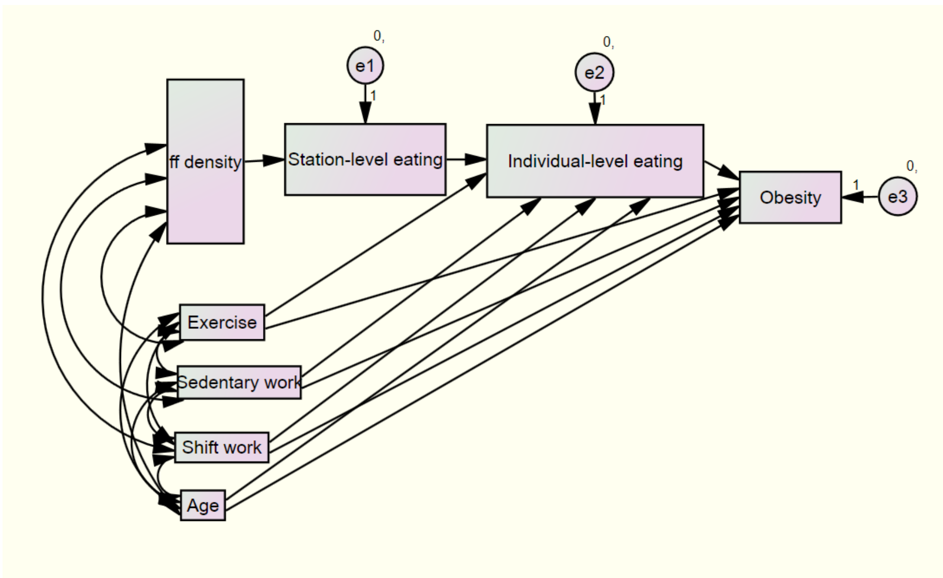

Figure 2. Path model linking fast-food density and obesity. Note that obesity refers to Waist circumference, BMI and Body fat percent analyzed individually (not aggregate).

Although BMI, Waist circumference and Body fat percent are highly correlated, previous studies show that each outcome has a divergent predicting value of cardiovascular disease risk factors (Choi, Steiss, et al., 2016). Therefore, as shown in figures 3, 4, and 5, outcomes were explored in individual models and not simultaneously. Adjusted direct and indirect effects were obtained using the output function in SPSS AMOS.

ii. Identification

Based on the t-rule and the recursive model rule, the presented model meets the required conditions of identification. The t-rule for structural equations with observed variables states $t \leq ½(p + q)*(p + q +1)$, where t is the number of unknown parameters and p + q is the number of observed variables (Bollen, 1989). According to the t-rule, the model is over-identified having 32 parameters (t) and 45 covariances. Although this is a necessary but not sufficient condition, the recursive rule states that all recursive models are identified, being this a sufficient but not necessary condition (Bollen, 1989).

iii. Goodness of fit

The data used for the analyses included missing values, therefore model analyses were carried out by estimating means and intercepts. When this is done, SPSS Amos does not report the goodness of fit index (GFI), which is a measure of fit between the hypothesized model and the observed data, the adjusted goodness of fit index (AGFI), which is a corrected index of the GFI and the standardized root mean square (SRMR), which is an index of the residuals between the observed and hypothesized covariance matrices. SPSS Amos does provide these indexes because it is not clear how to incorporate means and intercepts into the conventional formulas for these statistics. Since these measures are essentially transformations of the chi square, they can be affected by sample size. Alternatively, relative goodness-of-fit indexes such as the Bollen's incremental fit index (IFI) and the Tucker-Lewis index (TLI) are not affected by sample size. Cutoff criteria can be seen in table 6. It is known that samples above N=200 may yield significant chi square results and alter more traditional (GFI, AGFI, SRMR) fit indexes.

3. Results

3. 1 Descriptive results

The mean body mass index (BMI) was 27.64 (SD=3.07), waist circumference assessed in inches was 37.47 (SD=3.60) and body fat percent was 18.78 (5.72). Minimum and maximum measures can be seen in table 4.

Table 4. Descriptive statistics of measured variables in main model.

	Mean	SD	Min	Max	Range
Waist circumference	37.47	3.60	30.00	50.38	
BMI	27.64	3.07	21.76	40.30	
Body fat percent	18.78	5.72	6.53	37.04	
Individual eating habits	4.63	0.87	2	7	2-8
Station level eating habits	50.28	0.96	47.50	52.50	0-100
Fast-food density (3-mile radius)	10.12	5.5	0	27	

Regarding the observed variables, both station- and individual- level eating behaviors show a normal distribution. The 3-mile radius fast-food density indicator also showed a normal distribution and it was the better predictor when using a composite obesity measure which included all three obesity indicators (results not shown).

As to the included confounding variables in the multivariate model, shift work had a mean of 13.08 (SD=3.13) days, and 43.04 (SD=8.48) years for age. Sedentary work and exercise were measured in a 4 point Likert scale, their means and standard deviations were 2.39 (SD=0.73) and 3.28 (SD=0.85) respectively.

3. 2 Aim 1a: Ordinary least squares

As part of aim 1a, an analysis was done with each obesity indicator as outcome (BMI, Waist circumference and Body fat percent) and fast-food density at the 3 mile radius as predictor. After univariate analyzes all fast-food density levels (0.5, 1, 2 and 3 miles), no significant association was found between any of the first three radius levels and obesity. However, the association was statistically significant in two of the three measures (waist circumference and body mass index) when using the 3 mile radius level.

Working specifically with the 3-mile radius fast-food density measure, a small negative association on waist circumference and body mass index was observed (model 1). However these associations were not statistically significant after including confounders (model 2) and other mediating variables (model 3).

	Model 1	95% CI	Model 2	95% CI	Model 3	95% CI
Waist Circum.	-0.104	(-.19 – -.02)	-0.037	(-.12 – .05)	-.035	(-.12 – .05)
Body mass index	-0.072	(-.15 – .00)	-0.031	(-.10 – .04)	-.018	(-.09 – .06)
Body fat percent	-0.117	(-.25 – .02)	-0.011	(-.14 – .11)	.009	(-.12 – .13)

Table 5. Simple linear regression models with each obesity measure as outcome and the 3-mile radius as independent variable.
Model 1 is crude. Model 2 is adjusted for age, shift work, sedentary work, and exercise at work. Model 3 is adjusted for age, shift work, sedentary work, exercise at work, station-level eating habits, and individual-level eating habits.

3.3. Aim 1b: Path analysis

Although aim 1a was not confirmed i.e. no direct association was found between fast-food density and any of the obesity measures, aim 1b showed that the path direct associations are statistically significant. In all three models, fast-food density shows a coefficient of 0.19 in its association with station-level eating. The latter is in turn associated with individual-level eating behaviors; the coefficient for this association (0.15) was statistically significant. Finally, individual-level eating habits are associated with each obesity indicator: waist circumference (0.19), body mass index (0.22) and body fat percent (0.17), as shown in figures 3, 4, and 5.

There was a modest indirect association when considering a mediating path through negative (high fat and cholesterol content food plus low fruit and vegetable consumption) station-level eating habits and individual-level eating habits as elucidated in aim 1b and depicted the conceptual model (see figure 1).

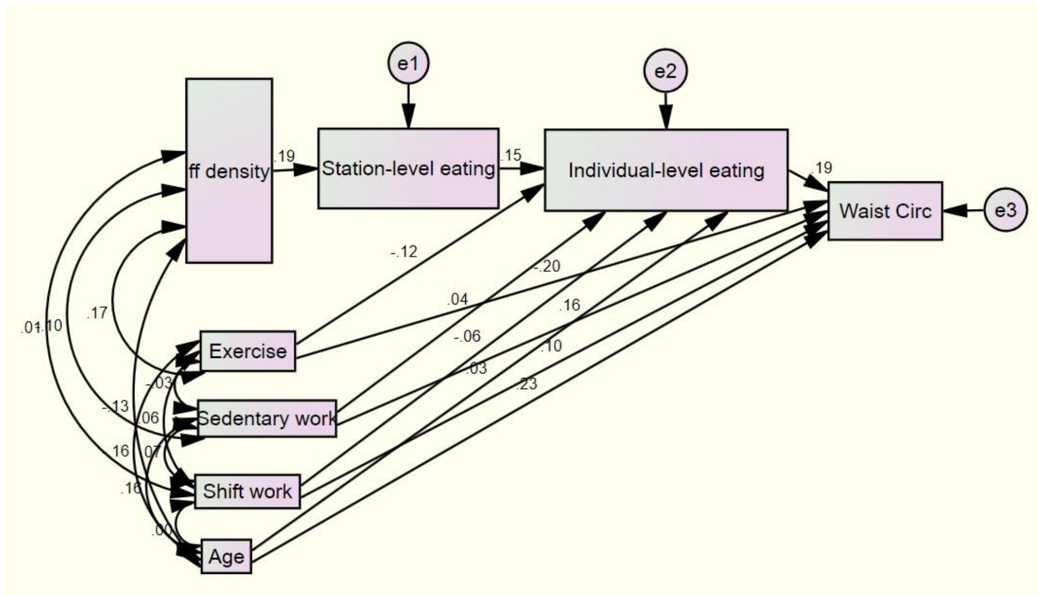

Figure 3. Waist circumference used as outcome in SPSS AMOS for path analysis defined in figure 2.

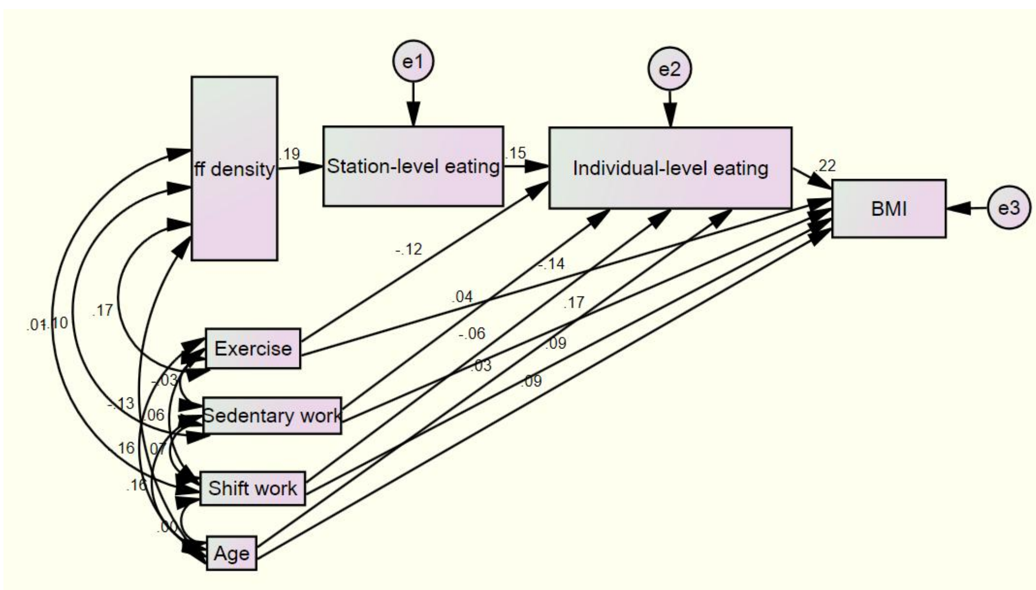

Figure 4. Body Mass Index used as outcome in SPSS AMOS for path analysis defined in figure 2.

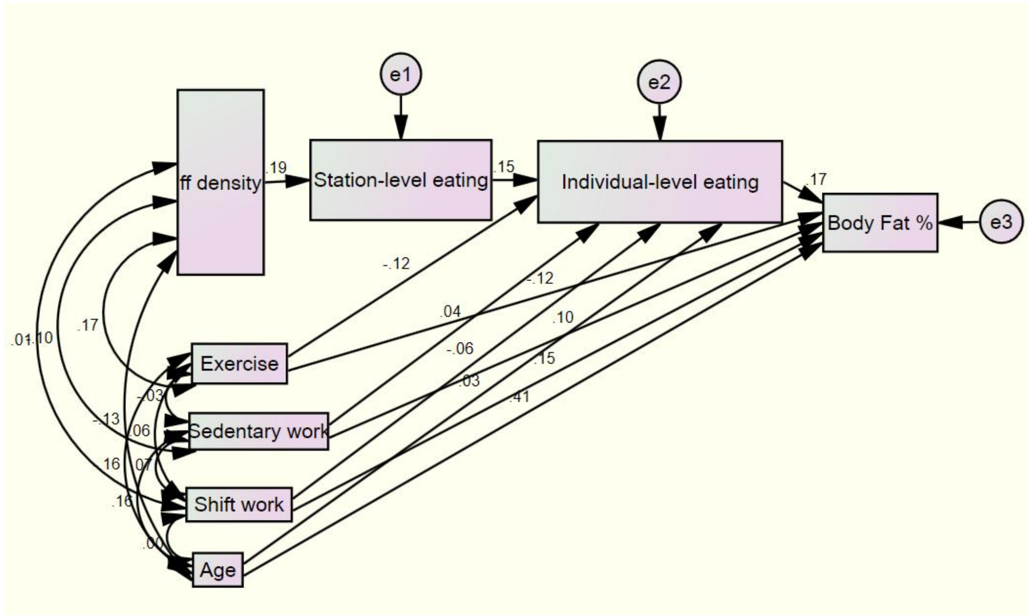

Figure 5. Body Fat Percent used as outcome in SPSS AMOS for path analysis defined in figure 2.

All causal pathways in the model were statistically significant and confounding variables were associated to the outcome measures in the direction reported in other studies.

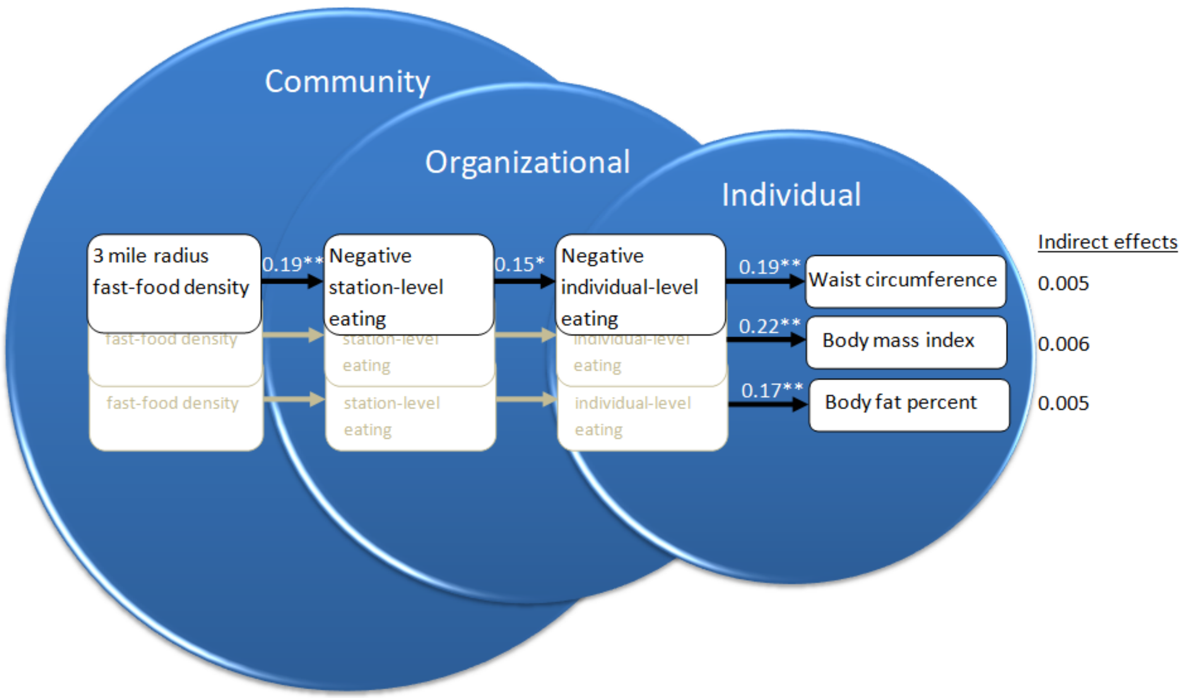

Figure 6. Standardized estimates and indirect effects on obesity outcome measures, including exercise, sedentary work, shift work and age in each model.

Model fit

All goodness-of-fit indexes were optimal (above .95) with the exception of the Tucker-Lewis index which shows results below 0.90: 0.833, 0.802 and 0.854 for the waist circumference, body mass index, and body fat percent models respectively. All other acceptable goodness-of-fit indicators are shown in table 6.

Table 6. Cutoff criteria (L. Hu & Bentler, 1999) and goodness-of-fit indexes for the path analysis of each model.

N=227	Cut off criteria	Waist circumference	Body mass index	Body fat percent
Chi square	p > 0.05	0.207	0.223	0.194
Incremental Fit Index – IFI	≥ 0.95	0.976	0.974	0.978
Tucker-Lewis Index – TLI	≥ 0.95	0.833	0.802	0.854
Comparative fit index – CFI	≥ 0.95	0.968	0.961	0.972
Root mean square error of approximation – RMSEA	< 0.06 to 0.08	0.041	0.039	0.043

4. Discussion

To the best of my knowledge, this study is the first to consider the fast-food environmental surrounding of the workplace in populations that work 24 hour shifts such as firefighters. So far, studies have explored food availability and quality inside the organization but do take into consideration the fast-food density surrounding the worksite. Most studies have focused on residence fast-food density but considering firefighters essentially live part-time at work (including sleep), it is imperative to bear in mind a multilayered model which takes into account the environmental, organizational and individual factors that interplay in the development of obesity in working populations.

Although the associations are modest, there is still a cascade effect from the environmental fast-food density to the individual obesity indicators in firefighters. Although Orange County firefighters have a lower prevalence of obesity in comparison to other regions in the U.S., they still show the same obesity prevalence as the general population where they belong. U.S. regions where the prevalence of obesity among firefighters (and other 24 shift workers) is higher may benefit from exploring the effects of fast-food density surrounding the workplace.

5. Limitations

The proposed recursive model is theoretically framed within the socio-ecological model and thus the causal pathways are explored in a “trickle-down” logic where the outcome is influenced by environmental, organizational, and individual factors. However, future studies may wish to analyze feedback loops in a non-recursive model. It is noteworthy that although the model indicators are adequate, they do not imply causation despite the depiction of the path diagram.

Path analysis in structural equation modeling treats observed variables as measured without error, which is not likely true in questionnaire-based constructs.

Limitations to the study’s external validity also exist. Although the sample is representative of the county’s fire department, the results may not be generalizable to other counties in the country, where obesity rates may differ considerably. However, a model which includes food availability as part of the work’s surrounding environment is recommendable.

Although the fast-food density measure may not fully capture the exact number of outlets and the quality of the food i.e. some fast-food may be unhealthier than others, it is an excellent tool that permits a geographical mapping of the workplace food surroundings (including supermarkets, full service restaurants and coffee shops).

6. Conclusions

This study adds to the existing literature of occupational risk factors of obesity among firefighters. Even though this is a worksite-based study, it includes an important environmental factor which has been investigated in large public health neighborhood studies. The amalgamation of these two traditionally independent lines of study (occupational and public health) is an important contribution of the present work. The role of Occupational Health in Public Health is not entirely clear and few studies are able to convey this link.

We observed an indirect association between fast-food density and obesity mediated by station- and individual-level eating behaviors. The present study suggests that the local food environment is a salient factor which should be considered in the ongoing efforts of occupational and public health researchers to improve the health of firefighters.

Although the indirect effect of environmental fast-food density on obesity is modest, the principal merit of this study lies on the theoretical and empirical framework that shows a plausible causal pathway in which obesity is the result of worksite and environmental conditions. This pathway is small albeit an important part of a complex process in which the workplace is a significant contributor in the development of obesity among male firefighters. Furthermore, the implications of this finding offer an additional layer of possible obesity intervention areas that would be beneficial to the health of firefighters.

Future studies in other firefighter and in the general working populations are needed to confirm the findings of this investigation.

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Chapter 3

(Aims 2a and 2b)

1. Background

Obesity is mainly regarded as the result of energy imbalance. A combination of high calorie intake and low calorie burning leads to fat storage and thus the development of obesity (Hill, Wyatt, & Peters, 2012). Obesity is an independent health-behavior risk factor for CHD mortality, partially mediated through other known cardiovascular risk factors (Jousilahti, Tuomilehto, Vartiainen, Pekkanen, & Puska, 1996; World Health Organization, 2000). US firefighters are a high risk occupational group for cardiovascular disease and sudden cardiac death accounting for almost half of on-duty deaths (Fahy, LeBlanc, & Molis, 2009; Haddock & Jahnke, 2011).

Although there is growing evidence that environmental factors (Brehm & D'Alessio, 2000; Sullivan, 2011) contribute to the increase of obesity in the US, there is still a lingering perception that obesity is a condition attributed only to personal responsibility (Brownell et al., 2010). While individual health behaviors are an important part in the prevention and control of obesity, it is noteworthy that many individual-level models often carry an intrinsic victim blaming component (Brownell, 1991; Crawford, 1977; Garro, 1995). Hence, it is important to situate individual-level factors in a contextual framework. In the present aim, this contextual framework refers to the worksite and its inherent organizational and psychosocial factors. Self-regulation behaviors seem to play an important role in the decision-making process and selection of food (Annesi, et al., 2015). Self-efficacy, which refers to the confidence in one's ability to modify behavior, has proven to be effective in predicting health-related behaviors (de Vries, Dijkstra, & Kuhlman, 1988). For example, it has been linked to a higher fruit and vegetable consumption (Brug, Lechner, & De Vries, 1995; Steptoe et al., 2003). Similarly, it has been associated with higher prevalence of exercise (Marcus, Selby, Niaura, & Rossi, 1992).

Figure 1 summarizes the conceptualization of the theoretical framework used in the present study. Aim 2a, depicted by path 2A in the figure describes the association between self-efficacy and obesity, this pathway also shows mediation through health behaviors. Aim 2b intends to explore the mediating role of health-related self-efficacy between social support at work and obesity in firefighters.

Health-related self-efficacy (nutrition and physical exercise)

Embedded in a socio-ecological model, the individual attitudes of firefighters along with the organizational and interpersonal level influences must be analyzed to understand their effects on the weight-related outcomes of firefighters. Self-efficacy has shown to be the most important individual level predictor of behavior change (Edell, Edington, Herd, O'Brien, & Witkin, 1987; Fontaine & Cheskin, 1997; J. Linde et al., 2004; J. A. Linde, Rothman, Baldwin, & Jeffery, 2006; Roach et al., 2003).

Bandura (1977) introduced the concept of self-efficacy as part of his Social Cognitive Theory which is aimed at predicting and explaining the mechanisms of human behavior and change. Bandura's Social Cognitive Theory underlies the importance of reciprocal determinism which refers to the interaction between environmental, cognitive, personal, motivational and emotional factors, among others (Bandura, 1994). This theoretical framework often overlaps conceptually and theoretically with other major health behavior change models such as the Health Belief Model, Transtheoretical model and Theory of Reasoned Action. However, self-efficacy is often considered the strongest construct in these models as a predictor of human behavior (Bandura, 1998).

Self-efficacy is essentially influenced by four factors: 1) Mastery Experience - Past successful experiences are the most important source of self-efficacy building, as these are based on perceived performance accomplishments. Repeated success on certain tasks increases positive self-efficacy. 2) Vicarious experience - Modeling is important because seeing (or imagining) other people successfully executing certain activities, may lead a person to believe that he or she has sufficient abilities to perform them with equal success. This source of self-efficacy acquires particular relevance in cases where individuals do not possess great knowledge of their own capacities or have little experience in the task. 3) Verbal Persuasion - Verbal persuasion is another important source of self-efficacy, especially in people who already have a high level of self-efficacy and need slightly more confidence to make an extra effort and achieve success. 4) Emotional Arousal - Multiple indicators of autonomic activation, as well as pain and fatigue may be interpreted by the individual as signs of their own ineptitude. In general, people tend to interpret elevated anxiety states as signs of vulnerability and as indicators of poor performance.

According to Bandura (2001), self-efficacy beliefs are the basis of human agency. This means that intentional behavior derives from perceptions of oneself having the ability and capacity to perform certain tasks.

Self-efficacy does not refer to a personality trait but to a specific attitude towards a certain behavior (AbuSabha & Achterberg, 1997). Therefore, it is unadvisable to measure self-efficacy as a stand-alone construct but rather linked to the behavior of interest (e.g. nutrition, exercise, weight loss, etc.). Accordingly, self-efficacy does not hold meaning by itself in terms of its measured level (high or low self-efficacy) without attaching it to a health behavior. One example of such operationalization, the health-specific self-efficacy scales, was created by Schwarzer and Renner (2009). In this paper, I explore two behavior specific dimensions of self-efficacy: nutrition and physical activity.

Social support

Social support can be generally regarded as "information leading the subject to believe that he is cared for and loved, esteemed, and a member of a network of mutual obligations" (Cobb, 1976). The three components in the definition are labeled as emotional, esteem and network support. These components are enclosed in what is known as emotional support. Other theoretical dimensions of social support include: instrumental support, informational support and appraisal support. Instrumental support refers to tangible aid and services that directly assist a person in need. Instrumental support is often provided by helping others do their work, take care of them, or help them pay their bills. House (1981) notes that instrumental support can also have psychological consequences on the recipient and therefore also be part of emotional support. Informational support includes the facilitation of advice, suggestions, and information that a person can use to address problems. Appraisal support involves the provision of information that is useful for self-evaluation purposes: constructive feedback, affirmation and social comparison. "Work supervisors, for example, may tell workers that they are doing good (or poor) work, or they may tell workers what constitutes the performance of an average worker and let them decide for themselves whether they are above or below average" (House, 1981).

Social support has long been studied as a predictor of health. In its absence, studies have identified a series of negative health outcomes from suicide to psychosocial and physiological health outcomes like tuberculosis (Cobb, 1976; Kumar et al., 2012; Reblin & Uchino, 2008). In its presence, it has shown to be a strong protective factor when compared to individuals lacking close social networks (Kumar, et al., 2012).

The association between self-efficacy and emotional social support has been confirmed in both the general population and firefighters (Karademas, 2006; Lambert, et al., 2012; Cheryl Regehr, Hill, Knott, & Sault, 2003; Warner, Ziegelmann, Schüz, Wurm, & Schwarzer, 2011). Specifically in firefighters, social support has been explored taking into account the "*who*" aspect of social support (who provides the support), given that almost all employees in work organizations have access to at least one supportive person at work (Cheryl Regehr, et al., 2003). This study simply found that firefighters with a higher seniority may have lower social support and lower self-efficacy. But, the PHLAME Study found that positive dietary support and positive exercise support were predictors of healthy behaviors (Elliot, et al., 2007). However, most studies use general scales that measure emotional social support and do not include items that capture other aspects of social support (e.g. instrumental, informational, appraisal) (Cowman, Ferrari, & Liao-Troth, 2004).

Some studies have used social support as mediator between high expectations (optimism or self-efficacy) and health (Dougall, Hyman, Hayward, McFeeley, & Baum, 2001; Scheier & Carver, 1985; Trunzo & Pinto, 2003). However, as this study is framed in a socio-ecological model that takes into account occupational characteristics as a higher aggregate level, social support is understood as part of the occupational setting which may enhance or diminish feelings of self-efficacy.

As is the case of self-efficacy, social support should be outcome-focused as this permits better aimed intervention proposals (Cohen & Wills, 1985). It is also important to note that perceived social support, i.e. self-reported, may be a more precise measure since it may only have an effect on the individual if actions are truly perceived as supportive (Varvel et al., 2007). However, self-reported outcomes may be biased by perceived self-efficacy; hence the use of objectively measured health outcomes in this study will partially control for this bias. Research that includes outcome-focused social support, as does the present work (including nutrition and exercise social support at work) represents a significant contribution in the theory and practice of social support. To be precise, this research addresses a central question posed by House (1981) regarding the foundation for practical application and intervention in social support: "*who gives what to whom regarding which problems?*"

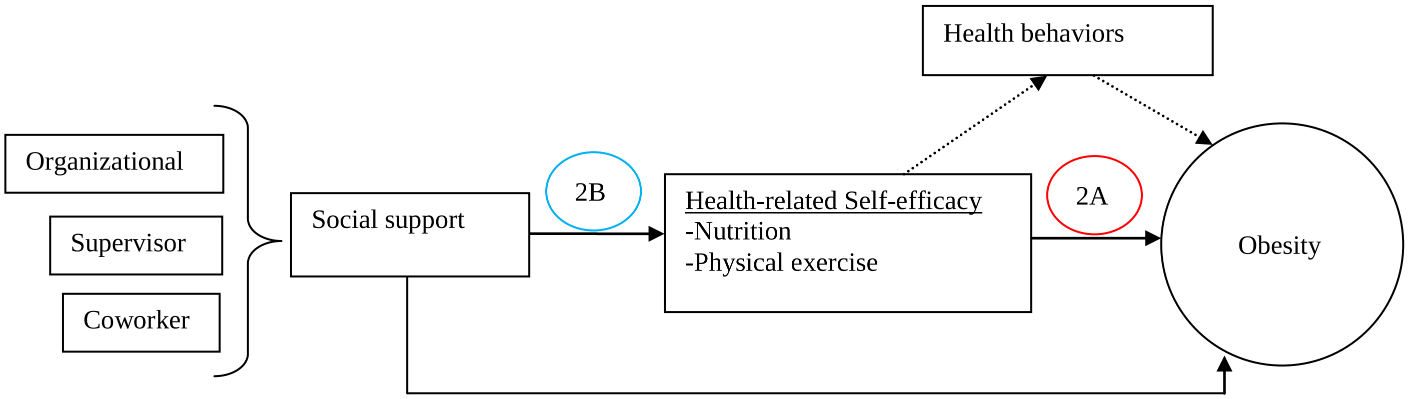

Figure 1. The conceptual model above shows the theoretical pathway of health-related self-efficacy and obesity.

Aims 2a and 2b in this chapter are structured to address specific gaps in the literature of both self-efficacy and social support. While self-efficacy has widely proven to be an important predictor of health, this association is found mostly with self-reported health outcomes (Gabriele Prati, Luca Pietrantoni, & Elvira Cicognani, 2010; Cheryl Regehr, et al., 2003). Aim 2a will explore the association of health-specific self-efficacy and objectively measured health indicators. Furthermore, as described above, social support research often lacks the clarity and inclusion of additional social support concepts (e.g. emotional, informational, etc.) and sources (e.g. supervisor, coworker, organizational) that can offer a more precise identification of the working conditions and dynamics that have an effect on health. Aim 2b will explore the association between social support and obesity through health-specific self-efficacy.

Aim 2 (a and b)

a. Determine whether health-related self-efficacy (nutrition and physical exercise) is associated with obesity among firefighters

b. Identify organizational and psychosocial work factors (e.g. organizational, supervisor and coworker support) that may facilitate health-related self-efficacy (nutrition and physical exercise).

2. Methods

2.1. Participants

Three hundred and sixty five (365) firefighters working under the Orange County Fire Authority participated in the FORWARD Study. The average age was 42.3 years, ranging from 18 to 61. There were 356 male and 9 female firefighters. Most were non-Hispanic white (79.2%), followed by Hispanic/Latinos (9.3%) and Asian (4.9%). Seventy-five percent (75.3%) were married. 52.5% had studied some high school or some college, 43.8% had college and 3.8% had graduate level education.

2.2. Measures

Height and weight were collected by an experienced exercise physiologist who recorded data to the nearest 1/8 of an inch. Weight was measured using a Detecto D1130 mechanical weight scale and height with a Seca 216 clinical stadiometer. BMI was obtained with the following formula: weight in pounds/(height in inches)2 * 703.

Health-related self-efficacy (nutrition and physical exercise) was each assessed on a 5-item Likert scale ranging from 1 "Very uncertain" to 4 "Very certain", with a score range of 5-20 (see appendix for a compendium of questionnaires). Both constructs are part of standard scales to measure health-related self-efficacy (Schwarzer & Renner, 2009). Nutrition self-efficacy is made up of 5 items (e.g. "I can manage to stick to healthy foods... even if I need a long time to develop the necessary routines"). According to authors of the scales, the reported Cronbach's alpha was 0.87 in a sample of 1,722 participants

(Schwarzer & Renner, 2009). Physical exercise self efficacy was also collected with the same response set for items like "I can manage to carry out my exercises intentions... even when I am tired". Shwarzer & Renner (2009) reported a Cronbach's alpha of 0.88 (N=1,567). The response range for both the nutrition and exercise self-efficacy scales is 5 to 20 points, with scores in the upper range meaning higher perceived self-efficacy towards the activity (see table 1).

An exploratory factor analysis using principal axis factoring based on Eigenvalues greater than 1 and Varimax-rotation yielded similar loading factor indicators for both scales in the FORWARD study sample and those reported by the original authors (Schwarzer & Renner, 2009). Cronbach's alpha for both scales was higher in the FORWARD Study sample, 0.94 and 0.92 for nutrition self-efficacy and exercise self-efficacy scales, respectively.

Table 1. Comparison of factor loadings and Cronbach's alpha between FORWARD Study and original scale authors.

	Nutrition self-efficacy		Exercise self-efficacy	
Items	FORWARD Study	Schwarzer & Renner, 2009	FORWARD Study	Schwarzer & Renner, 2009
Routines	0.871	0.831		
Try	0.902	0.771		
Rethink	0.890	0.808		
Support	0.788	0.780		
Planning	0.750	0.813		
Worries			0.815	0.843
Depressed			0.887	0.857
Tense			0.844	0.814
Tired			0.771	0.800
Busy			0.756	0.753
Cronbach's alpha	0.94	0.87	0.92	0.88

Co-worker support was made up of two items ("My coworkers encourage me to exercise" and "My coworkers exercise with me") on a four point Likert scale response set: 1 – strongly disagree and 4 – strongly agree (questionnaire response range: 2-8) (Choi, Steiss, et al., 2016). The items were obtained and adapted from the PHLAME firefighter study (Elliot, et al., 2007). Cronbach's alpha for coworker support was 0.853. A nutrition-specific coworker support questionnaire was not available in the FORWARD Study questionnaire.

Supervisor support was measured with a six-item scale with a score range of 6-24. Participants rated items across a Likert scale with a response set ranging from 1 – strongly disagree to 4 – strongly agree (e.g. "My supervisor is concerned about the welfare of those under him/her", "My supervisor is successful in getting people to work together"). The scale includes four items from the Job Content Questionnaire (JCQ) and two additional items from the House and Wells 1978 instrument (Choi, Ko, et al., 2014; House, 1981; Karasek et al., 1998). The JCQ includes items to reflect the emotional and instrumental social support, so additional items from the House and Wells instrument were added to capture the informational and appraisal social support. Cronbach's alpha for the six item scale was 0.977.

Independently, exercise-specific supervisor support was available as a single item dichotomized as "My supervisor… encourages me to exercise / not". Because, there was interest in the exercise-specific component of this item, it was used as a single item not part of the general supervisor support construct.

Organizational support was composed of six items measured by a four point Likert scale ranging from 1 – strongly disagree to 4 – strongly agree with a possible score range of 6-24. These items are a compendium from several instruments measuring procedural justice, organizational support (Beaton & Murphy, 1993; Choi, et al., 2011b; Karasek et al., 2017). Examples of the items used are "In the Fire Dept, there are procedures in place to hear the concerns of all those affected by a decision", "Management cares about my opinions". An item intended to measure conflicts between management and local union was dropped as it does not meet the definition of social support. The Cronbach's alpha for the six-item organizational support scale was 0.793. The complete items for the scale are available in appendix 1.

2.3 Covariates

Exercise was measured with a single item considering the amount of time spent at work doing exercise: "On average during the past year, how many days a week have your aerobic or cardio EXERCISE (work outs) met the following two criteria AT THE FIRE STATION:

• 30 minutes or more in duration
•Medium (work up a sweat and slight heart rate increase) to vigorous intensity (work up a good sweat and rapid heart rate increase)".

The response options were: 0 days/week; 1 day/week; 2 days/week; 3 or more days/week.

Eating habits at the fire station level was assessed with two validated items (Thompson, et al., 2002): "Estimate the % of firefighters in my station eating more than 5 servings of fruits (1 serving =1 medium fruit) and vegetables (1 serving = 1/2 cup) each day" and "Estimate the % of firefighters in my station eating foods that are high in cholesterol or fat". These items are recorded via a multiple choice percentage estimate of the number of firefighters that consume fruit/vegetables and foods high in fat/cholesterol i.e. 0%, 20%, 40%, 60%, 80%, 100%. The vegetable and fruit item was previously validated against food diary information from a subsample of firefighters in the FORWARD study (Choi, Schnall, & Dobson, 2016). This item was used to create an individual-level eating observed variable in chapter 2.

2.3 Statistical analysis

In order to compare results from the original developers of the nutrition and exercise self-efficacy scales. Exploratory factor analyses were performed mimicking those by the original authors of the scales (Schwarzer & Renner, 2009). The exploratory factor analysis was done using principal axis factoring based on Eigenvalues greater than 1 and Varimax-rotation.

Confirmatory factor analyses of both, nutrition and exercise self-efficacy questionnaires were performed as individual scales and as a general model.

Analyses were done in SPSS AMOS 18. Structural equation modeling analyses were performed with maximum likelihood discrepancy function and estimating means and intercepts to account for missing data.

Specification

Structural equation modeling (SEM) helps with the estimation of the simultaneous relationships between multiple latent variables. SEM is considered an extension of regression models (Hox & Bechger, 1998). The purpose of the SEM stemmed from the conceptual model presented in figure 2 (path 2a) is to determine the association between self-efficacy and obesity. The model for aim 2a is specified in figure 5 whereas the full structural equation model for aim 2b is specified in figure 7.

Identification

Models for aims 2a and 2b meet the required conditions of identification. The t-rule for structural equations modeling is based on the following formula $t \leq ½ (p + q) (p + q + 1)$, where t is the number of unknown parameters and p + q is the number of observed variables (Bollen, 1989). According to the t-rule, the models used to test pathways 2a and 2b are over-identified, meaning there is more than enough information in the data to estimate the parameters in the structural equation model. Although this is a necessary but not sufficient condition, the recursive rule is sufficient but not necessary. This rule indicates that all recursive models are identified (Bollen, 1989).

SEM1 to SEM12 are all models to test aim 2a. The first 3 models (SEM1, SEM2 and SEM3) are performed with the original 5-item scales for nutrition self-efficacy and exercise self-efficacy. Models SEM7 to SEM9 also explore the 5-item scales but include confounding variables (age, gender and ethnicity).

SEM4 to SEM6 analyze 3-item scales for nutrition and exercise self-efficacy without confounders and SEM10 to SEM12 include confounders: age, gender and ethnicity.

Table 2. Summary of the characteristics and location of each structural equation model in this chapter.

	5-item self-efficacy scales			3-item self-efficacy scales		
Aim 2a	Waist circumference	Body mass index	Body fat percent	Waist circumference	Body mass index	Body fat percent
No confounders	SEM1	SEM2	SEM3	SEM4	SEM5	SEM6
Found in…	Figure 3	Appendix 2	Appendix 2	Figure 4	Appendix 2	Appendix 2
Confounders	SEM7	SEM8	SEM9	SEM10	SEM11	SEM12
Found in…	Figure 5	Appendix 2	Appendix 2	Figure 6	Appendix 2	Appendix 2
Aim 2b						
Full model	SEM13	SEM14	SEM15	n/a	n/a	n/a
Found in…	Figure 7	Appendix 2	Appendix 2	n/a	n/a	n/a

Results for each structural equation model are summarized in tables 3, 4 and 5.

Goodness-of-fit

Goodness-of-fit indexes for structural equation rely primarily in indicators like Chi-square ($\chi 2$) and root mean square error of approximation (RMSEA). The first must be statistically non-significant ($\leq .05$) and the latter under 0.06-0.08. As alternative indicator of good fit for Chi-square, some authors have suggested $\chi 2/df$ ratios between 2 and 5 (Marsh & Hocevar, 1985). Additionally, IFI, TLI and CFI indexes are also used as indicators of goodness-of-fit when under 0.90 according to Hu & Bentler (1999).

3. Results

Confirmatory Factor Analysis

Confirmatory factor analysis of the nutrition self-efficacy scale was done with the 5 items in the original scale. Although the r-square results of the items support and planning were not substantially low, a 3-item version was also analyzed. Although there was a slight improvement in the model fit estimates, Chi-square and RMSEA did not reach the ideal cut points described in table 3, Chi-square > 0.05 and RMSEA < 0.06-0.08. All other indicators (IFI, TLI, CFI) were above the desired > 0.90 cut point.

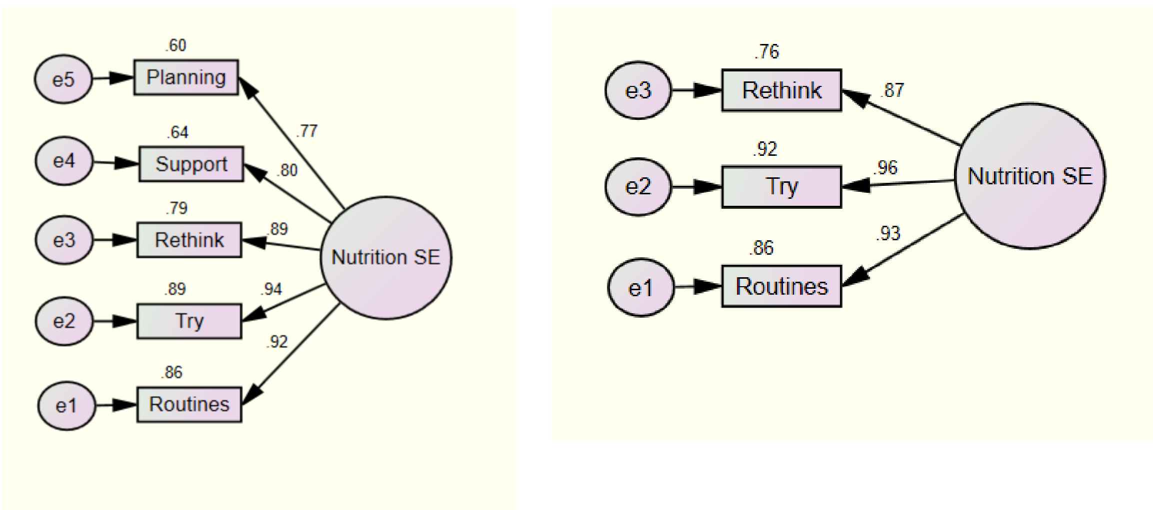

Figure 2. 5-item and 3-item CFA models for nutrition self-efficacy scales
5-item Model fit: Chi2 = 0.00 (CMIN/DF = 11.89) IFI=0.967, TLI=0.900, CFI=0.967, RMSEA=0.173
3-item Model fit: Chi2 = 0.00 (CMIN/DF = 5.96) IFI=0.990, TLI=0.970, CFI=0.990, RMSEA=0.117

Similarly, the exercise self-efficacy scale showed slight improvements in all model fit indicators, yet not enough to be considered optimal, especially the Chi-quare, RSMEA and CFI indicators.

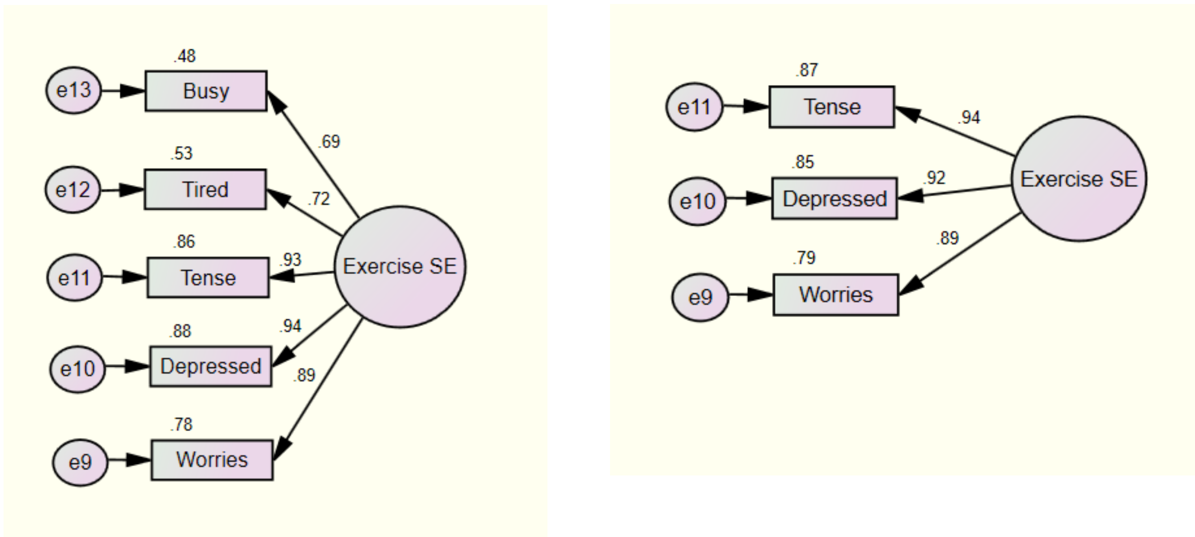

Figure 3. 5-item and 3-item CFA models for exercise self-efficacy scales
Model fit: Chi2 = 0.00 (CMIN/DF = 42.61) IFI=0.871, TLI=0.612, CFI=0.871, RMSEA=0.338
Model fit: Chi2 = 0.00 (CMIN/DF = 24.68) IFI=0.952, TLI=0.854, CFI=0.951, RMSEA=0.255

Interestingly, when the scales were analyzed as a general model, the 3-item version yields optimal results for all model fit indicators. Although statistically, the 3-item version shows better results statistically, there is no substantial theoretical justification for removing the two items in each scale. Therefore, analyses for the subsequent sections were performed taking into account the original 5-item version of both scales but also exploring its differences the 3-item versions.

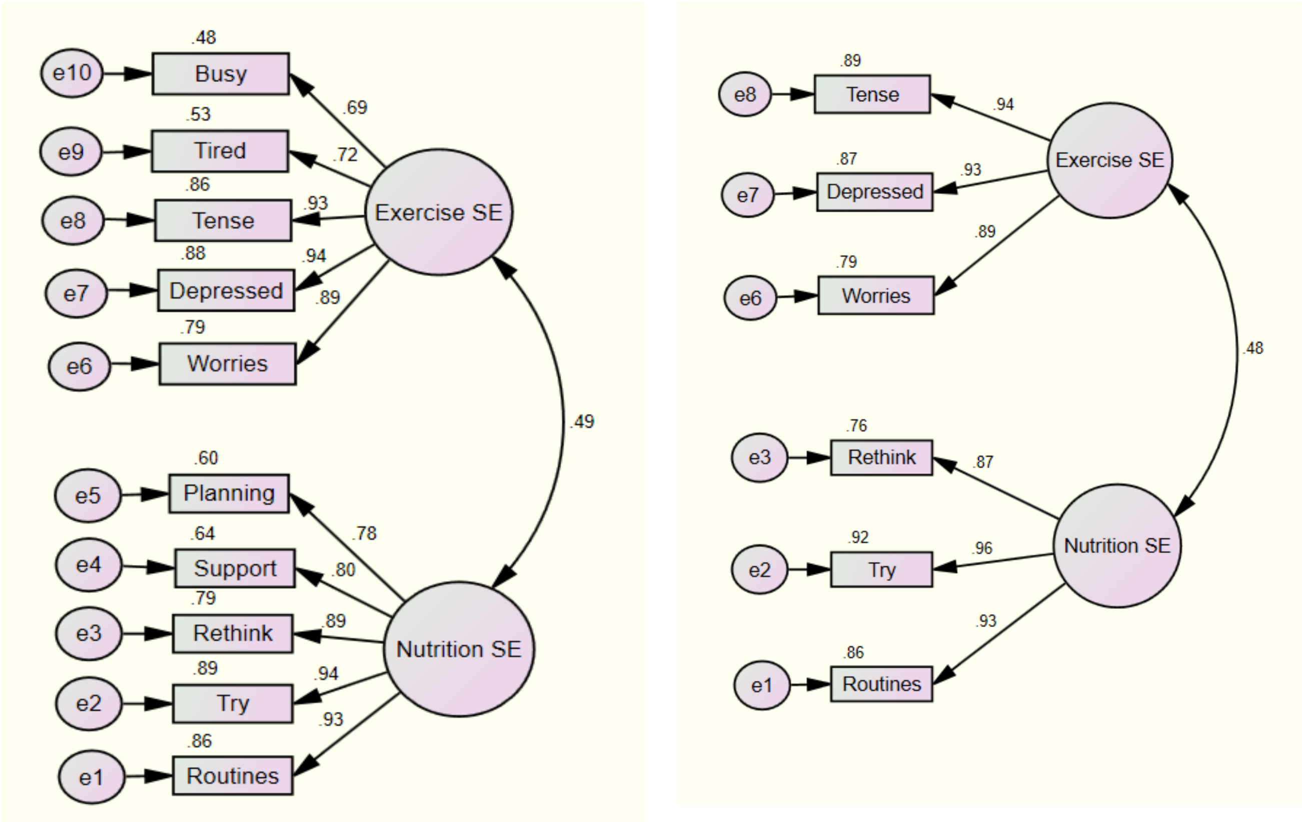

Figure 4. 5-item and 3-item CFA models for nutrition self-efficacy scales Model fit: Chi2 = 0.00 (CMIN/DF = 9.32) IFI=0.916, TLI=0.864, CFI=0.916, RMSEA=0.151
Model fit: Chi2 = 0.19 (CMIN/DF = 1.41) IFI=0.998, TLI=0.996, CFI=0.998, RMSEA=0.033

Nutrition and Exercise Self-Efficacy and Obesity Outcomes

In order to tackle aim 2a, structural equation modeling was used to find the association between self-efficacy and obesity as shown in figure 5. Each obesity indicator (i.e. Waist circumference, BMI and Body fat percent) is explored in individual models as observed variables and not as part of a larger latent construct since they have been shown as factors of distinct importance in predicting cardiovascular disease risk factors (Choi, Steiss, et al., 2016). For the sake of straightforwardness, only a visual representation of waist circumference is shown in the main text, but results for all three outcome measures are included in subsequent tables. Figures that include body mass index and body fat percent are shown in appendix 2.

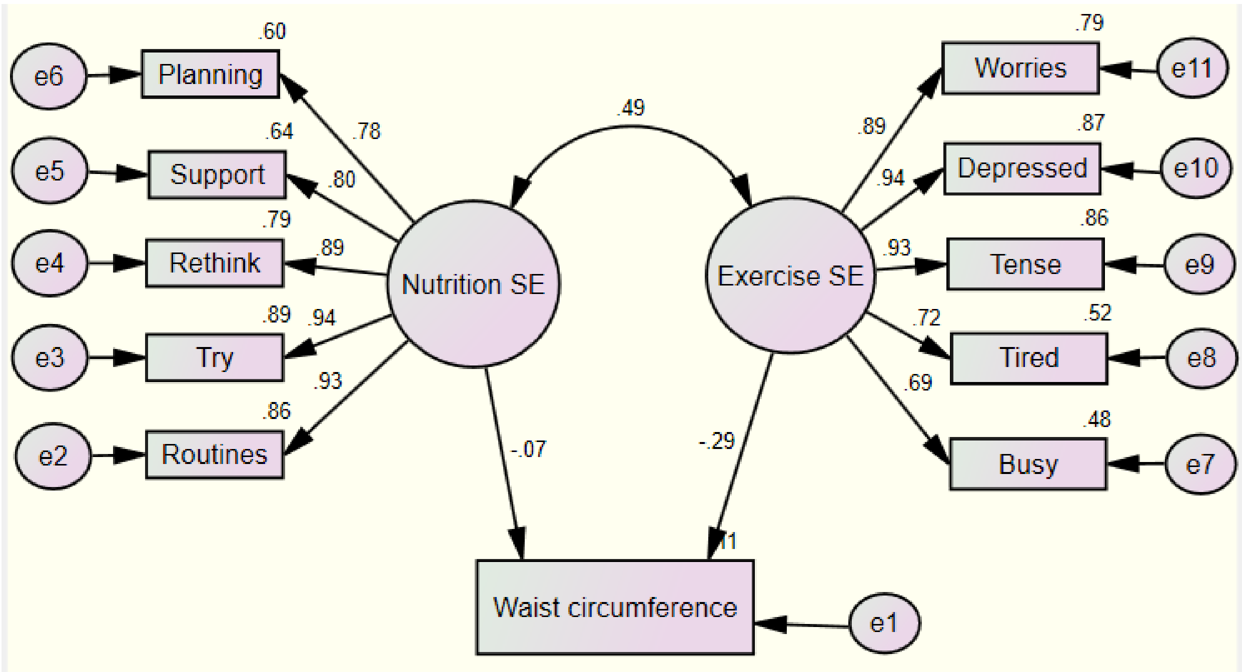

Figure 5. Standardized estimates of 5-item nutrition and exercise self-efficacy structural equation model with waist circumference as outcome.

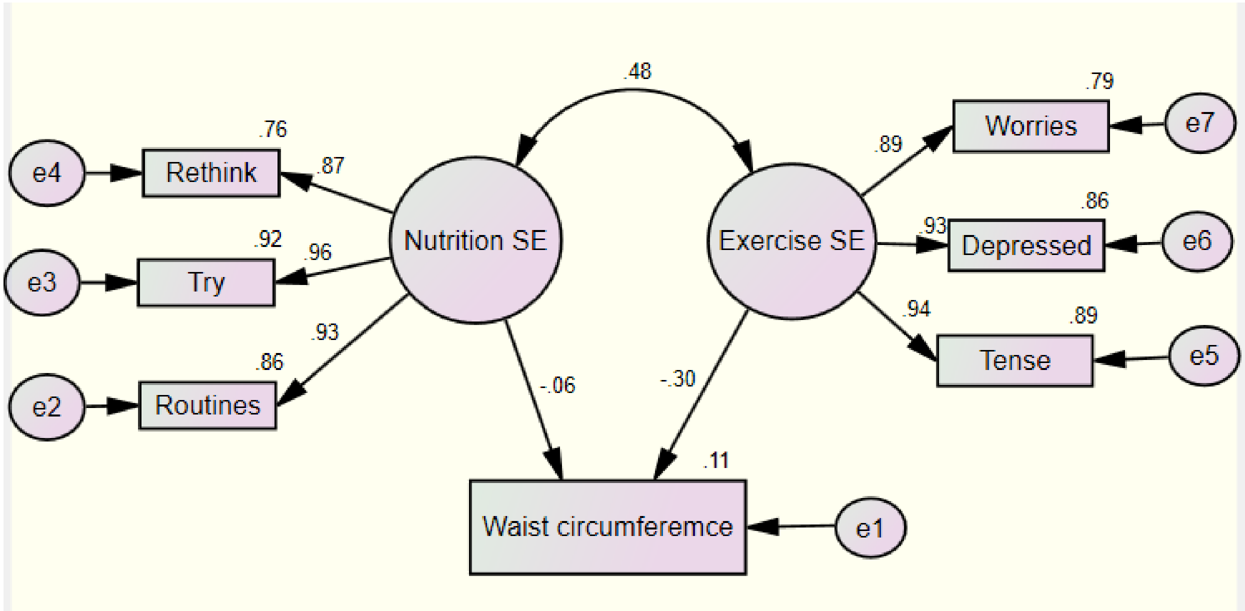

Figure 6. Standardized estimates of 3-item nutrition and exercise self-efficacy structural equation model with waist circumference as outcome.

The full (5-item) nutrition and exercise self-efficacy scales were used in the SEM, however the model did not entirely show satisfactory indicators (see table 3). These indicators improved to optimal levels when the items with lower loading were dropped (2 for each scale), resulting in two 3-item scales. The SEM with the 3-item scales shows the best goodness-of-fit indicators, but the ML estimates do not vary significantly between the 5- and 3 -item scales. No CFA or SEM analyses were performed by the original authors of the scales (Schwarzer & Renner, 2009). The two items removed from the self-efficacy scales show larger measurement error variances in comparison to all other observed variables. The items “support” (e4 = 0.18) and “planning” (e5 = 0.19) in the nutrition self-efficacy scale have larger error variances with regards to all other three items. The same occurs in the exercise self-efficacy scale with the items “tired” (e9 = 0.35) and “busy” (e10 = 0.36) across the three models, i.e. for each obesity indicator (waist circumference, BMI and body fat percent). Once these 4 items are omitted as shown in figure 4, better goodness-of-fit indexes are observed (see table 3).

All goodness-of-fit indexes were optimal in the 3-item (above 0.95). Conversely, the 5-item scale models show marginally appropriate Tucker-Lewis goodness-of-fit indexes and significant Chi-square values. The Root mean square error of approximation-RMSEA, Incremental fit index-IFI and Comparative fit index-CFI were within optimal levels based on the criteria presented in table 3.

Table 3. Cutoff criteria (L. Hu & Bentler, 1999) and goodness-of-fit indexes for the 3-item and 5-item structural equation models.

		SEM with 3-item scales			SEM with 5-item scales		
N=365	Cut-off criteria	SEM1. Waist circumference	SEM2. Body mass index	SEM3. Body fat percent	SEM4. Waist circumference	SEM5. Body mass index	SEM6. Body fat percent
Chi square	p > .05	.380	.416	.200	.000	.000	.000
Incremental Fit Index – IFI	≥ .95	1.00	1.00	.998	.918	.918	.917
Tucker-Lewis Index – TLI	≥ .95	.999	1.00	.996	.871	.871	.869
Comparative fit index – CFI	≥ .95	1.00	1.00	.998	.918	.918	.917
Root mean square error of approximation – RMSEA	< .06 to .08	.014	.009	.030	.135	.135	.135

Regarding the association between self-efficacy and obesity as proposed in aim 2a, only exercise self-efficacy appears to have an important significant association with all three obesity measures (waist circumference, BMI and body fat percent) in the expected direction after including confounding variables. Table 4 shows estimates for each outcome variable. Body mass index is the only obesity measure associated to nutrition self-efficacy after including confounders in the model (SEM8 and SEM14).

Table 4. Standardized regression estimates for nutrition and exercise self-efficacy for each obesity measure as outcome. **=p-value<.01

SEM7, SEM8, SEM9, SEM10, SEM11 and SEM12 include confounding variables: eating habits, exercise, age, gender, and ethnicity. **=p-value<.01

5-ITEM SCALES

	SEM1.Waist circum.	P-value	SEM2.Body mass index	P-value	SEM3.Body fat percent	P-value
Nutrition self-efficacy	-0.06	0.31	-0.16	**	-0.10	0.12
Exercise self-efficacy	-0.30	**	-0.19	**	-0.23	**

	SEM7.Waist circum.	P-value	SEM8.Body mass index	P-value	SEM9.Body fat percent	P-value
Nutrition self-efficacy	-0.03	0.64	-0.12	**	-0.08	0.28
Exercise self-efficacy	-0.23	**	-0.14	**	-0.20	0.01

3-ITEM SCALES

	SEM4.Waist circum.	P-value	SEM5.Body mass index	P-value	SEM6.Body fat percent	P-value
Nutrition self-efficacy	-0.37	0.31	-0.82	**	-0.94	0.12
Exercise self-efficacy	-1.66	**	-0.92	**	-2.12	**

	SEM10.Waist circum.	P-value	SEM11.Body mass index	P-value	SEM12.Body fat percent	P-value
Nutrition self-efficacy	-0.20	0.59	-0.66	0.04	-0.70	0.23
Exercise self-efficacy	-1.27	**	-0.67	0.02	-1.40	**

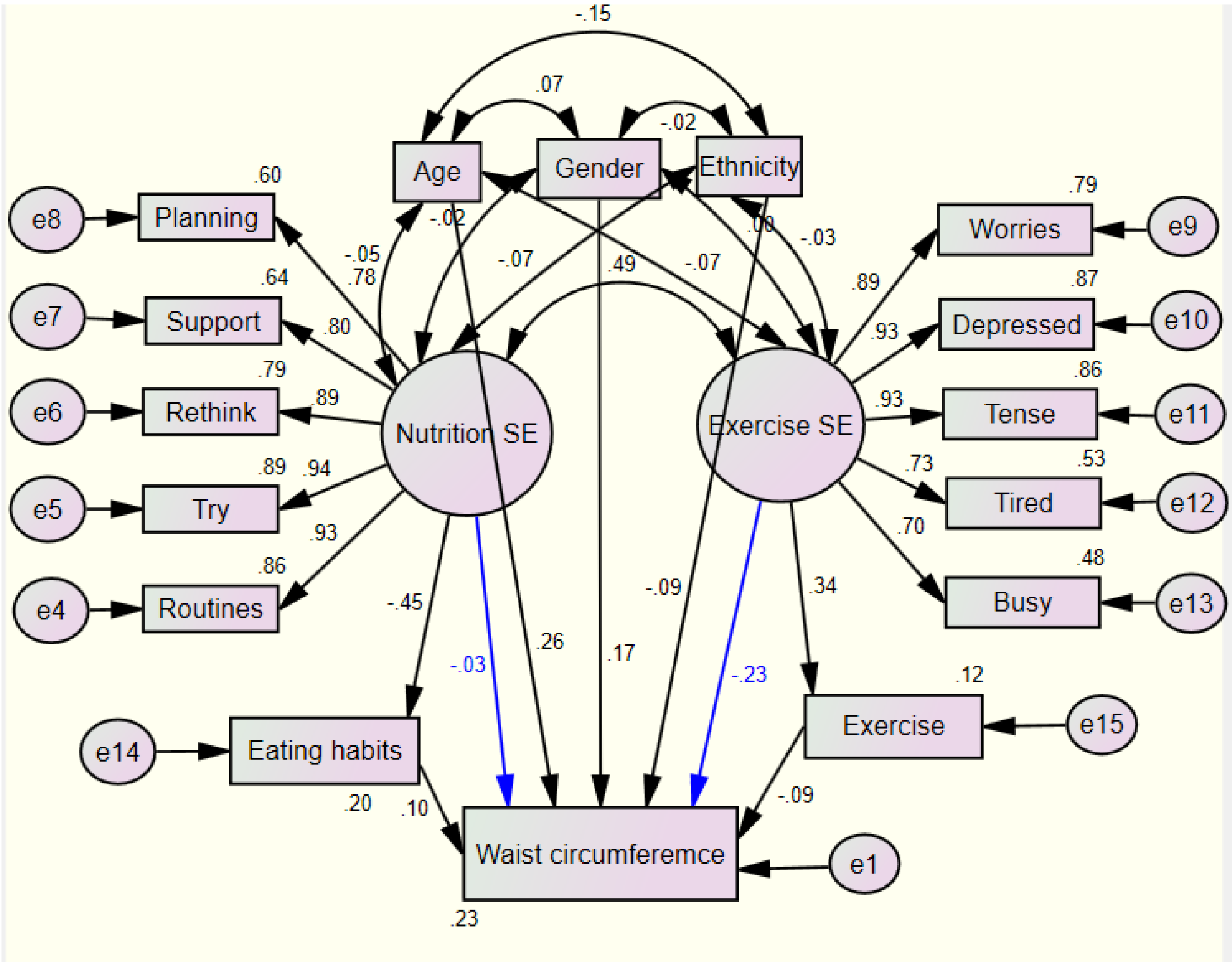

Figure 7. SEM7 includes confounding variables and waist circumference as outcome. SEM8 and SEM9 included BMI and Body fat percent as outcomes, respectively.

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A visual representation of SEM7 is shown in figure 7. Note that the outcome "waist circumference" in figure 7 was substituted by Body mass index and Body fat percent for SEM8 and SEM9, which can be found in appendix 2. Similarly, figure 8 depicts SEM10, the "waist circumference" was also replaced by Body mass index and Body fat percent as outcomes in SEM14 and SEM15, respectively. As concluded in the CFA analyses, because there was no theoretical justification for dropping the two items in each scale, the final structural equation modeling was performed using the 5-item self-efficacy scales.

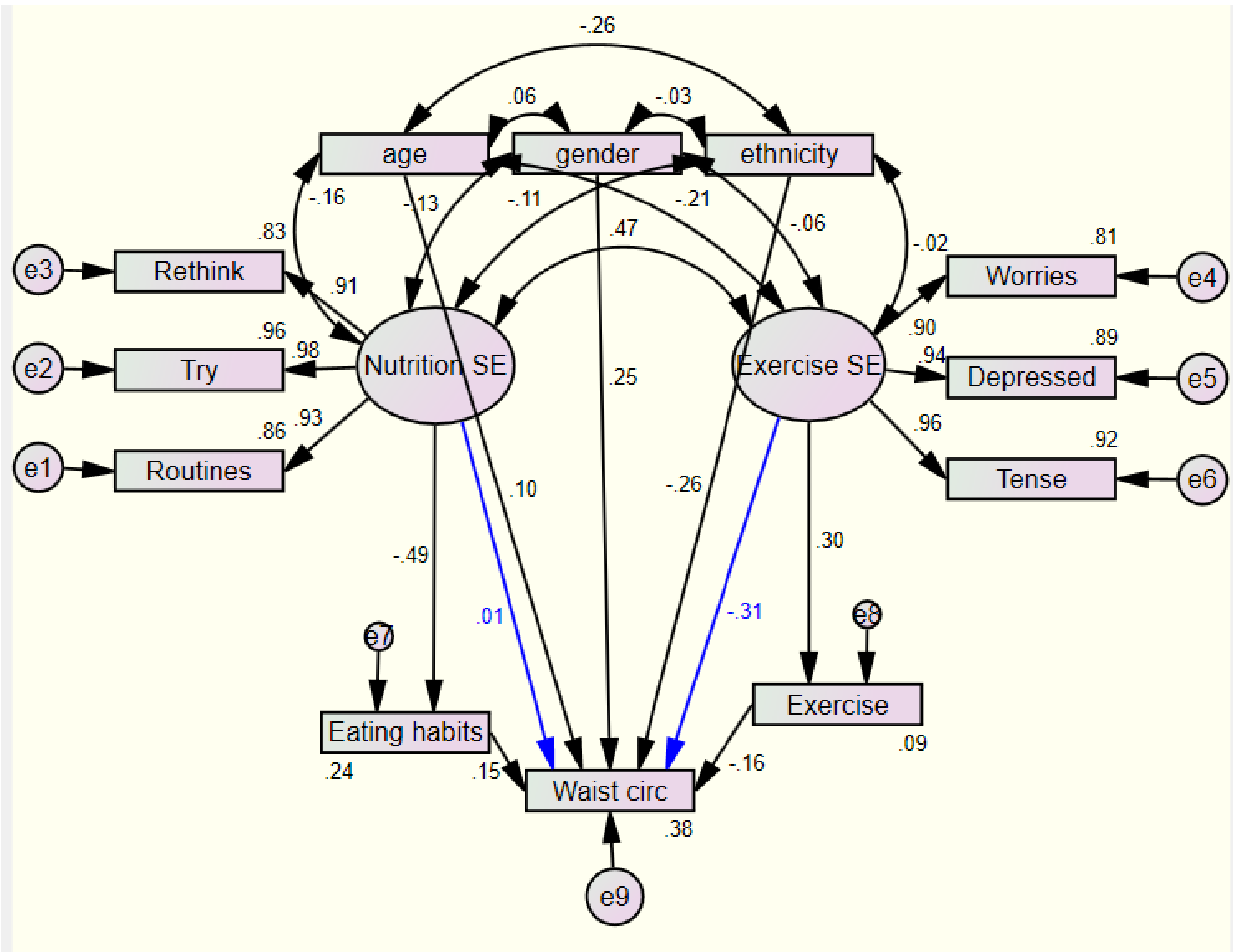

Figure 8. SEM10 includes confounding variables and waist circumference as outcome. SEM11 and SEM12 replaced waist circumference by BMI and Body fat percent as outcomes and can be found in appendix 2.

The full structural equation model, shown in figure 9, includes the three proposed social support factors in the conceptual framework (coworker, supervisor and organizational support). SEM facilitates the simultaneous analysis of all exogenous variables and their effect on nutrition and exercise self-efficacy.

As stated in aim 2b and depicted in figure 1, the analyses to explore the occupational factors associated with health-related self-efficacy suggest that organizational support is the only determinant associated with both, nutrition and exercise self-efficacy even after including confounders. It is noteworthy to recall that coworker support for nutrition was not obtained as part of the FORWARD Study database but coworker support for exercise was available (see appendix 1).

Table 5. Standardized coefficients from the full structural equation model SEM13, where coworker support, supervisor support and organizational support are predictors of nutrition and exercise self-efficacy.
** ≤ .01

	Full Structural equation model (SEM13)					
	Coworker support	P-value	Supervisor support	P-value	Organizational support	P-value
Nutrition self-efficacy	N/A	N/A	-0.02	0.78	0.18	**
Exercise self-efficacy	0.03	0.62	0.06	0.27	0.23	**

The analyses shows that organizational support is the most important occupational factor for both exercise and nutrition self-efficacy. Supervisor support and coworker support were not statistically significant predictors of nutrition or exercise self-efficacy.

As expected, organizational support was positively associated with exercise self-efficacy. Table 5 shows the standardized coefficient obtained ($\beta = .23$, $p < .05$) as predictor of exercise self-efficacy remained significant even after including all covariates and confounders. Likewise, organizational support was positively associated with nutrition self-efficacy ($\beta = .18$, $p < .05$).

Regarding the goodness-of-fit indexes for the full SEM13 (see figure 7), the $\chi 2$ test was statistically significant ($\leq .05$). As alternative indicator of good fit, some authors have suggested $\chi 2/df$ ratios between 2 and 5 (Marsh & Hocevar, 1985). The model in this study yielded a ratio of 2.25 (929.094/413). The IFI, TLI and CFI indexes were .935, .921 and .934, respectively. The root mean square error of approximation was under 0.06 (0.059), below the threshold recommended by Hu & Bentler (1999). As expected from the 5-item vs 3-item self-efficacy scales comparison as part of aim 2a, the goodness-of-fit indexes improve when the 3-item scales are used i.e. $\chi 2/df = 1.785$, IFI= .965, TLI= .956, CFI= .965 and the RMSEA= .046. The $\chi 2$ significance remained significant ($\leq .05$) even in the model with the 3-item scales.

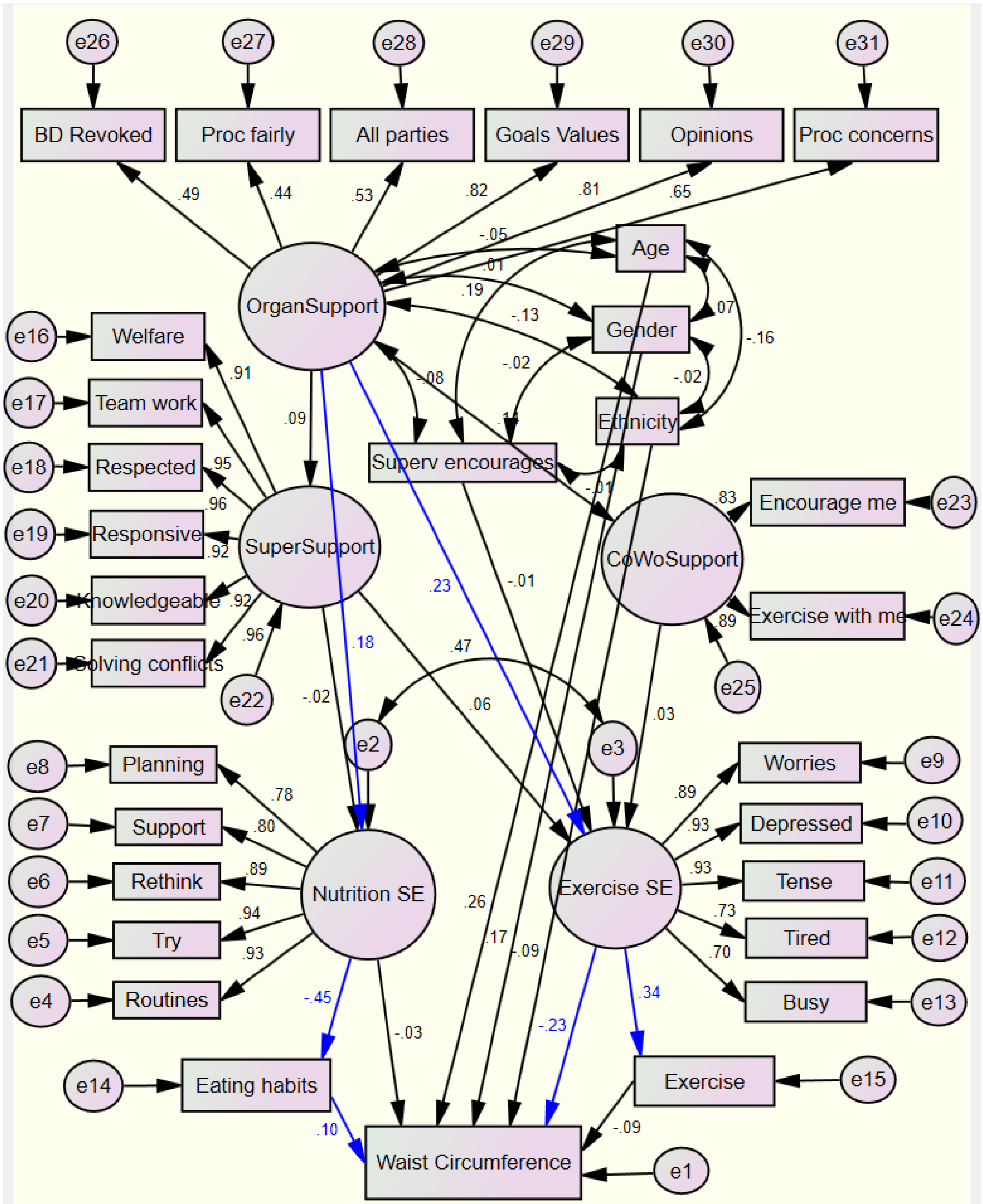

Figure 9. Block recursive full structural equation model (SEM13) including all three workplace social support factors and confounding covariates.

4. Discussion

To the best of my knowledge, this is the first study that takes into account the health-specific nutrition and exercise self-efficacy in the worksite context of firefighters in order to explore its effects on obesity. This study confirms the association between self-efficacy and obesity in firefighters. This association is significant with exercise self-efficacy and indirectly through individual eating with nutrition self-efficacy. Organizational support is the most important predictor of nutrition and exercise self-efficacy. No association with supervisor or coworker support was found. The socio-ecological framework adopted for this work innovatively explores the contextual effects of social support on self-efficacy and health. Additionally, the health outcome measures used in the present work were obtained objectively in a clinical setting. Finally, this study has not been previously conducted in firefighters, a population which is made up of 1.1 million workers with high risk of on-duty cardiovascular disease.

This study has found what House defines as "buffering" effect of social support according to his theoretical model illustrated in (House, 1981, p. 31). It is important to note that the actual effect depicted in House's model is a mediating effect of social support. This means that the effects of social support on health occur through other factors in the work stress-health continuum. Particularly, in this study that "buffering" effect is observed on obesity outcomes though feelings of self-efficacy.

Furthermore, the full structural equation model in the present study is a step forward from the findings of the PHLAME study, where positive dietary support and positive exercise support were considered as predictors of healthy behaviors (Elliot, et al., 2007). However, the authors did not take into account the workers' perception of organizational support. Additionally the proposed model herein includes self-efficacy as mediating pathway between support and behavioral outcomes. This adds a contribution to the theoretical gap of self-efficacy and health outcomes in the work context of firefighters.

In this study, the scales used to measure health-related self-efficacy showed optimal indicators when compared to the original publication of the questionnaires (Schwarzer & Renner, 2009). Furthermore, exercise self-efficacy demonstrated an association with the three obesity indicators among firefighters. This association remained after including confounders and mediating variables from the theoretical model depicted in figure 2 (i.e. health behaviors). Nutrition self-efficacy was only associated to BMI according to the structural equation modeling analyses and non-significant results were obtained for waist circumference and body fat percent when used as outcomes (see appendix 2). However, an indirect association was observed between nutrition self-efficacy and obesity through eating habits. This may be due to the influence of family style eating habits by worksite traditions and peer-pressure reported in earlier findings, where firefighters describe a family style eating for which firefighters take turns to cook and demand that food is "hot, brown and plenty of it" (Dobson et al., 2013).

Confirmatory factor analyses show that a 3-item self-efficacy scale for both, nutrition and exercise, yields better goodness-of-fit indicators than the 5-item original scales. From the conflicting items, there is one that may be a bit different semantically from the rest. In the nutrition self-efficacy scale, "*I can manage to stick to healthy food… even if I do not receive a great deal of support from others when making my first attempts*", may be understood as social support rather than self-efficacy. The other three items: "*…even if I have to make a detailed plan*", also form nutrition self-efficacy and "*I can manage to carry out my exercise intentions …even when I am tired*", "*…even when I am busy*" do not seem to have a distinct meaning. Although the 3-item self efficacy scales were statistically superior in SEM indicators, there was no theoretical justification for removing the items and subsequent analyses were performed using the complete 5-item scale. Future studies, should further explore this comparison.

The full structural equation model, including worksite social support latent variables and covariates, shows that the overall conceptual model is adequate. With regards to the occupational factors theorized as associated with health-related self-efficacy, only organizational support seems to play an important role in increased feelings of nutrition and exercise self-efficacy. Although firefighters work as a type of command hierarchy organization, it appears organizational support is more important than direct supervisor's support or coworker support. It is worth mentioning that the relevance of organizational support may be bolstered by changes in OCFA's protocols regarding sports and exercise activities during work hours. These changes occurred while data collection for the FORWARD Study took place.

The first important change occurred in team sports. Based on OCFA standard operation procedures put in place during the FORWARD study data collection, firefighters were banned from participating in any recreational, competitive or contact sport activities that posed a risk of injury or illness. Apparently, management viewed this as a preventive measure to lower work-related injuries. Physical fitness activities were not limited but were subject to approval of peer fitness trainers. These measures may have been viewed by firefighters as a managerial shortcoming in supporting healthy habits.

Moreover, firefighters were no longer allowed to visit neighboring gyms. The measure forced employees to adapt fire station spaces as small gyms in order to comply with the suggested (not mandatory) on-the-job workout. This situation was not generalized since some fire stations already possessed well-equipped gym areas, however many firefighters reported feeling this affected the morale of the employees in trying to maintain a healthy work lifestyle.

Limitations

The present study has several limitations. First and foremost, the data is cross-sectional; therefore causality cannot be determined from the results obtained. Also, no measures of specific behavior support were collected (e.g. nutrition supervisor support) which may partially explain the non-significant findings. Also the results in the present study are representative of OCFA firefighters where the data was collected and generalizability to the general population is not possible. It may be plausible however, to obtain similar results in organizations which have a structure analogous to that of firefighters.

Conclusions

The implications of the study are twofold. Firstly, the results demonstrate the importance of health-related self-efficacy and its association with objectively measured obesity indicators. This contrasts with the many self-efficacy studies that often include health outcomes as perceived wellness or other self-reported measures. This implies that any efforts to improve nutrition and exercise self-efficacy will likely have an effect on biomarkers of obesity in firefighters. It is well-established that obesity is an important modifiable risk factor for some of the most prevalent diseases in the US (e.g. diabetes, CVD, cancer). Secondly, the application of a socio-ecological framework to lay out the interrelationships between the organization, supervisor, and coworker support with health-related self-efficacy and thus its effects on obesity is a novel proposal in occupational health. This may help to identify organizational procedures and culture that contribute to unhealthy work habits. Particularly, this investigation has identified specific organizational flaws that affect the self-efficacy and ultimately the health of firefighters.

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Appendix 1

Nutrition self-efficacy
Response options: Very uncertain (1); Rather uncertain (2); Rather certain (3); Very certain (4)
I can manage to stick to healthful foods ...
Routines. ...even if I need a long time to develop the necessary routines.
Try. ...even if I have to try several times until it works.
Rethink. ...even if I have to rethink my entire way of nutrition.
Support. ...even if I do not receive a great deal of support from others when making my first attempts.
Planning. ...even if I have to make a detailed plan.

Exercise self-efficacy
Response options: Very uncertain (1); Rather uncertain (2); Rather certain (3); Very certain (4)
I can manage to carry out my exercise intentions ...
Worries. ...even when I have worries and problems.
Depressed. ...even if I feel depressed.
Tense. ...even when I feel tense.
Tired. ...even when I am tired.
Busy. ...even when I am busy.

Coworker support
Response options: Strongly disagree (1); Disagree (2); Agree (3); Strongly agree (4)
Encourage me. My coworkers encourage me to exercise.
Exercise with me. My coworkers exercise with me.

Supervisor support
Response options: Strongly disagree (1); Disagree (2); Agree (3); Strongly agree (4)
Welfare. My supervisor is concerned about the welfare of those under him/her. (EMOTIONAL)
Team work. My supervisor is successful in getting people to work together. (INSTRUMENTAL)
Respected. My supervisor is respected by those under him/her. (APPRAISAL)
Responsive. My supervisor is responsive to my concerns. (EMOTIONAL)
Knowledgeable. My supervisor is knowledgeable. (INFORMATIONAL)
Solving conflicts. My supervisor is good at solving conflicts. (INSTRUMENTAL)

Superv encourages.
My supervisor...
Response options: Encourages me to exercise (1); Neither encourages or/and discourages me (2)

Organizational support
Response options: Strongly disagree (1); Disagree (2); Agree (3); Strongly agree (4)
BD revoked. Where I work, bad decisions by management or supervisors can be revoked or changed.
Proc fairly. In my station, procedures are implemented so that decisions can be made fairly.
All parties. For major decisions in the Dept, all parties are represented.
Goals and values. Management considers my goals and values.
Opinions. Management cares about my opinions.
Proc concerns. In the Fire Dept, there are procedures in place to hear the concerns of all those affected by a decision.

Appendix 2

SEM2

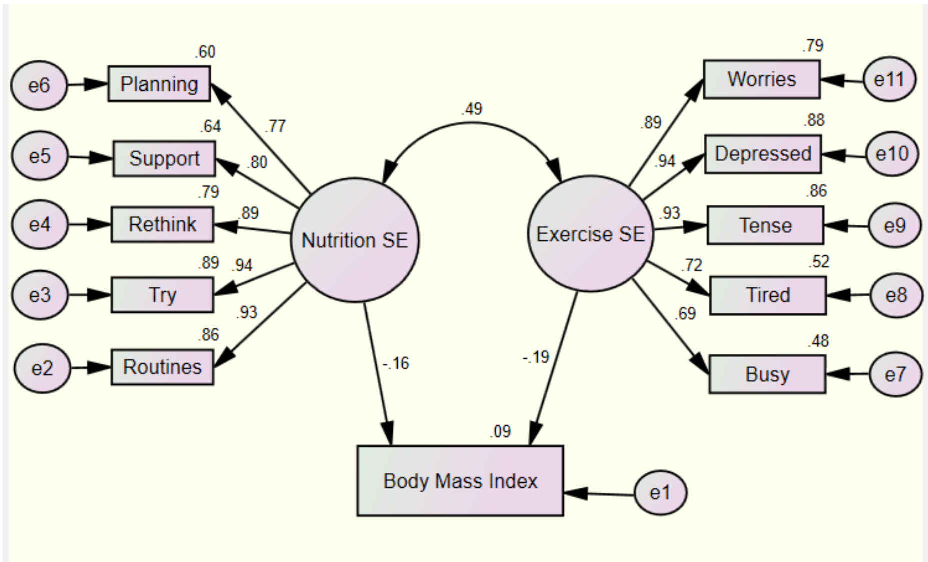

Figure 10

SEM3

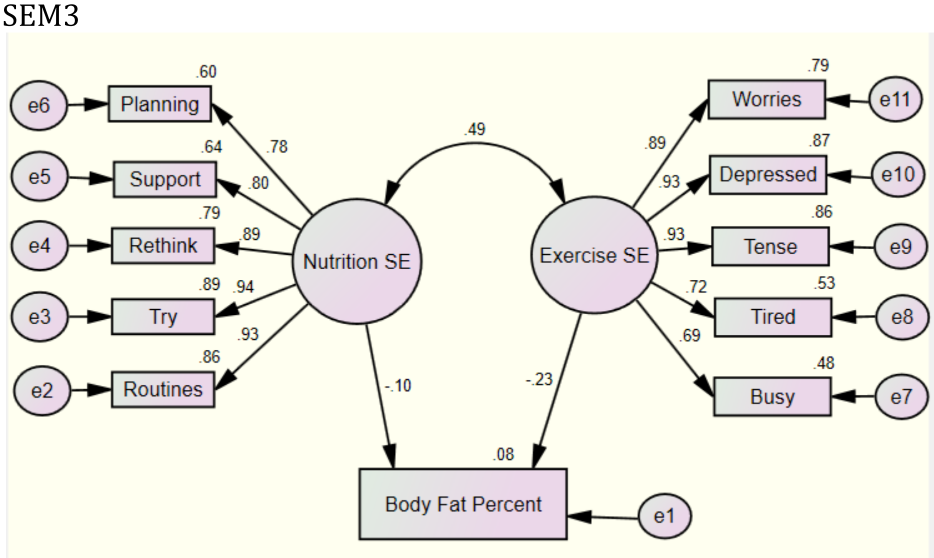

Figure 11

SEM 5

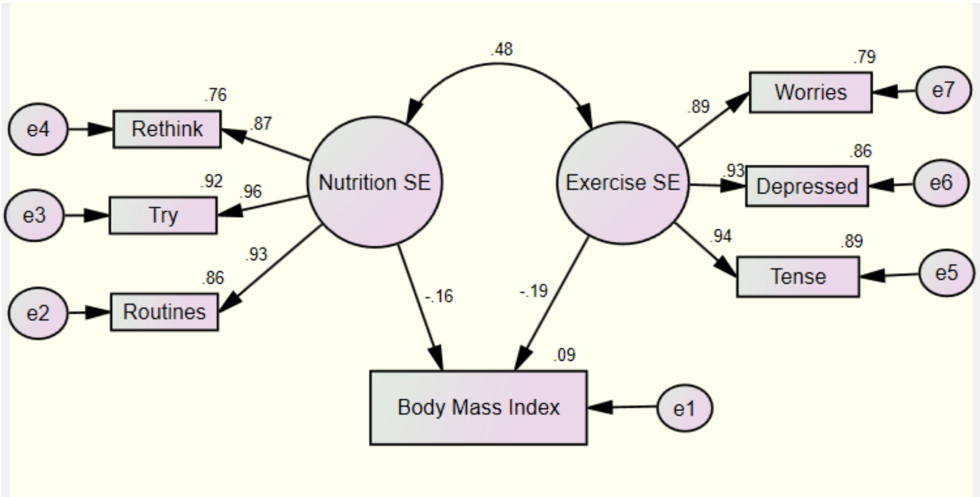

Figure 12

SEM6

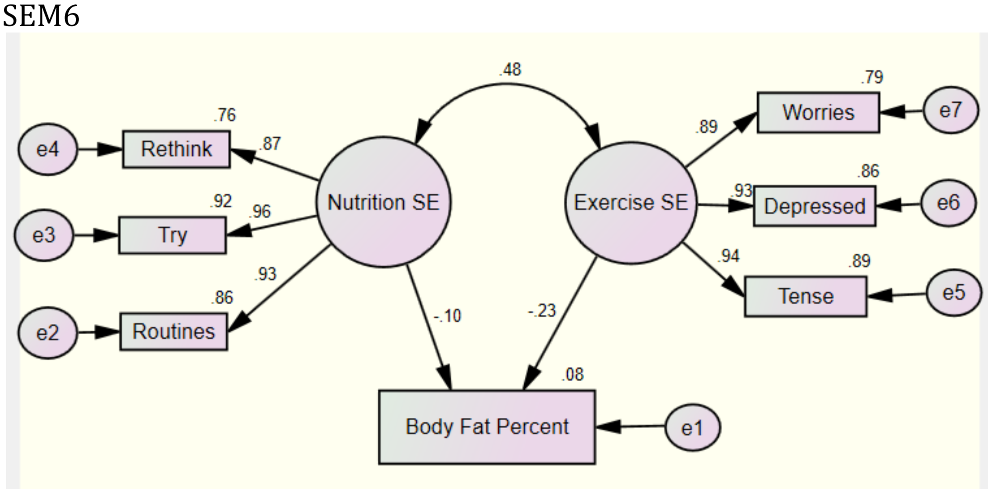

Figure 13

SEM8

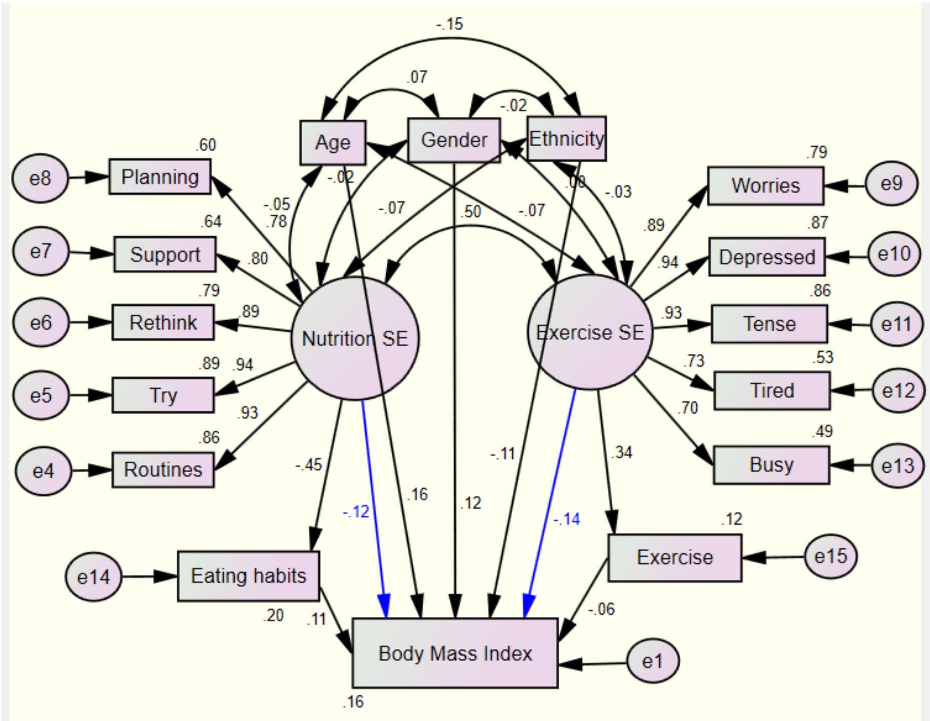

Figure 14

SEM9

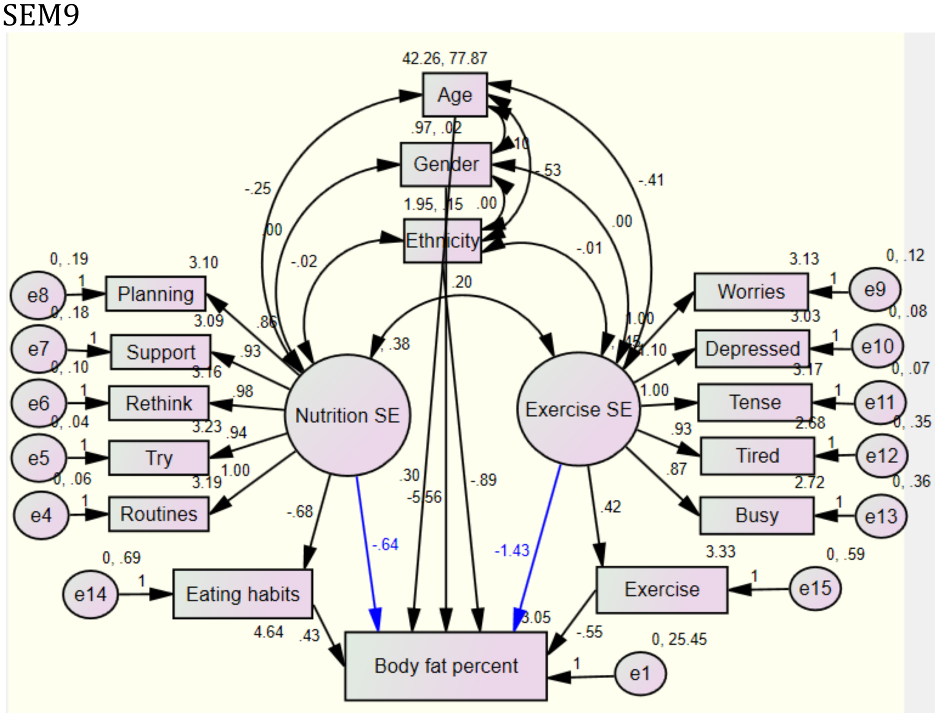

Figure 15

SEM11

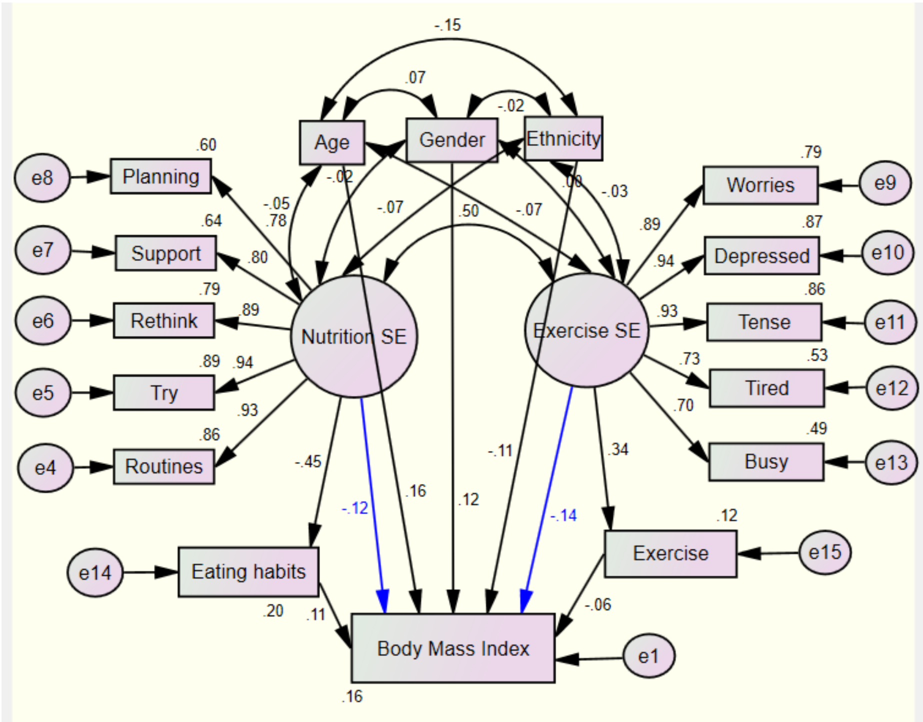

Figure 16

SEM12

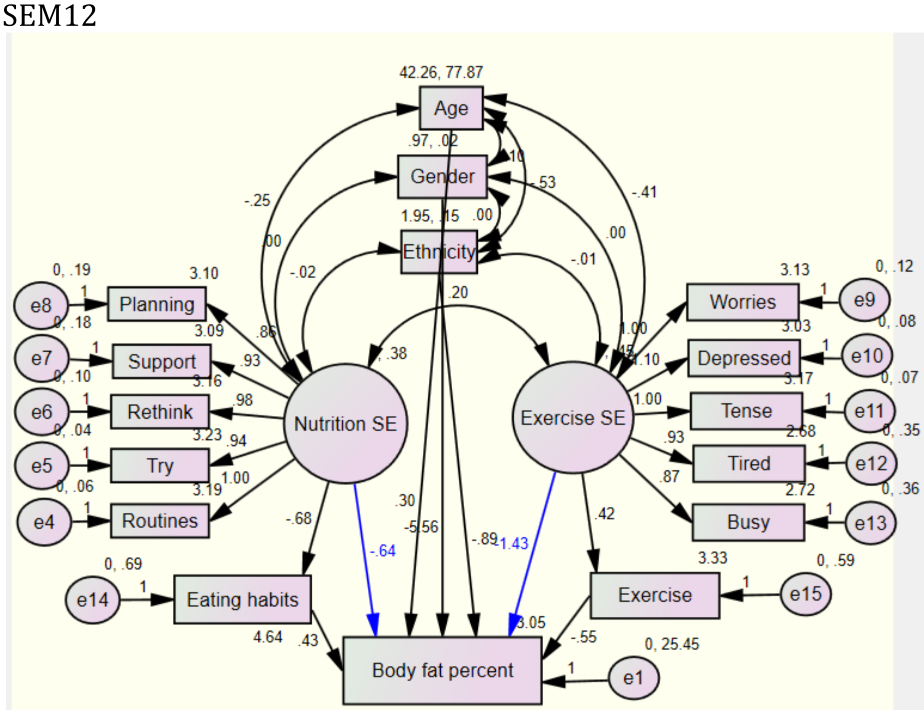

Figure 17

SEM14

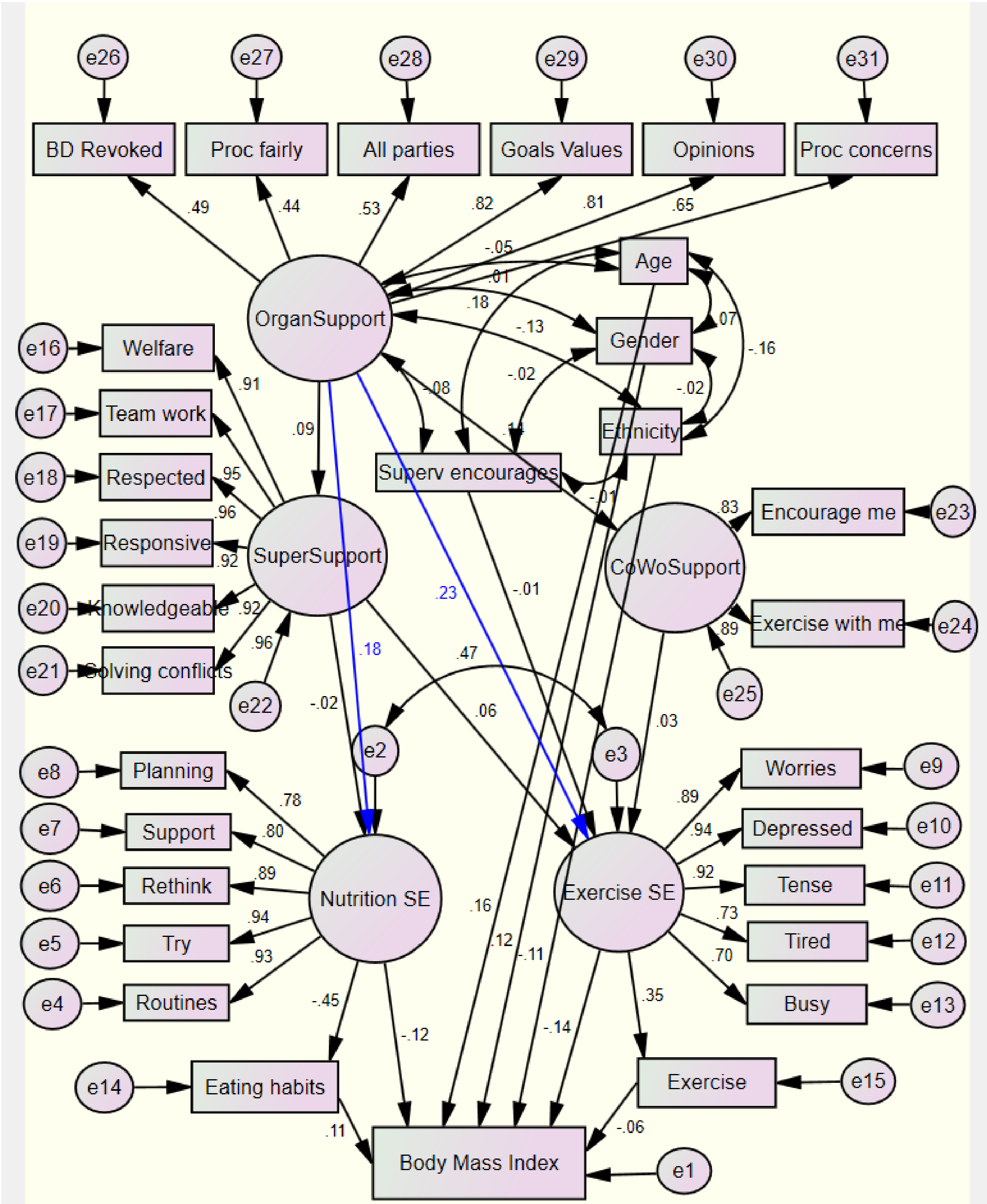

Figure 18

SEM15

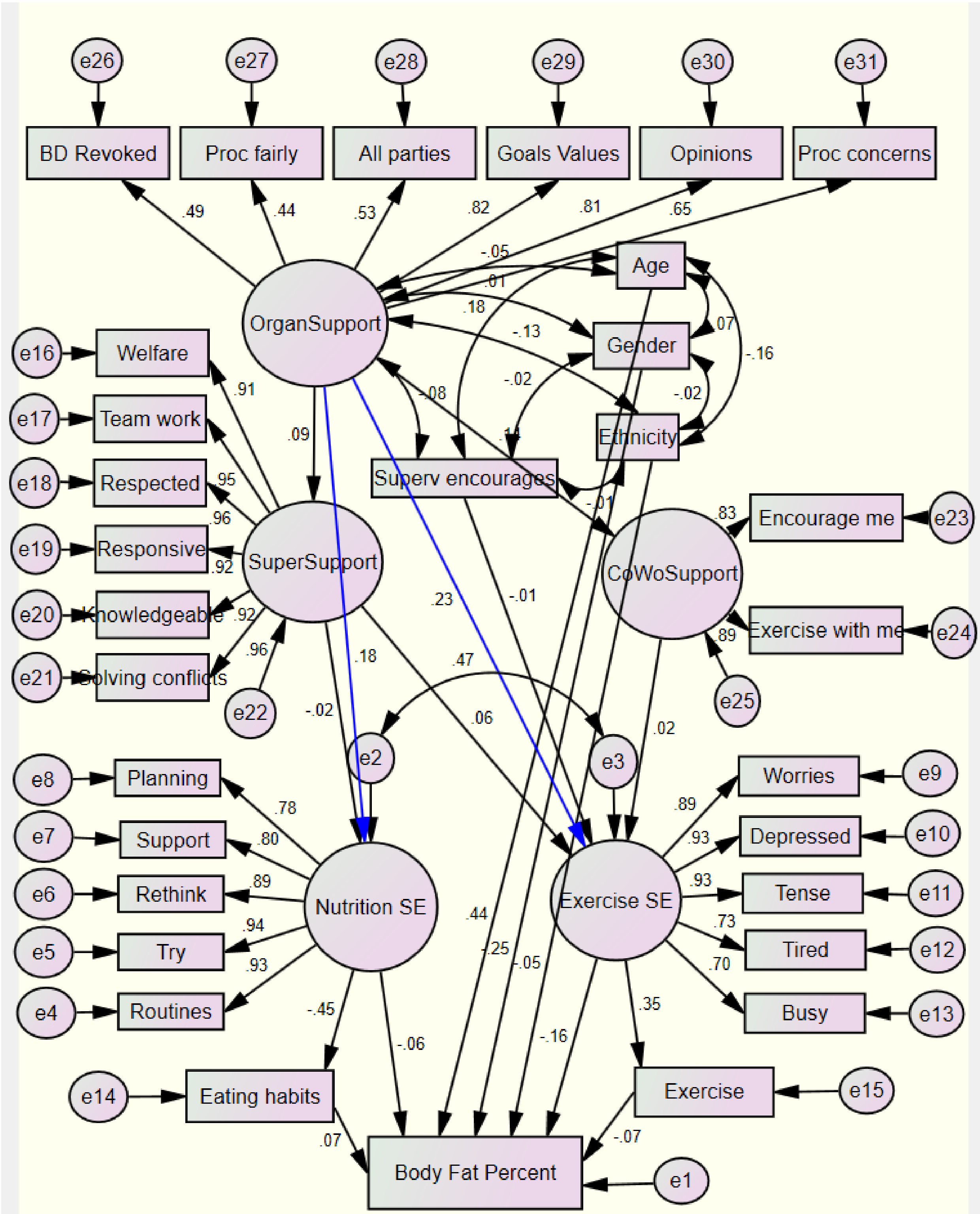

Figure 19

Chapter 4

(Aim 3)

1. Introduction

Measuring physical activity is an important part of health promotion efforts to address physical inactivity and sedentary behavior (Choi, et al., 2010; Dalle Grave, et al., 2013; Dunstan, et al., 2010). Increased physical activity and reduced sedentary behavior are now considered as important as tobacco control in efforts to minimize the burden of noncommunicable diseases (Bloom et al., 2012).

Physical activity and sedentary behavior have traditionally been measured by self-report (Gibbs, Hergenroeder, Katzmarzyk, Lee, & Jakicic, 2015). This often carries the inherent issues of questionable validity and reliability (Arias, Caban-Martinez, Umukoro, Okechukwu, & Dennerlein, 2015), and the common overestimation of self-reported physical activity along with the underestimation of sedentary behavior (Dall, Coulter, Fitzsimons, Skelton, & Chastin, 2017; Troiano et al., 2008). Accurate and reliable measurement, along with monitoring behaviors is considered an important part of health promotion research and evaluation practice (Hamilton, Healy, Dunstan, Zderic, & Owen, 2008). Therefore, optimal physical activity and sedentary behavior measurement is an important element of the empirical evidence for health promotion and health practices (Oldenburg, Sallis, Ffrench, & Owen, 1999; World Health Organization, 2000).

More recently, with the introduction of modern and affordable devices, it has become easier to obtain measures of objective physical activity by detection of either step count or body movements. Modern devices in the realm of what is known as *actigraphy* can measure activity continuously and evaluate the intensity of movement in workplace settings (Erickson et al., 2015). The utility of this tools is to accurately characterize the total volume of activity (Welk, 2002). However, the relatively new technique for measuring physical activity and sedentary behavior is faced with the challenge of identifying parameters that can establish the predictive association with specific health outcomes. Additionally, the challenge of measuring physical activity in non-laboratory settings requires improved designs in order to control factors that may affect proper detection of the various types of physical activity i.e. vigorous, moderate, sedentary (Hills, Mokhtar, & Byrne, 2014).

The work environment is a promising setting to explore the validity of measurements considering the relative uniformity of tasks among work groups within each organization. Among firefighters for instance, it is possible to know specific activities and work tasks either by self-report (hours of exercise) and emergency calls (from organizational emergency call logs).

It is important to make a distinction among the different conceptualizations of sedentary behaviors. The definitions of sedentary behavior are inherently linked to their operationalization. For instance, sedentary behavior obtained from counts per minute does not necessarily include sitting time. Activities with minimum motion like standing still and lying down will be characterized as *sedentary behavior*, not necessarily sitting position. Consequently, data obtained from position sensor (inclinometer) includes the amount of time a person remains in sitting position; this is referred as *sitting time*. Also, sitting time is unarguably considered the core aspect of sedentary behavior. Finally, self-reported sedentary behaviors can include specific activities done while reporting decreased physical activity (e.g. playing video games, watching TV, working on a computer) and overall sedentary time throughout the day (Genevieve N Healy et al., 2011). In the present study, sedentary behavior reported as a characteristic of the work environment will be referred to as *sedentary work*, captured by an item from the MIDUS II Study that asks participants to rate their agreement to the phrase "my job often requires sitting for long periods of time" (Ryff, et al., 2007). This item implies that work activities may not exclusively be performed in sitting position but may require occasional walking, lifting and carrying as defined by the Physical Exertion Requirements in the Code of Federal Regulations (2018). *Occupational inactivity* is proposed here as an overarching term which includes all three measures of sedentary work.

The ActigraphGtX3 is one of the most widely used devices to assess physical activity and sedentary behavior. It measures motion with a tridimensional axis, using a piezoelectric device and microprocessors that detect the acceleration of the body and convert it into a quantifiable digital signal. The resulting units from such signals are known as counts per minute (cpm), which measure the intensity, duration and frequency of recorded movement, based on the principle that when an individual moves, his body accelerates in proportion to the muscular force applied in such acceleration (Chomistek et al., 2017). Accelerometers offer a more accurate method of measuring physical activity than other tools (e.g. pedometers) because they may be more sensitive to activities like slow walking and standing. Also, actigraphs have been validated against the gold standard, doubly labeled water and in large sample studies like the National Health and Nutrition Examination Survey (NHANES) (Chomistek, et al., 2017; Matthew, 2005). However, a remaining major problem in the use of accelerometers for the measurement of physical activity is that the unit of measure has not yet been entirely standardized (Hills, et al., 2014). This situation has led to the issue of inadequate cut-off points for categorizing physical activity and sedentary behavior. For example, the standard definition of accelerometry for sedentary behavior is activity under 100 counts per minute (cpm). However, empirical evidence is still required to clarify if the <100 counts per minute threshold is supported by other objective measures (e.g. use of inclinometers) and whether inclinometry may a better alternative in non-laboratory settings and among specific adult working populations. This issue with the current cut-off points arises due to three main problems. Firstly, the <100cpm threshold was suggested in 2004 based on research with a female teenage population where sedentary behavior was defined as watching T.V. and playing video games, activities which are clearly different from the sedentary behavior during work in adult populations (Clarke-Cornwell, Farragher, Cook, & Granat, 2016; Treuth, et al., 2004). Secondly, the <100 cpm cut-point was set in an older version of the Actigraph (Actigraph 7164), newer and more precise models warrant for research that may eventually help to establish more accurate cut-points in specific populations. Thirdly, there are reports of measurement errors where low activity such as standing position with no movement is categorized as sedentary behavior under the <100cpm cut points (Kerr et al., 2013), whereas riding a car shows measures exceeding this threshold 26% of the time (Gibbs, et al., 2015). Additionally, other studies have suggested that a threshold of 150 counts per minute provides a better assessment of sedentary behavior, relative to direct observation (Kozey-Keadle, Libertine, Lyden, Staudenmayer, & Freedson, 2011).

Step count by use of pedometers has been validated in controlled conditions and in comparison to accelerometry (Le & Tudor-Locke, 2003; Tudor-Locke, Williams, Reis, & Pluto, 2002). Its simplicity in use and interpretation makes it an accessible and affordable tool for measuring physical activity. A once arbitrary 10,000 step count threshold has become the norm for healthy guidelines of physical activity (Tudor-Locke & Bassett, 2004). It has shown health benefits in reducing insulin levels, hypertension and body mass in diverse populations (Iwane et al., 2000; Moreau et al., 2001; Swartz et al., 2003). In firefighters, a 10,000 step physical activity program was used in combination with a low glycemic diet to successfully reduce the prevalence of metabolic syndrome in a 12 week program (Carey, Al-Zaiti, Liao, Martin, & Butler, 2011).

Alternatively, self-reported sedentary behavior has shown good test-retest reliability (Choi, Dobson, Schnall, & Garcia-Rivas, 2016). In contrast, the agreement between self-reported and objectively measured sedentary behavior has also been reported as fair to poor (Bauman, Phongsavan, Schoeppe, & Owen, 2006).

Sedentary time is associated to cardiovascular health indicators and obesity regardless of time spent in objectively measured moderate-to-vigorous physical activity (Dunstan, et al., 2010; Hamilton, et al., 2008; F. B. Hu, Li, Colditz, Willett, & Manson, 2003; Owen, Healy, Matthews, & Dunstan, 2010; A. A. Thorp, et al., 2011; Tigbe, Granat, Sattar, & Lean, 2017).

Several studies have reported beneficial effect associations with metabolic biomarkers when sedentary time is reduced by frequent breaks (Genevieve N Healy et al., 2008; Shephard, 2010; Tigbe, et al., 2017). Tools such as inclinometry are a new addition to modern devices which might offer improved information on the position time of individuals during work. The Actigraph is known to be an accurate device for measuring sedentary behaviors in laboratory settings using the inclinometer (Peterson, et al., 2015). However, little is known about its performance in everyday working conditions.

In controlled settings, the inclinometer function for the Actigraph GT3X+ has performed satisfactorily against direct observation of body position (Carr & Mahar, 2012; Peterson, et al., 2015). It is plausible that the precision of position in sitting versus standing is more accurate than self-reported measures and the inconsistent threshold of <100 counts per minute in actigraphy. Hence, the objective of this methodological study is to compare the association between sedentary behavior from posture sensor and obesity and other CVD risk factors in comparison to <100 counts per minute (intensity) and self-reported sedentary behavior at work. Additionally, I will compare the <100cpm threshold versus the proposed alternative of <150cpm threshold (Donaldson et al, 2016).

Aim 3: Compare physical activity (step count) and three occupational inactivity measures (counts per minute in actigraphy, sitting time with inclinometer and self-reported sedentary work) as predictors of obesity and cardiovascular disease risk indicators.

Conceptual model:

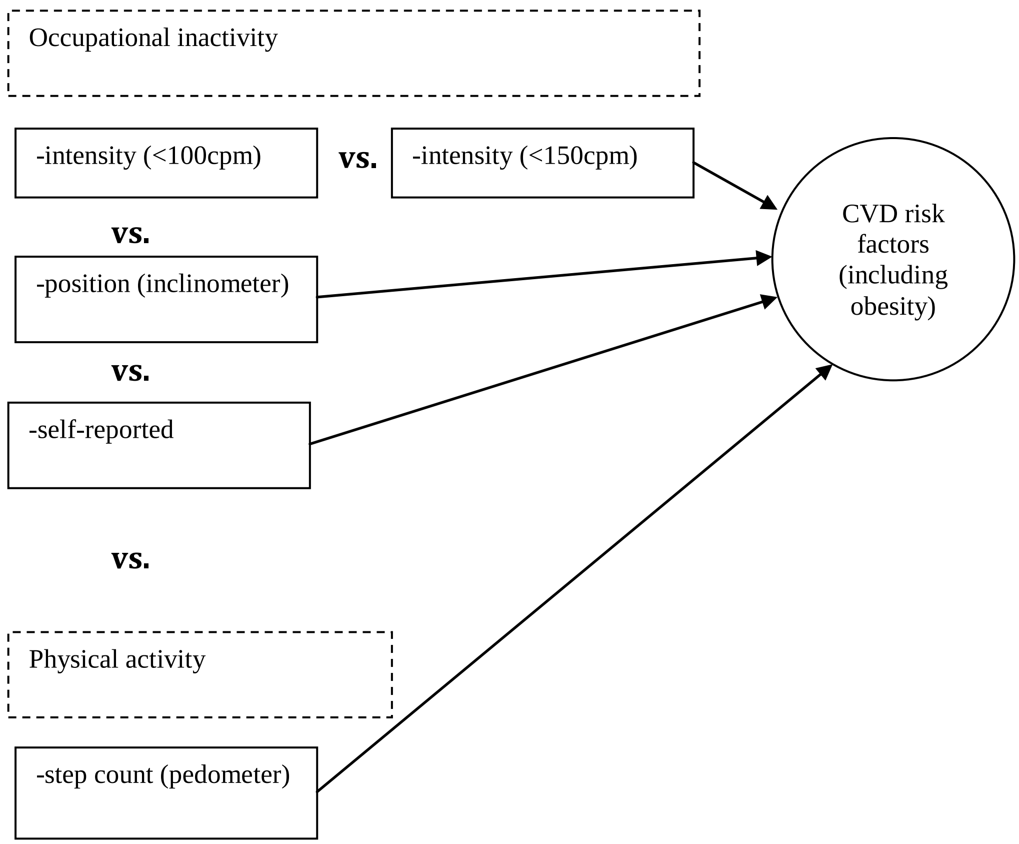

Figure 1. Association between sedentary work measures and obesity/CVD risk factors.

2. Methods

2.1 Participants

83 firefighters were randomly recruited as part of phase III of the FORWARD Study with a 50% participation rate. This subsample was selected from the 365 firefighters recruited during phase II (83% participation rate). The 83 male firefighters agreed to be part of a follow-up group that were asked to complete a short version of the FORWARD Questionnaire, keep a food diary and wear an activity monitor (actigraphs) during one 24-hour on-duty day and one 24-hour off-duty day. The Actigraph was programmed and installed at the start of the 24-hour work shift, detached by the firefighter at the end of the shift and reattached by the firefighter on their second off-duty day. There was missing actigraph data in 2 firefighters (N=81).

2.2 Measures

Actigraph data was downloaded in 10 second epochs using ActiLife software. This same software was used to calculate minutes in sedentary behavior based on the <100 and <150 counts per minute thresholds, and the sitting time using inclinometer sensor in the Actigraph. Because the present study intends compare measures of workplace sedentary behavior, only the on-duty day actigraphs data was used for this chapter.

Self-reported sedentary work

Sedentary work was measured with a single item “My job often requires sitting for long periods of time” and a 4 point Likert scale response set (1 = Strongly disagree, 2 = Disagree, 3 = Agree, 4 = Strongly agree). This item is part of a validated and widely used psychosocial working conditions scale (Karasek, et al., 1998). Choi et al. (2016) have also reported test-retest reliability of this item. The item was dichotomized into no/yes chategories. “No” including options 1 and 2, and “yes” including options 3 and 4 from the response set above.

Physical activity

Physical activity was measured as the number of steps recorded in the pedometer function included in the actigraph during the 24-hour work schedule.

Sedentary behavior using actigraphy

In actigraphy, sedentary behavior is defined as inactivity that falls below the widely established <100 counts per minute. This means that when the device detects and records less than 100 body movements (in any direction); it is categorized as sedentary behavior. The same procedure applies for the <150 counts per minute cut-point.

With use of ActiLife 5, raw data was analyzed to calculate the number minutes that firefighters spent under the <100cpm and the <150cpm thresholds during their 24-hour work day.

Sitting time using inclinometry

The Actigraph GT3X+ inclinometer function detects and records standing, sitting and lying down position when worn at the hip (sleep quality research requires the actigraphs to be work at the wrist). Inclinometer data is downloadable as string i.e. “lying”, “sitting”, “standing”, so it was recoded into numerical values to calculate total sitting time in minutes.

The inclinometer function has reported accurate measurement during moving activities while sitting i.e. riding a bicycle and pedaling (Carr & Mahar, 2012). Although this may not be ideal for characterizing sitting as sedentary behavior, it is helpful in determining position regardless of vehicle movement in the present study. For example, as firefighters sit in a fire engine while travelling to an emergency scene.

In order to validate sitting position in our sample, emergency call records provided by participants were used to identify specific activities that required a determined position. For instance, firefighters remain sitting and buckled up as the fire engine moves to emergency scenes. Four firefighters that reported emergency calls during their 24-hour shift were randomly selected in order to observe their activities before, during and after an emergency call.

As part of the sub-study (Phase III of the FORWARD Study), firefighters were asked to provide an emergency call record. This is an official digital log that records the time, place and type of emergency call. The log is fed by headquarters personnel, e.g. dispatch, and Captains, e.g. on scene arrival time, type of response and return to fire station. For validation of the sitting position sensor in the present study, only three events were taken into consideration: dispatch, on scene arrival time, and fire station return time. It is expected that at least short-time bouts of sitting time occur between these selected activities i.e. sitting during fire engine ride to the emergency scene.

Validation of inclinometer position sensor in firefighting response

Based on the provided call records, time of emergency call was identified (dispatch) and compared with real time position sensor records. I used direct observation of the reported time of day and night calls to determine the approximate time of sitting position while riding the fire engine.

For instance, the call record for the participant in figure 2 (firefighter #212) shows an emergency call dispatched at 6:39 pm, he was on scene at 6:45pm and returned to the fire station at 7:35pm. According to the real time inclinometry record, the firefighter was sitting down (labeled in yellow), got up (labeled in green as standing position) at the time of the dispatch and sat down again a few minutes to get to the emergency scene. The ride time confirms device noise since some data points were recorded as standing, this has been reported in previous studies which suggest moving while sitting is coded correctly 74-85% of the time (Carr & Mahar, 2012).

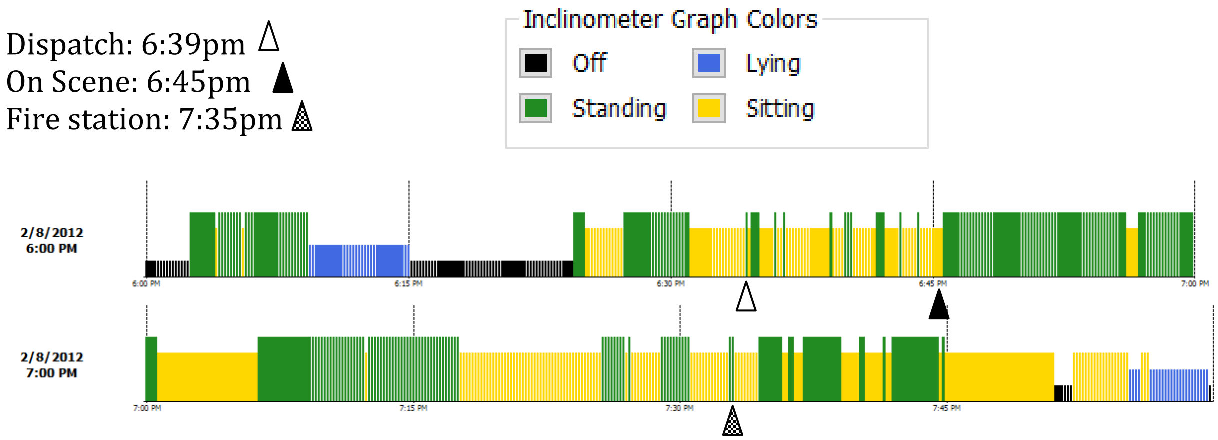

Figure 2. Position sensor information of emergency call response for firefighter #212

The trends in position can be more clearly identified during sleep hours, when the Actigraph is either in lying down (blue) or off (black) position. "Off" means that the device has been idle for a few minutes, this often occurs during sleep or nap time as the actigraphs does not register any movement.

The call record for firefighter #112 includes 3 night emergency calls. The first call's position patterns are shown in figure 112 below. According to self-reported sleep time and based on the position patters before 12:45am, it can be seen that the firefighter was asleep. A few seconds after dispatch, standing position is registered (as firefighters get in gear), followed by sitting position during the fire engine ride. The call record identifies 12:51am as the time of arrival on scene, where the inclinometer sensor identifies standing, it can be assumed to get off the engine. At 1:04am firefighters get back to the fire station and it can be seen that the participant goes back to bed and sleep at around 1:10am.

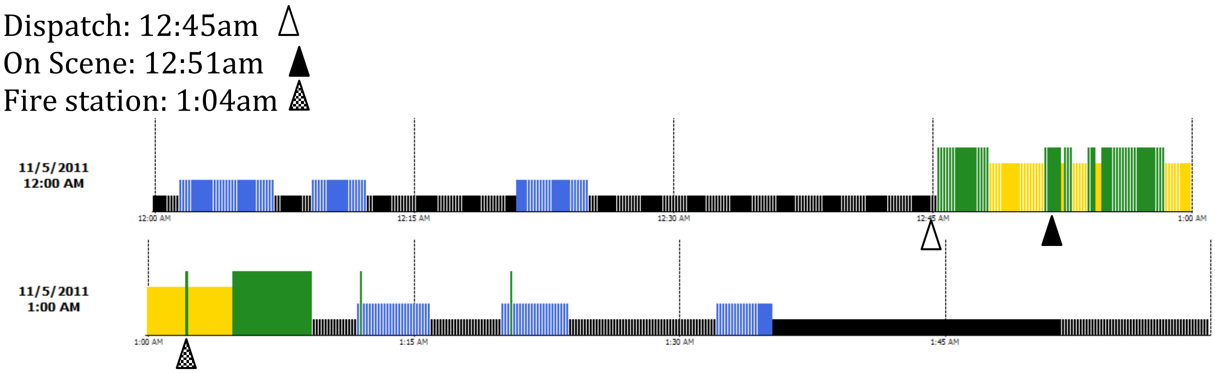

Figure 3. Position sensor information of emergency call response for firefighter #112

Position trends for all four sampled firefighters can be observed in Appendix 1. Future studies will need to study in detail the position patterns of all 81 firefighters to confirm the trends observed in the present sample.

Measurement of cardiovascular disease risk factors

Resting heart rate readings were collected during the firefighters' wellness and fitness (WEFIT) biennial medical examination at the Center for Occupational and Environmental Health, University of California Irvine. Experienced clinical personnel assessed the pulse rate of each firefighter for 10 seconds and then multiplied by six to get his RHR (beats per minute: bpm). Blood pressure was also assessed by experienced clinical staff 5 minutes after rest in sitting position. A second blood pressure reading was taken 1 minute apart, the average of both readings was used to ensure consistent measurement. Fasting serum lipid profiles (glucose, high-density lipoprotein (HDL), low-density lipoprotein (LDL) and triglycerides) were collected in external laboratories 2 weeks before and after visiting the WEFIT clinic. Firefighters returned their results to the WEFIT clinic.

Covariates

Age and ethnicity are well-established confounders for both physical activity and CVD risk factors. Age was entered into statistical analyses as continuous and ethnicity was categorized as White, Hispanic and Asian. No African-Americans participated in the FORWARD Study. Female firefighters made up 2% of the original sample (N=365) and none participated in the sub-study (N=83).

Worksite exercise was assessed with a single item asking "On average during the past year, how many days a week have your aerobic or cardio EXERCISE (work outs) met the following two criteria: •30 minutes or more in duration and •Medium (work up a sweat and slight heart rate increase) to vigorous intensity (work up a good sweat and rapid heart rate increase) at the fire station" with a four point response set (0 days/week; 1 day/week; 2 days/week; and 3 or more days/week.

Sleep hours was self reported as the number of total hours the participants slept during their 24-hour shift.

Eating habits were made up of two items: "How many servings of food do you eat (per day) that are high in fiber, such as whole grain bread, high fiber cereal, fresh fruits or vegetables? (a serving size: 1 slice bread, ½ cup vegetables, 1 medium fruit, ¾ cup cereal)" and "How many servings of food do you eat (per day) that are high in cholesterol or fat such as fatty meat, cheese, fried foods or eggs? (a serving size: 3 ½ oz meat, 1 egg, 1 oz/slice cheese)" with a four point Likert scale 1=5-6 servings a day; 2=3-4 servings a day; 3=1-2 servings a day; 4=never/rarely. The fruit and vegetable item was inverted and added to the fat intake item. The response range is 2-8, with higher values indicating unhealthier eating habits.

Shift work was self-reported as the total number of 24-hour shifts firefighters worked during the past month. This was categorized into 8 groups as follows: 0-7, 8-11, 12, 13, 14, 15, 16, and 17-21. This categorization has been used in previous publications (Choi, Dobson, Schnall, & Garcia-Rivas, 2016).

Medication was a binary variable coded as 1 = medication for “heart trouble”, “blood pressure”, “hyperlipidemia”, or “diabetes mellitus”; and 0 = no medication.

2.3 Statistical analysis

One-way ANOVA was conducted to explore the association between self-reported sedentary work and other physical activity and occupational inactivity measures. Pearson's correlation was used to compare the physical activity and sedentary measures: number of steps, sitting time assessed by inclinometer; and sedentary behavior measured by the <100 counts per minute and <150 counts per minute thresholds.

Simple linear regression was used to analyze the univariate association between each physical activity and occupational inactivity (sedentary work, sitting time and sedentary behavior) and CVD risk factors (body mass index, body fat percent, waist circumference, blood pressure, resting heart rate, glucose, cholesterol, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol and triglycerides). All outcome variables had acceptable skewness and kurtosis indicators between -2 and +2, *triglycerides* was marginally within these parameters (George & Mallery, 2010). Additional multiple linear regression analyses where conducted while controlling for known confounders (age, ethnicity, shift work, worksite exercise, sleep hours, unhealthy diet and medication).

3. Results

Descriptive statistics

The mean age of the sample was 39 years SD=8.8 with a majority of participants identifying as "White". The sample size was 81 but for CVD risk outcomes it was N=75. 6 firefighters taking medication were removed for analyzing non-obesity CVD outcomes. Additionally, there were 7 serum laboratory results. Table 1 shows all other variables used for statistical analyses.

Table 1. Descriptive statistics

	Unit	Mean	SD	Min	Max	N
Step count	steps	10,402	3,051	4,118	21,212	81
Sitting time	minutes	417.12	114.37	108.50	711.17	81
<100 cpm	minutes	721.24	104.56	500.00	1018.67	81
<150cpm	minutes	742.27	104.02	522.67	1043.67	81
Sedentary work	dichotomous		No = 65.4%	Yes = 34.6%		81
Body mass index	w/h ratio	27.35	3.42	22.31	38.26	81
Waist circumference	inches	36.88	3.84	30.00	47.25	80
Body fat percent	percentage	17.34	6.21	6.44	30.42	79
Systolic blood pressure	mgHg	114.77	11.99	97.00	150.00	75*
Diastolic blood pressure	mgHg	75.49	8.58	60.00	97.00	75*
Glucose	mg/dL	93.25	8.36	73	120	67*
Resting heart rate	beats/min.	59.83	8.63	42	84	75*
Total cholesterol	mg/dL	190.47	32.23	132	290	68*
HDL	mg/dL	56.15	14.43	32	100	68*
LDL	mg/dL	115.00	31.19	53	200	68*
Triglycerides	mg/dL	91.26	45.29	30	280	68*
Age	years	39.89	9.05	18	59	81
Sleeping hours	hours	7.12	1.65	0.75	9.50	72
Unhealthy eating habits	Likert 2-8	4.69	0.83	2.00	7.00	81
Worksite exercise	Likert 1-4	3.49	0.76	1	4	81
Shift work	8 categories	0-7 10%	8-11 5%	12shifts 21%	13 shifts 11%	81
		14 shifts 26%	15 shifts 9%	16 shifts 11%	17-21 7%	
Ethnicity	3 categories	82.7% White	8.6% Hispanic	4.9% Asian		81
Medication	dichotomous		Yes = 7%	No = 93%		81

* 6 firefighters taking heart medication were removed for analyzes of non-obesity CVD outcomes

Sedentary work

Regarding the self-reported sedentary work item: "My job often requires sitting for long periods of time", the "strongly disagree" and "disagree" responses were collapsed together into a "no" category, which corresponded to 65.4% of respondents. Likewise, the options "agree" and "strongly agree" were categorized into a "yes" group that included 34.6% of respondents. As sensitivity analysis, self-reported sedentary work was associated to number of steps (p=0.03).

Table 2. One-way ANOVA results for dichotomized self-reported sedentary work and objectively measured physical activity and occupational inactivity.

(N=81), df(1,79)

	No sedentary work		Sedentary work			
	M	SD	M	SD	F	p
Step count	10,928	3,171	9,407	3,051	4.76	0.032
Sitting time	413	112	424	120	0.17	0.685
<100cpm	720	91	723	128	0.02	0.904
<150cpm	741	89	743	129	0.00	0.960

Physical activity and occupational inactivity

The correlation between physical activity and occupational inactivity measures were analyzed at the 0.05 significance level as shown in table 3. There was no statistically significant association between step count and any occupational inactivity measure, however the coefficients were in the expected direction. The correlation between sitting time measured by inclinometer and sedentary behavior <100cpm was r=0.336 (p<0.01) and r=0.317 (p<0.01) with <150cpm.

An important finding is that the <100cpm and <150cpm had a correlation of 0.974 (p<0.01). This would suggest there is virtually no difference in the cut-point used when analyzing physical activity; however, as shown in tables 1 and 2, there is a slight increased number of minutes in sedentary time when using the <150cpm threshold.

Table 3. Pearson's correlation coefficients of occupational inactivity (N = 81)

	Step count	Sitting time	<100cpm	<150cpm
Step count	--------			
Sitting time	-0.069	--------		
<100cpm	-0.113	0.336**	--------	
<150cpm	-0.082	0.317**	0.974**	--------

** p < 0.01

Association between sedentary measures and CVD risk factors

In the univariate regression analyses, self-reported sedentary work was positively associated with body mass index, body fat percent, waist circumference and total cholesterol. These associations remain significant after including confounding variables. Table 4 shows the standardized coefficients of dichotomized self-reported sedentary work and CVD risk outcomes. There was also an association with blood pressure (systolic and diastolic), glucose, and LDL cholesterol. However these associations become non-significant as confounding variables are included. No association was found with resting heart rate, HDL cholesterol and triglycerides.

Table 4. Predicting CVD risk factors using self-reported sedentary work

	Body Mass Index				**Body Fat Percent**				**Waist Circumference**				Systolic Blood Pressure			
	β	*p*	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*p*
Sedentary Work	**0.47**	**0.000**	**0.53**	**0.000**	**0.36**	**0.001**	**0.29**	**0.010**	**0.42**	**0.000**	**0.39**	**0.001**	**0.26**	**0.022**	0.24	0.079
Age			0.11	0.308			0.44	0.000			0.22	0.062			0.02	0.868
Ethnicity			0.05	0.664			0.04	0.732			-0.06	0.604			-0.07	0.609
Unhealthy diet			0.20	0.062			0.12	0.258			0.09	0.434			0.04	0.739
Worksite exercise			-0.02	0.886			-0.15	0.167			-0.07	0.578			-0.01	0.948
Sleep hours			0.01	0.936			-0.06	0.600			0.01	0.933			0.17	0.201
Shift work			0.06	0.590			0.18	0.106			0.05	0.673			-0.10	0.469

β = standardized regression coefficients
p = significance value

Cont. Table 4

	Diastolic Blood Pressure				Resting Heart Rate				Glucose				**Cholesterol**			
	β	*p*	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*p*
Sedentary Work	**0.24**	**0.035**	0.20	0.121	0.09	0.438	0.10	0.480	**0.24**	**0.0046**	0.20	0.159	**0.34**	**0.004**	**0.27**	**0.028**
Age			0.16	0.221			0.11	0.429			0.19	0.177			0.36	0.004
Ethnicity			-0.13	0.290			0.01	0.915			-0.03	0.816			0.07	0.558
Unhealthy diet			0.12	0.344			-0.03	0.825			-0.03	0.825			0.32	0.008
Worksite exercise			-0.18	0.144			-0.20	0.137			-0.04	0.736			-0.15	0.178
Sleep hours			0.16	0.204			-0.02	0.902			0.25	0.081			-0.10	0.444
Shift work			0.06	0.678			-0.05	0.736			0.15	0.305			-0.11	0.399

β = standardized regression coefficients
p = significance value

Cont. Table 4

	HDL				LDL				Triglycerides			
	β	*p*	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*p*
Sedentary Work	-0.04	0.729	-0.24	0.868	**0.32**	**0.007**	0.22	0.068	0.11	0.381	0.12	0.382
Age			-0.04	0.804			0.39	0.002			0.24	0.074
Ethnicity			-0.07	0.630			0.11	0.371			0.00	0.987
Unhealthy diet			0.13	0.373			0.28	0.018			0.31	0.018
Worksite exercise			-0.02	0.907			-0.19	0.107			0.14	0.258
Sleep hours			0.07	0.649			-0.01	0.959			-0.22	0.108
Shift work			0.13	0.412			-0.12	0.341			-0.10	0.467

β = standardized regression coefficients
p = significance value

Number of 24-hour step count was associated with body fat percent and diastolic blood pressure. However, these associations disappear once covariates are added. Worksite exercise was not used as a covariate for these analyses. Although non-significant, all coefficients were in the expected direction.

Table 5. Predicting CVD risk factors using number of steps from pedometer

	Body Mass Index				Body Fat Percent				Waist Circumference				Systolic Blood Pressure			
	β	*p*	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*p*
Step count	-0.15	0.195	-0.08	0.544	**-0.28**	**0.014**	**-0.26**	**0.019**	-0.17	0.144	-0.10	0.433	-0.20	0.087	-0.12	0.370
Age			0.25	0.044			0.47	0.000			0.32	0.012			0.05	0.693
Ethnicity			-0.02	0.893			0.00	0.992			-0.11	0.378			-0.09	0.478
Unhealthy diet			-0.27	0.029			0.16	0.149			0.14	0.244			0.08	0.552
Sleep hours			0.05	0.693			-0.15	0.169			-0.05	0.676			0.14	0.321
Shift work			0.06	0.636			0.18	0.108			0.04	0.747			-0.10	0.488

β = standardized regression coefficients
p = significance value

Cont. Table 5																
	Diastolic Blood Pressure				Resting Heart Rate				Glucose				Cholesterol			
	β	*p*	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*p*
Step count	**-0.26**	**0.024**	-0.20	0.124	-0.18	0.116	-0.13	0.334	-0.03	0.834	-0.01	0.964	-0.13	0.299	-0.03	0.827
Age			0.16	0.212			0.11	0.443			0.25	0.090			0.45	0.001
Ethnicity			-0.16	0.214			0.01	0.982			-0.05	0.704			0.04	0.734
Unhealthy diet			0.15	0.238			-0.02	0.905			-0.01	0.933			0.34	0.006
Worksite exercise			-0.12	0.344			-0.16	0.217			-0.02	0.892			-0.12	0.318
Sleep hours			0.12	0.354			-0.04	0.773			0.24	0.105			-0.12	0.381
Shift work			0.06	0.670			-0.05	0.740			0.16	0.288			-0.11	0.457

β = standardized regression coefficients
p = significance value

Cont. Table 5												
	HDL				LDL				Triglycerides			
	β	*p*	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*p*
Step count	0.11	0.381	0.08	0.604	-0.15	0.222	-0.04	0.763	-0.11	0.350	0.04	0.761
Age			-0.01	0.938			0.46	0.001			0.28	0.047
Ethnicity			-0.07	0.641			0.08	0.491			-0.01	0.941
Unhealthy diet			0.13	0.358			0.30	0.014			0.32	0.015
Worksite exercise			-0.04	0.784			-0.16	0.188			0.16	0.227
Sleep hours			0.08	0.599			-0.02	0.863			-0.23	0.099
Shift work			0.12	0.432			-0.11	0.384			-0.10	0.486

β = standardized regression coefficients
p = significance value

Sitting time as measured by inclinometer was positively associated with body fat percent, waist circumference, systolic blood pressure, glucose, and HDL cholesterol. However, only the associations with systolic blood pressure and HDL cholesterol remain significant after holding all other covariates constant. All coefficients were in the expected direction.

Table 6. Predicting CVD risk factors using sitting time from position sensor inclinometer																
	Body Mass Index				Body Fat Percent				Waist Circumference				**Systolic Blood Pressure**			
	β	*p*	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*p*
Sitting time	0.16	0.159	0.05	0.715	**0.33**	**0.003**	0.17	0.126	**0.22**	**0.046**	0.13	0.281	**0.26**	**0.022**	**0.33**	**0.009**
Age			0.26	0.038			0.49	0.000			0.32	0.012			0.04	0.745
Ethnicity			-0.03	0.845			-0.02	0.890			-0.12	0.331			-0.12	0.355
Unhealthy diet			0.27	0.032			0.15	0.180			0.13	0.287			0.04	0.775
Worksite exercise			0.05	0.719			-0.10	0.369			-0.01	0.944			0.07	0.589
Sleep hours			-0.05	0.688			-0.09	0.437			-0.03	0.794			0.18	0.168
Shift work			0.03	0.848			0.15	0.214			0.01	0.935			-0.13	0.347

β = standardized regression coefficients
p = significance value

Cont. Table 6

	Diastolic Blood Pressure				Resting Heart Rate				Glucose				Cholesterol			
	β	*p*	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*p*
Sitting time	0.18	0.125	0.18	0.153	0.06	0.603	0.02	0.865	**0.23**	**0.054**	0.11	0.401	0.01	0.939	-0.05	0.648
Age			0.19	0.131			0.13	0.316			0.23	0.087			0.45	0.000
Ethnicity			-0.17	0.182			0.00	0.989			-0.06	0.646			0.47	0.703
Unhealthy diet			0.13	0.316			-0.02	0.895			-0.02	0.899			0.35	0.006
Worksite exercise			-0.13	0.294			-0.18	0.175			-0.01	0.943			-0.13	0.291
Sleep hours			0.17	0.203			-0.02	0.885			0.24	0.097			-0.11	0.372
Shift work			0.04	0.755			-0.05	0.733			0.14	0.329			-0.09	0.491

β = standardized regression coefficients
p = significance value

Cont. Table 6

	HDL				LDL				Triglycerides			
	β	*p*	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*p*
Sitting time	**-0.28**	**0.019**	**-0.27**	**0.043**	0.09	0.441	0.05	0.696	0.21	0.085	0.10	0.424
Age			-0.01	0.943			0.45	0.000			0.27	0.040
Ethnicity			-0.04	0.770			0.08	0.516			-0.02	0.882
Unhealthy diet			0.14	0.307			0.30	0.015			0.30	0.016
Worksite exercise			-0.04	0.752			-0.16	0.189			0.17	0.189
Sleep hours			0.06	0.652			-0.02	0.865			-0.22	0.098
Shift work			0.16	0.283			-0.12	0.363			-0.11	0.431

β = standardized regression coefficients
p = significance value

Sedentary behavior measured by actigraphy using the <100 counts per minute threshold was only associated with body fat percent and remains marginally significant when controlling for confounders. Sedentary behavior measured by actigraphy with the <100cpm was not associated with any other CVD risk factor. Table 7 shows the standardized coefficients and p-value for all CVD risk outcomes.

Table 7. Predicting CVD risk factors using <100 counts per minute threshold

	Body Mass Index				Body Fat Percent				Waist Circumference				Systolic Blood Pressure			
	β	*p*	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*p*
<100cpm	0.04	0.720	0.04	0.730	**0.25**	**0.028**	0.19	0.082	0.16	0.158	0.17	0.171	0.08	0.488	0.11	0.384
Age			0.27	0.034			0.51	0.000			0.32	0.009			0.08	0.529
Ethnicity			-0.03	0.835			-0.03	0.823			-0.13	0.291			-0.10	0.429
Unhealthy diet			0.28	0.027			0.18	0.109			0.16	0.199			0.09	0.514
Worksite exercise			0.05	0.709			-0.09	0.428			0.01	0.975			0.06	0.667
Sleep hours			-0.06	0.654			-0.12	0.308			-0.06	0.652			0.16	0.242
Shift work			0.02	0.886			0.11	0.349			0.00	0.886			-0.12	0.409

β = standardized regression coefficients
p = significance value

Cont. Table 7

	Diastolic Blood Pressure				Resting Heart Rate				Glucose				Cholesterol			
	β	*p*	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*p*
<100cpm	0.09	0.458	0.06	0.644	-0.04	0.759	0.09	0.518	0.15	0.217	-0.03	0.814	0.04	0.751	0.00	0.975
Age			0.21	0.094			0.14	0.272			0.25	0.068			0.00	0.975
Ethnicity			-0.16	0.207			0.01	0.928			-0.05	0.726			0.45	0.000
Unhealthy diet			0.15	0.229			-0.02	0.883			-0.01	0.925			0.04	0.733
Worksite exercise			-0.14	0.290			-0.20	0.136			-0.02	0.856			0.34	0.006
Sleep hours			0.15	0.240			-0.02	0.881			0.24	0.100			-0.12	0.312
Shift work			0.05	0.733			-0.03	0.828			0.16	0.276			-0.11	0.379

β = standardized regression coefficients
p = significance value

Cont. Table 7

	HDL				LDL				Triglycerides			
	β	*p*	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*p*
<100cpm	-0.12	0.323	-0.06	0.680	0.04	0.766	-0.06	0.608	0.10	0.397	0.16	0.207
Age			-0.04	0.771			0.46	0.000			0.27	0.036
Ethnicity			-0.06	0.676			0.09	0.458			-0.03	0.828
Unhealthy diet			0.12	0.389			0.30	0.015			0.33	0.012
Worksite exercise			-0.03	0.836			-0.17	0.156			0.18	0.146
Sleep hours			0.07	0.621			-0.02	0.886			-0.24	0.079
Shift work			0.14	0.376			-0.10	0.455			-0.13	0.339

β = standardized regression coefficients
p = significance value

As expected, results for the <150cpm threshold did not differ from those obtained with the <100cpm cut point. The only statistically significant association was also with body fat percent but not with any other outcome. Results for sedentary behavior using the <150 cpm threshold are presented in Table 8.

Table 8. Predicting CVD risk factors using <150 counts per minute threshold

	Body Mass Index				Body Fat Percent				Waist Circumference				Systolic Blood Pressure			
	β	*p*	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*p*	*β*	*p*
<150cpm	0.01	0.915	0.03	0.835	**0.23**	**0.041**	0.19	0.082	0.13	0.239	0.16	0.208	0.06	0.604	0.10	0.442
Age			0.27	0.031			0.52	0.000			0.33	0.007			0.09	0.492
Ethnicity			-0.03	0.846			-0.03	0.807			-0.13	0.292			-0.11	0.430
Unhealthy diet			0.28	0.027			0.18	0.099			0.16	0.191			0.09	0.504
Worksite exercise			0.04	0.730			-0.10	0.377			-0.01	0.962			0.05	0.711
Sleep hours			-0.05	0.672			-0.11	0.348			-0.05	0.706			0.16	0.230
Shift work			0.02	0.862			0.11	0.370			-0.02	0.889			-0.12	0.411

β = standardized regression coefficients
p = significance value

Cont. Table 8

	Diastolic Blood Pressure				Resting Heart Rate				Glucose				Cholesterol			
	β	p	β	p	β	p	β	p	β	p	β	p	β	p	β	p
<150cpm	0.04	0.703	0.03	0.818	-0.03	0.813	-0.05	0.684	0.13	0.287	-0.06	0.668	0.02	0.852	-0.03	0.834
Age			0.22	0.087			0.14	0.292			0.25	0.066			0.45	0.000
Ethnicity			-0.16	0.216			0.01	0.942			-0.05	0.741			0.45	0.719
Unhealthy diet			0.15	0.233			-0.02	0.884			-0.02	0.913			0.34	0.006
Worksite exercise			-0.15	0.258			-0.19	0.153			-0.03	0.832			-0.13	0.298
Sleep hours			0.16	0.236			-0.02	0.886			0.24	0.103			-0.11	0.377
Shift work			0.05	0.709			-0.04	0.806			0.17	0.261			-0.09	0.491

β = standardized regression coefficients
p = significance value

Cont. Table 8

	HDL				LDL				Triglycerides			
	β	p	β	p	β	p	β	p	β	p	β	p
<150cpm	-0.12	0.315	-0.06	0.670	0.03	0.833	-0.07	0.560	0.08	0.488	0.13	0.293
Age			-0.04	0.764			0.46	0.000			0.27	0.034
Ethnicity			-0.06	0.675			0.09	0.454			-0.02	0.852
Unhealthy diet			0.12	0.393			0.30	0.015			0.33	0.012
Worksite exercise			-0.03	0.837			-0.17	0.153			0.18	0.159
Sleep hours			0.07	0.638			-0.02	0.861			-0.24	0.093
Shift work			0.14	0.377			-0.10	0.456			-0.13	0.371

β = standardized regression coefficients
p = significance value

4. Discussion

Self-reported sedentary work has proven to be an important predictor of obesity in male firefighters (Choi, Dobson, Schnall, & Garcia-Rivas, 2016). Although the present study is not epidemiological per se but rather methodological, the association between sedentary work and all three obesity indicators (BMI, body fat percent and waist circumference) remains after adjustment of known confounders, including physical activity (work exercise). This contributes to the growing evidence that the association between sedentary work and obesity may have an independent effect and a different causal pathway from that of physical activity. Serum total cholesterol also showed a positive association with sedentary work but was not associated with any other CVD risk outcome when taking into account confounding variables.

The pedometer function in the actigraph recorded a mean of 10,402 steps (SD 3,051). This average is within the 10,000 step recommendation. However, step count was only associated with body fat percent.

The mean number of minutes in sitting position using the inclinometer was 417 (SD 114) during the 24-hour work day. This represents 29% of the work day spent sitting down. It is important to note that the discrepancy between these two methods may be due to in part to the inherent definition of sedentary behavior with actigraphy (i.e.) activity that is registered below 100 counts per minute, this often includes lying down as part of pre and post sleeping periods, and standing while not moving moderately to vigorously.

Sitting time was positively associated with systolic blood pressure HDL cholesterol. Other studies have found similar associations in cross-sectional and cohort studies using self-reported sitting time (Heffernan et al., 2013; Mainsbridge et al., 2018).

The mean number of minutes in sedentary activity at work using <100cpm threshold was 721 minutes (SD 104.5) in a 24-hour work period. Likewise, the mean number of minutes while using the <150cpm threshold was 742 (SD 104). This represents around 50% and 52%, respectively, of an entire 24-hour work day. This amount of time in sedentary behavior is considerably less than that reported in other working populations using the <100cpm threshold. For example, office workers are reported to average 76% of an entire work schedule in sedentary behavior; 83% in call center employees; and 74% in customer service workers (Alicia A Thorp et al., 2012).

Sedentary behavior assessed by actigraphy using the <100cmp threshold was only associated with body fat percent but the association became non-significant after adjustment of confounding variables. This measure of sedentary behavior was not associated with any other CVD risk outcome. Practically identical results were obtained with the <150cpm threshold. It is worth noting that sedentary behavior measured by actigraphy cannot discriminate sitting time versus other non-vigorous activities like standing still. Results in the present study suggest that sedentary behavior using actigraphy may not be an adequate measure for 24-hour active occupations. However, more research is needed in larger representative samples to confirm these findings.

Interestingly, all measures of occupational inactivity and physical activity were associated with body fat percent. Although the main objective of this study is to identify the best predictive measure of physical activity and occupational inactivity, the finding that body fat percent is consistently associated with all predictors is in itself an important contribution. Body fat percent uses a combination of adiposity measures in three different body locations in contrast with waist circumference (single site) and body mass index with its widely known disadvantages. Similarly, albeit providing important health information, serum laboratory results are easily contaminated by behavioral factors.

Limitations

The analyses presented in this study were done with a small sample size. Thus, there is an issue with generalizability. However, it is important to mention that results from the self-reported sedentary work item are consistent with findings in an epidemiological study with a larger representative sample of firefighters (Choi, Dobson, Schnall, & Garcia-Rivas, 2016).

Regarding the physical activity monitoring techniques, a single 24-hour work day may not be sufficient to fully determine the effect of physical activity and occupational sitting in firefighters. Future epidemiological studies should consider continuous recordings of several work days.

Because firefighters may be active at night, physical activity monitors will include such activity as sedentary if it falls under the 100 or 150 cpm thresholds. This is an important factor that needs further research i.e. whether activity in times while the person is expected to be at rest should be considered sedentary behavior or rather a disturbance in sleeping patterns. Although this study included self-reported hours of sleep, there is no precise information on the actual time and quality of sleep. Actigraphs can track sleep patterns along with a light sensor, but this technique requires the device to be work at the wrist. Nevertheless, positioning the device on the wrist will affect the quality of physical activity data.

Conclusions

Self-reported sedentary work is a practical tool composed of a single item. Because the concept is easy to understand similar to others like absenteeism (e.g. how many days have missed from work…?), there is no need for additional items to make up the construct. The results in this study show that self-reported sedentary work is the most important predictive indicator of CVD risk factors, including obesity. This is in line with findings in previous publications (Choi, Dobson, Schnall, & Garcia-Rivas, 2016).

Although self-reported sedentary work continues to be a relevant predictor of obesity, CVD risk factors and all-cause mortality as demonstrated in the literature, there is still value in including ambulatory measures. The systematic surveillance of sedentary behavior will facilitate improved predictive models in epidemiological studies that intend to research the health effects of occupational sitting. For example, identifying specific thresholds of sitting time can help establish healthy behavior cut points for the implementation of intervention programs. Based on the findings presented here, sitting time by inclinometry is an important physiological alternative for obtaining ambulatory measures of occupational inactivity.

Alternatively, objectively measured sitting time has shown to be a useful and accurate tool for occupational sitting. No other study has validated this tool in 24-hour "free-living" working conditions. This study has used the emergency call records of firefighters to identify position based on the expected activity (e.g. sitting while riding the fire engine).

Inclinometry information of actual sitting time in comparison with more abstract measures (e.g. counts per minute and its translation to sedentary behavior), may offer better baseline measurement for future intervention studies. Identifying concrete measurable behaviors (e.g. minutes spent in sitting position) will improve the identification of the intervention effect regarding changes in sedentary time. This may be helpful as to establish a recommended maximum occupational sitting time cut point, comparable to the current recommendation of 10,000 steps as a healthy physical activity.

The present study offers seminal groundwork for the worksite measurement of physical activity and occupational inactivity. Future epidemiological studies should consider including inclinometry in addition to self-reported sedentary work in order to clearly elucidate the effects of occupational inactivity on CVD risk.

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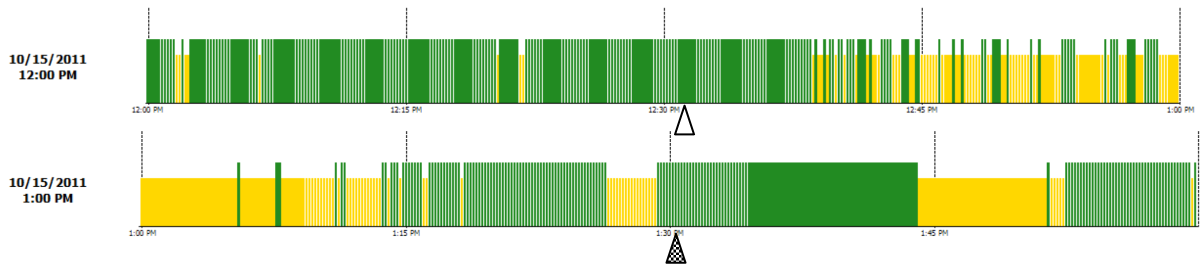
Appendix 1

Validity of sitting position by inclinometer based on fire call record provided by firefighters.

<u>Firefighter #107</u>

Dispatch: 12:33pm △

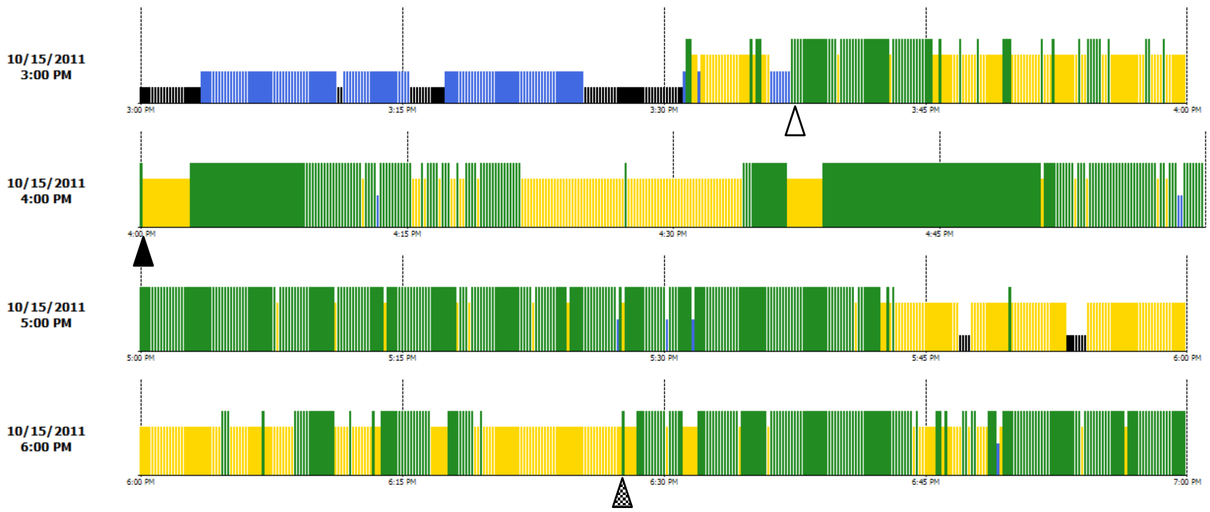
Fire station: 1:31pm



Dispatch: 3:40pm △

On Scene: 4:00pm ▲

Fire station: 6:27pm

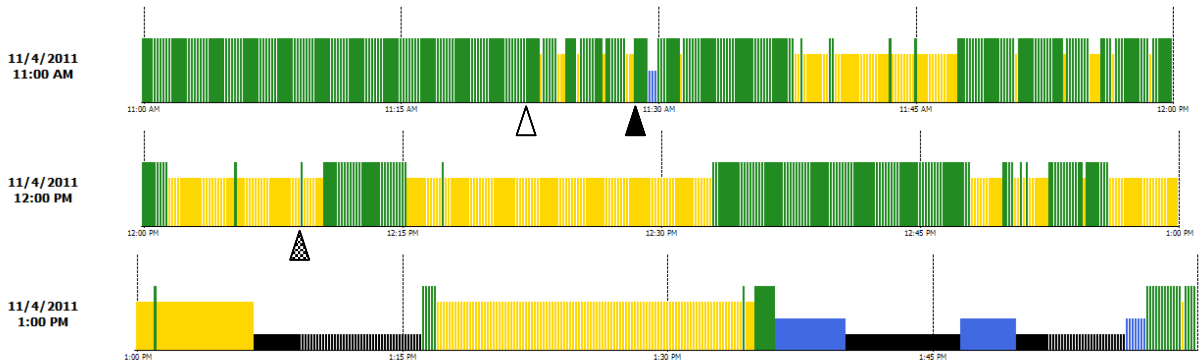


Firefighter #112

Dispatch: 11:20am △

On Scene: 11:25am ▲

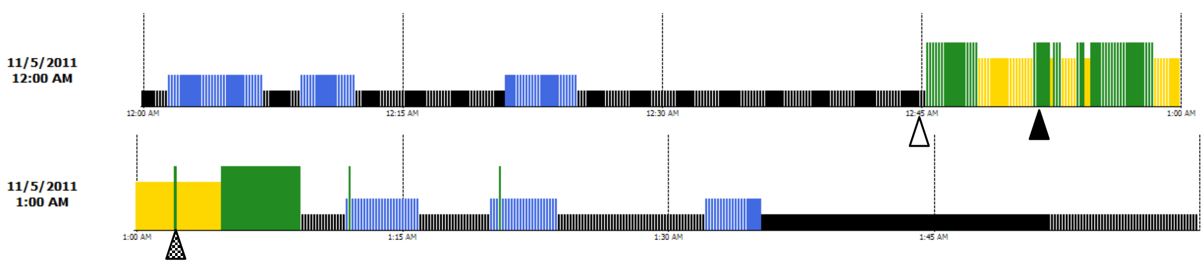
Fire station: 12:09pm



Dispatch: 12:45am △

On Scene: 12:51am ▲

Fire station: 1:04am

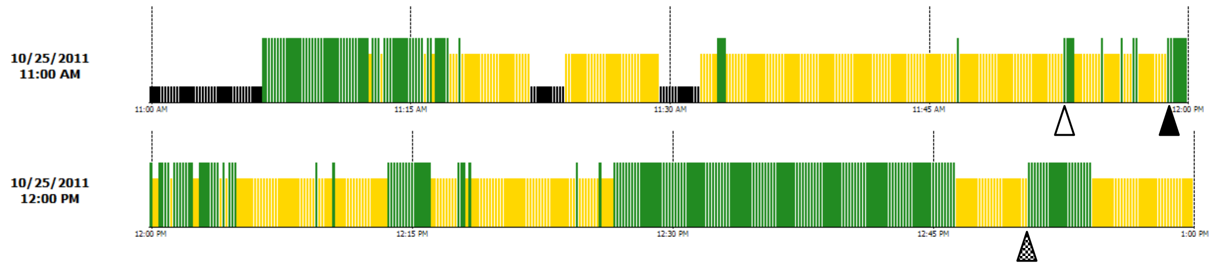


Firefighter #118

Dispatch: 11:52am △

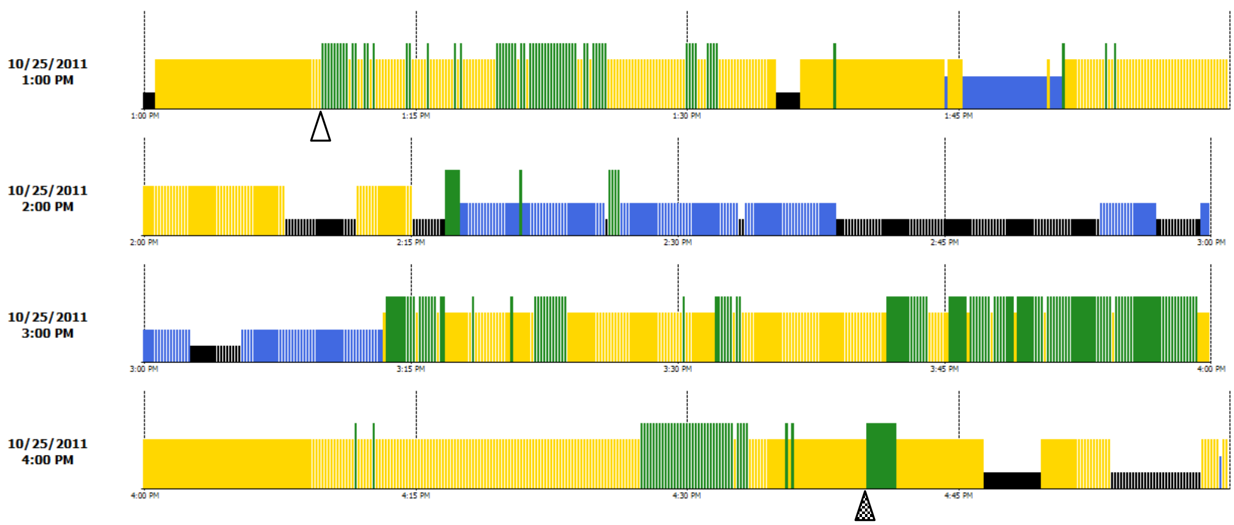
On Scene: 11:57am ▲

Fire station: 12:49pm



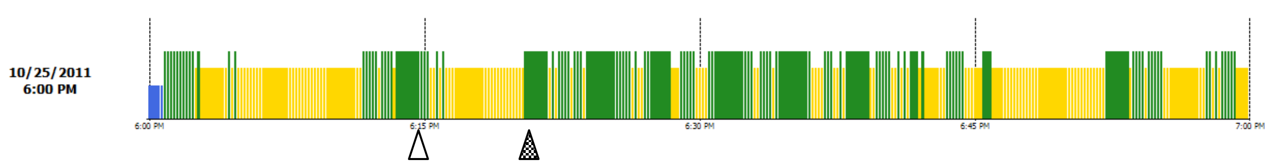
Dispatch: 1:09pm △

Fire station: 4:39pm



Dispatch: 6:14pm △

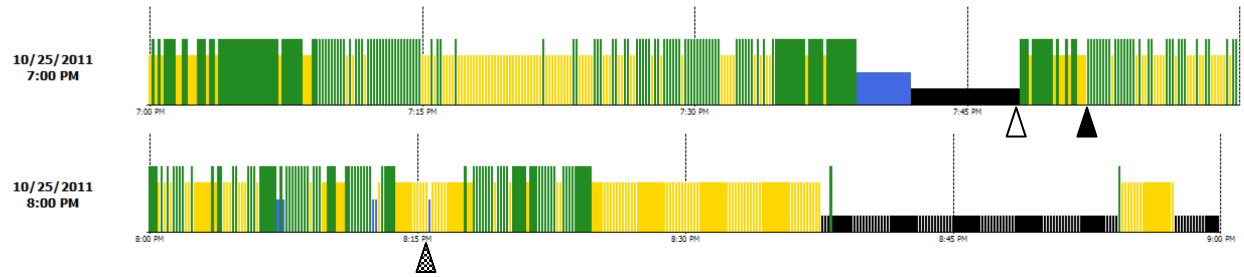
Fire station: 6:19pm



Dispatch: 7:48pm △

On Scene: 7:51pm ▲

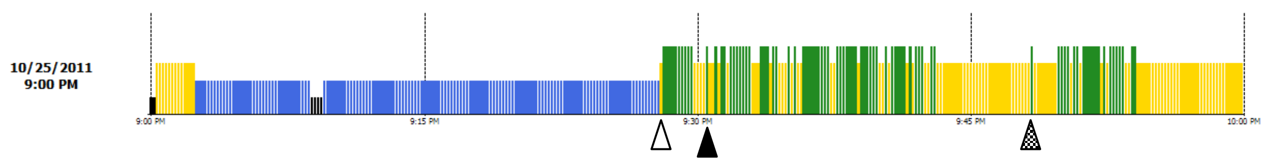
Fire station: 8:16pm



Dispatch: 9:28pm △

On Scene: 9:31pm ▲

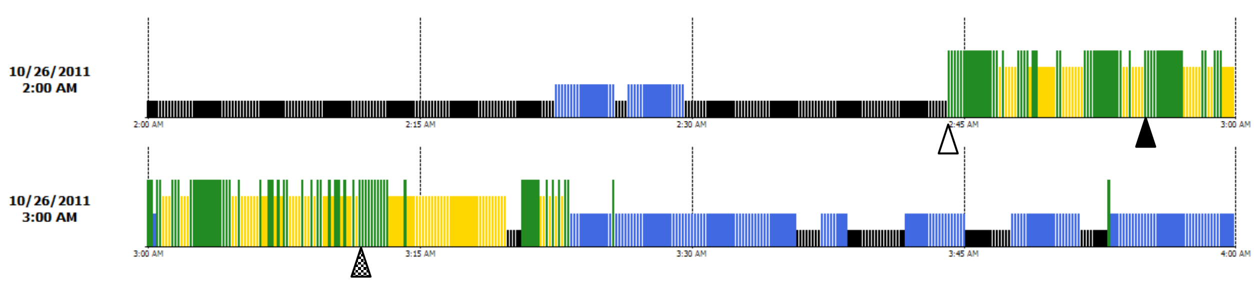
Fire station: 9:48pm



Dispatch: 2:44am △

On Scene: 2:50am ▲

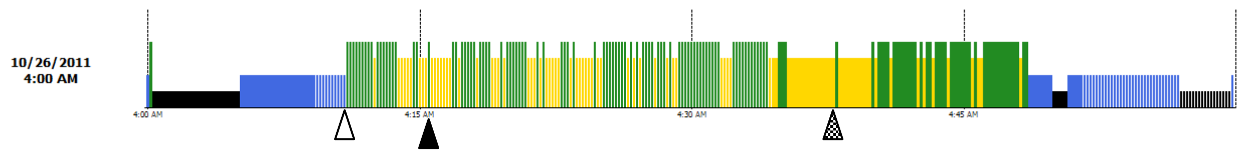
Fire station: 3:10am



Dispatch: 4:11am

On Scene: 4:16am

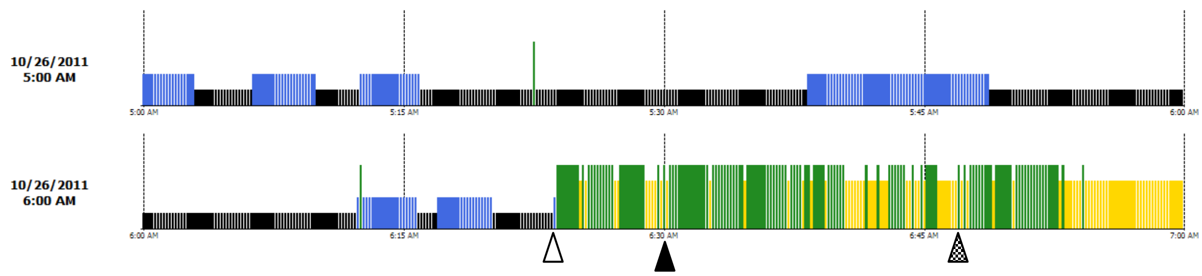
Fire station: 4:38am



Dispatch: 6:23am

On Scene: 6:30am

Fire station: 6:48am

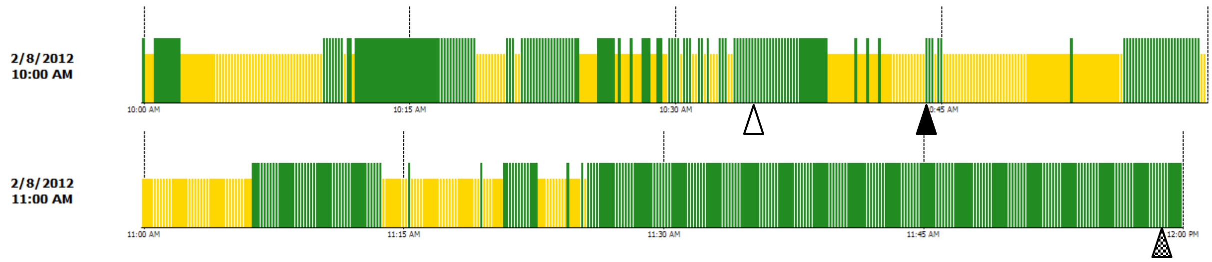


Firefighter #212

Dispatch: 10:36am △

On Scene: 10:43am ▲

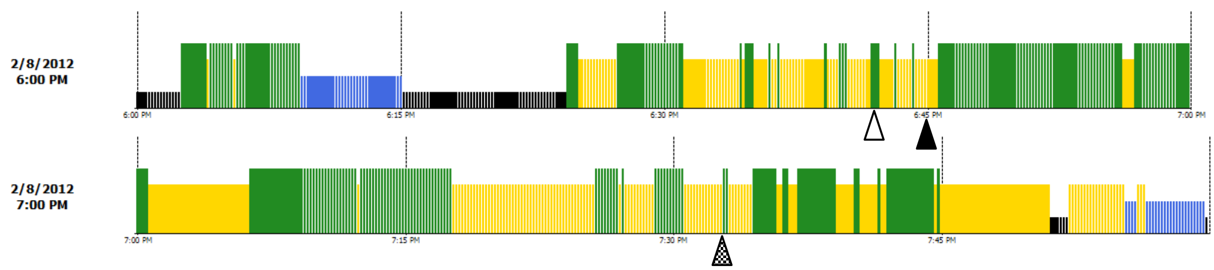
Fire station: 11:57am



Dispatch: 6:39pm △

On Scene: 6:45pm ▲

Fire station: 7:35pm



Chapter 5

Conclusions

Bernardino Ramazzini (1633-1714), also known as the father of occupational medicine, stressed the importance of considering the job an individual performs as an central part of health and disease prevention in the 1700s. Ramazzini, as many occupational health researchers support nowadays, recommended including "what is your occupation?" to Hippocrates' set of medical practice questions. Although occupational health has not been overall embraced as a major area in the medical community, efforts in European and Scandinavian epidemiological research has shown the relevance of the work as a major contributor of health and disease. In the 70s and 80s, the United States made important advances in the field of occupational health with the signing of the Occupational Safety and Health Act (OSHA) and the formal establishment of the National Institute of Occupational Safety and Health (NIOSH). Traditionally, these institutions have primarily focused on safety and injury prevention, but work organization still plays a crucial role in the health-disease continuum of workers. Since then, theoretical progress and research from prominent scholars and research groups, including the Center for Occupational and Environmental Health at UC Irvine, have made important contributions to advance the understanding of the effects of the workplace on the physical and mental health of workers.

The FORWARD Study is part of such projects aimed at advancing research and improving deleterious working conditions for a population made up of over 1 million workers. Firefighters are more likely to die on the job from cardiovascular disease related conditions than from any other work-related cause. Also, they are at a higher risk of such ailments than other occupations. The FORWARD Study was developed to investigate working conditions that may contribute to the development of obesity and other CVD risk factors in firefighters. A random sample of 365 firefighters was obtained with 84% participation rate. The Study was crafted as a mixed-methods approach to ensure optimal quality data collection grounded on a thorough theoretical framework that took into consideration virtually all major occupational risk factors in the literature (Choi, et al., 2011b). However, the overall framework failed to capture the environmental factors in a worksite contextual dynamic. Chapter 2 was aimed at filling this gap by including relevant information about the environmental characteristics surrounding the fire stations that could affect the health of firefighters.

The aims of chapter 2 were to investigate the direct and indirect association between the environmental fast-food density (i.e. the number of fast-food outlets) surrounding each fire station and the objectively-measured obesity outcomes of firefighters (waist circumference, body mass index and body fat percent). Three distinct obesity measures were used since other studies have shown that they respond differently to certain predictors and some are better than others when working with firefighters. For example, body mass index is known to be affected by muscle mass in athletic body compositions like those of firefighters (Choi, Steiss, et al., 2016). The same logic was carried throughout the other two aims of the dissertation, using all three weight outcomes individually to explore the advantages and shortcomings of each measure.

Using data obtained from a commercially available database to determine the number of fast-food outlets surrounding each fire station, I explore the area fast-food density and obesity in firefighters. There was no direct association between area fast-food density and obesity. However, there was an indirect association mediated through organizational and individual –level eating behaviors. Although the indirect effects were modest, the mechanism through which the environment around the worksite affects the individual health of firefighters is an important theoretical and empirical finding that should be considered in future studies.

Although the environment is a relevant risk factor for obesity in firefighters, organizational and interpersonal relations remain essential aspects of workers' health in the realm of occupational health psychology. Chapter 3 explores the role of (organizational, supervisor and coworker) social support and (nutrition and exercise) self-efficacy in the development of obesity among firefighters with use of structural equation modeling. Organizational support was observed as the most important factor associated with obesity through health-related self-efficacy. Surprisingly, supervisor support and coworker support did not contribute to higher feelings of self-efficacy in firefighters in spite of working in teams (fire crews) and being part of a hierarchical organization. The relevance of organizational support in this study may have been due in part to recent managerial standard operation procedural changes that affected the established workplace customs regarding physical activity (e.g. banning of team sports and prohibiting the use of gyms outside the fire station). The effect of this organizational decision may have been twofold. Firstly, by directly affecting the obesity indicators of firefighters, and by lowering the morale of firefighters, which may have had an effect on their perceive self-efficacy.

Physical activity is one more indispensable part of the obesity puzzle in the present dissertation. Research on physical activity (PA) and sedentary behavior (SB) has shown their effects on obesity is not as straight forward as once perceived. PA and SB have traditionally been viewed as opposite sides of the healthy behavior spectrum. However, new findings may suggest that they are independent predictors of health. In spite of these innovative proposals, there is no established consensus on the measurement of both PA and SB. Self-report has been widely used with its intrinsic disadvantages (e.g. report bias, recall bias, etc.). Nevertheless, modern technology offers alternative promising tools that may reduce measurement error. GPS tracking step counting, accelerometry and position sensors are just some of the new available tools that can be used to track the PA and SB of research participants. In chapter 4, a methodological study compared four of these measuring tools (self-report, step count, accelerometry/actigraphy, and position sensor/inclinometry) to identify the better tool/technique for predicting cardiovascular disease risk factors, including obesity. In our study, self-reported sedentary work remains as an important predictive tool associated with several CVD outcomes. Sedentary behavior by inclinometry also proved helpful in predicting CVD risk factors, especially, blood-related outcomes (e.g. systolic blood pressure and HDL). Although the study is not epidemiological, the regression coefficients remained significant after controlling for known confounders. Step count and sedentary behavior by accelerometry were only associated to body fat percent, but the association only remained significant in step count when including covariates. Due to the nature of the study, it was not possible to determine why some obesity indicators are associated to different predictors. More research is needed to determine the mechanisms of these associations.

The present dissertation offers an integral theoretical approach to a public health issue. As the complex phenomenon obesity is, it demands for well-targeted research that can eventually help to develop better aimed individual, occupational and public health interventions to prevent weight-related diseases and improve the health of firefighters and the general public.

Appendix A

Firefighter Work and Health Survey

FORWARD
Firefighter Obesity Research:
Workplace Assessment to Reduce Disease

UC Irvine Center for Occupational
and Environmental Health

March 22, 2012

Center for Occupational and Environmental Health
University of California, Irvine

Study Website: http://www.coeh.uci.edu/forward

5201 California Ave. Suite 100
949-824-5130
Principal Investigator: Dr. BongKyoo Choi
Email: b.choi@uci.edu

Dear OCFA Firefighter:

Thank you for your willingness to fill out this UCI/OCFA FORWARD study questionnaire.

Please complete the following questionnaire. This will take you approximately 30 minutes.

Please complete the questionnaire at this WEFIT visit and return it to Javier Garcia at the end of your WEFIT.

We would like to remind you that your questionnaire will be kept completely CONFIDENTIAL and none of your responses will be RELEASED TO OCFA OR ANY OTHER AGENCY. The questionnaire information you provide us will be computerized and linked with your WEFIT exam data. When the study is over your questionnaire will be destroyed and all personal identifiers will be removed from our database.

Please carefully read all instructions and answer **all** the questions as best as you can.

If you have **ANY** question about the questionnaire as you are completing it, please feel free to talk to the Project Manager Javier Garcia or the Principal Investigator Dr. BongKyoo Choi at 949 824 5130.

I. **<u>OCFA Job Characteristics</u>:** Please provide the following information:

1. **Last Name** ________________________________ **First Name**:____________________________
(PLEASE PRINT)

2. **Date of Birth**: __________/____________/____________
Month Day Year

3. **Current OCFA position** (CHECK ALL THAT APPLY)

❒ Rookie Firefighter ❒ Firefighter ❒ Hazmat
❒ Heavy equipment operator ❒ Helicopter pilot ❒ Urban Search and Rescue
❒ Fire apparatus engineer ❒ Paramedic ❒ Captain
❒ Battalion Chief ❒ Division Chief ❒ Assistant Fire Chief
❒ Deputy Fire Chief ❒ Other________________________

4. **What year did you begin with the OCFA:** Year:__________(e.g., 2010)

5. **When did you begin your current position**: Year:______________(e.g., 2010)

6. **Current work location**: ❒ Fire station (if so, station number, ____________)
❒ Central Office/Headquarters
❒ Other:________________________

7. **Have you changed work location during the past 5 years?** ❒ Yes ❒ No (**If NO, go to Q.7b)**

7a. If Yes, when was the latest change? Year: __________ (e.g., 2010)

Work location at that time:
❒ Fire station (if so, fire station number, ____________)
❒ Central Office/Headquarters
❒ Other:____________________

7b. Do you intend to change your work location (station or company) in the next year?

❒ Yes ❒ No, if Yes, main reason(s):_______________________________________

8. **If you work in a fire station, how many units (e.g. engines, trucks) are there in total?**_________

8a. Do you work mostly on:
❒ Engine
❒ Truck
❒ Other:_______________________________

9. **Number of 24 hour shifts you worked in the past month, including overtime, backfill and/or shift trades:___________**

❒ N/A, I don't typically work 24 hour shifts – **please skip to Q. 10**

9a. Is the amount of overtime (etc.) in the past month typical of your usual overtime schedule?

❒ Yes, it is typical/the same

❒ No, it was MORE than I usually do

❒ No, it was LESS than I usually do

9b. Are your overtime/backfill/shift trades USUALLY at:

❒ My current station

❒ At a busier station(s)

❒ At a slower station(s)

❒ At a station with about the same number of calls

10. **If you don't typically work 24 hour shifts, number of hours and days/week you typically work? (e.g. 48 hours/week and 5 days/week)**

Hours/week:________________ Days/week:________________

11. **If you worked 24 hour shifts in the past month including overtime, backfill or shift trades, how many times did you work:**

a) 48 hours in a row: ________
b) 72 hours in a row: ________
c) 96 hours in a row:________

12. **On a typical work shift, approximately how many calls on average do you go on?** _________

12a. How many hours/day on a typical shift, are you out of the station on emergency calls? _______

13. **Do you have a second job? ❒ Yes ❒ No, If No, please go to the next page.**

If Yes, how many hours per MONTH do you work on the second job? ______ hours/month
(please estimate monthly hours if you do intermittent or seasonal work)

II. WORK CHARACTERISTICS

Please answer the following questions about your work by considering both work at the station AND while out on calls. Please indicate the extent to which you agree or disagree (Please check one box per question).

	Strongly Disagree (1)	Disagree (2)	Agree (3)	Strongly Agree (4)
1. My job requires that I learn new things.	❐	❐	❐	❐
2. My job requires me to be creative.	❐	❐	❐	❐
3. I have an opportunity to develop my own special abilities.	❐	❐	❐	❐
4. On my job, I am given a lot of freedom to decide how I do my work.	❐	❐	❐	❐
5. I have a lot to say about what happens on my job.	❐	❐	❐	❐
6. My job requires working very fast.	❐	❐	❐	❐
7. My job requires working very hard.	❐	❐	❐	❐
8. My job requires lots of mental effort.	❐	❐	❐	❐
9. My job requires lots of physical effort.	❐	❐	❐	❐
10. My job often involves lifting loads weighing 50 pounds or greater.	❐	❐	❐	❐
11. My job often involves crouching, stooping, or kneeling.	❐	❐	❐	❐
12. My job often requires sitting for long periods of time.	❐	❐	❐	❐
13. I am not asked to do an excessive amount of work.	❐	❐	❐	❐
14. I have enough time to get the job done.	❐	❐	❐	❐
15. I am free from conflicting demands others make.	❐	❐	❐	❐
16. My job security is good.	❐	❐	❐	❐
17. My job provides me with many opportunities to help people in need.	❐	❐	❐	❐
18. My job provides me with many opportunities to protect the community.	❐	❐	❐	❐
19. I have many interruptions and disturbances in my job.	❐	❐	❐	❐
20. Over the past years, my job has become more and more demanding.	❐	❐	❐	❐
21. I am treated unfairly at work.	❐	❐	❐	❐
22. My job promotion prospects are poor.	❐	❐	❐	❐
23. I receive the respect and prestige I deserve at work.	❐	❐	❐	❐

24. My salary/income is adequate.	❐	❐	❐	❐

Please answer the following questions about your work at the station OR on calls:

	Strongly Disagree (1)	Disagree (2)	Agree (3)	Strongly Agree (4)
25. My job AT THE STATION requires working very hard?	❐	❐	❐	❐
26. My job AT THE STATION can be 'boring' at times.	❐	❐	❐	❐
27. My job while ON CALLS requires working very hard?	❐	❐	❐	❐

28. **I have subordinates, people who I supervise ❐ Yes ❐ No (If NO, go to Q. 29)**

If yes, please answer the following:	Strongly Disagree (1)	Disagree (2)	Agree (3)	Strongly Agree (4)
a) People/co-workers I work with are friendly.	❐	❐	❐	❐
b) People/co-workers I work with are helpful in getting the job done.	❐	❐	❐	❐
c) I am exposed to hostility or conflict from people I work with.	❐	❐	❐	❐

29. **I have "co-workers" who I work with regularly ❐ Yes ❐ No (If NO, go to Q. 30)**

If yes, please answer the following:	Strongly Disagree (1)	Disagree (2)	Agree (3)	Strongly Agree (4)
a) My coworkers are friendly	❐	❐	❐	❐
b) My coworkers are helpful in getting the job done	❐	❐	❐	❐
c) I am exposed to hostility or conflict from my coworkers	❐	❐	❐	❐

30. **I have a supervisor who I work closely with ❒ Yes ❒ No (If NO, go to Q. 31)**

If yes, please answer the following:	**Strongly Disagree (1)**	**Disagree (2)**	**Agree (3)**	**Strongly Agree (4)**
a) My supervisor is concerned about the welfare of those under him/her.	❒	❒	❒	❒
b) My supervisor is successful in getting people to work together.	❒	❒	❒	❒
c) My supervisor is respected by those under him/her.	❒	❒	❒	❒
d) My supervisor is knowledgeable.	❒	❒	❒	❒
e) My supervisor is good at solving conflicts.	❒	❒	❒	❒
f) I am exposed to hostility or conflict from my supervisor.	❒	❒	❒	❒
g) My supervisor is responsive to my concerns.	❒	❒	❒	❒

Please answer the following questions in regard to the Department (OCFA), your Station, or to Management.

	Strongly Disagree (1)	**Disagree (2)**	**Agree (3)**	**Strongly Agree (4)**
31. In the Fire Dept, there are procedures in place to hear the concerns of all those affected by a decision.	❒	❒	❒	❒
32. In my station, procedures are implemented so that decisions can be made fairly.	❒	❒	❒	❒
33. Management cares about my opinions.	❒	❒	❒	❒
34. There are frequent conflicts between the management and union (IAFF Local).	❒	❒	❒	❒
35. Management considers my goals and values.	❒	❒	❒	❒
36. Where I work, bad decisions by management or supervisors can be revoked or changed.	❒	❒	❒	❒
37. For major decisions in the Dept, all parties are represented.	❒	❒	❒	❒

The following questions are about group conflicts at your workplace. Please consider your "group" to be your company or "crew" or other crews. Please indicate the extent to which you agree or disagree (Check one box per question). If you typically work alone, without a company (crew), skip to Question 43

	Strongly Disagree (1)	**Disagree (2)**	**Agree (3)**	**Strongly Agree (4)**
38. There is harmony within my company (crew).	❒	❒	❒	❒
39. In our company (crew), we have lots of bickering over how to do our job.	❒	❒	❒	❒
40. There is dissension in my company (crew).	❒	❒	❒	❒
41. The relationship between my company (crew) and other companies (crews) is harmonious.	❒	❒	❒	❒
42. There is cooperation between my company and other companies (crews).	❒	❒	❒	❒

43. **At your workplace, have you ever been discriminated* against, harassed** or witnessed the harassment of others because of race, ethnicity, gender, sexual orientation, age, physical appearance, or other characteristics?**

❒YES ❒NO

* Discrimination - unfair treatment of a person or group on the basis of a prejudice
** Harassment - behavior which is found threatening or disturbing (physical or verbal)

44. **At your workplace, have you ever been discriminated against, harassed or witnessed the harassment of others because of weight?**

❒YES ❒NO

Please continue on the NEXT PAGE…

Please answer the following questions about YOUR INTERACTIONS WITH THE GENERAL PUBLIC WHILE ON DUTY. How frequently do you find yourself doing the following while working with the public (Check one box per question):

	Never/ Not at all (1)	Rarely/ Once in a while (2)	Some-times (3)	Often/ Most of the Time (4)	Always/ Constantly (5)
45. I often handle complaints or misunderstandings with the public	❒	❒	❒	❒	❒
46. I have to deal with people who are difficult or disrespectful.	❒	❒	❒	❒	❒
47. My work is emotionally demanding.	❒	❒	❒	❒	❒
48. I make an effort to actually feel the emotions I need to display toward the public/victims.	❒	❒	❒	❒	❒
49. I hide my genuine emotions about things that happen when in the field.	❒	❒	❒	❒	❒
50. My training has helped me to have the appropriate emotional distance in emergency situations.	❒	❒	❒	❒	❒
51. I put on the appearance of being calm and professional for my job, even when not feeling that way.	❒	❒	❒	❒	❒
52. I easily contain my emotions and express myself calmly and professionally to the public/emergency victims when in the field.	❒	❒	❒	❒	❒

Please answer the following questions about HOW FREQUENTLY you are exposed to these critical incidents (Check one box per question):

	Never/ Not at all (1)	Rarely/ Once in a while (2)	Some-times (3)	Often/ Most of the Time (4)	Always/ Constantly (5)
53. I am exposed to the severe injuries, death or dying of victims.	❒	❒	❒	❒	❒

54. I convey news of tragedy to survivors.	❐	❐	❐	❐	❐
55. I am exposed to situations where I am not able to keep people from dying.	❐	❐	❐	❐	❐
56. I am exposed to the traumatic injury or death of children.	❐	❐	❐	❐	❐
57. I have been exposed to a major disaster or mass casualty event.	❐	❐	❐	❐	❐
58. I am exposed to the serious injury or death of fire personnel.	❐	❐	❐	❐	❐

Please answer the following questions about your Personal Safety/Potential Danger. Please indicate the extent to which this affects you (Check one box per question):

With regard to exposure to…	**Not exposed (1)**	**I am exposed but it is a slight problem (2)**	**I am exposed and it is a sizeable or great problem (3)**
59. Fire, burns, or shocks?	❒	❒	❒
60. Dangerous tools, machinery, or equipment?	❒	❒	❒
61. Air pollution from dusts, smoke, gas, fumes, fibers, or other things on your job?	❒	❒	❒
62. Biological hazards (e.g., hepatitis viruses)?	❒	❒	❒
63. Biomechanical hazards (e.g., heavy lifting)?	❒	❒	❒

The following questions are about work and family. Please indicate the extent to which you agree or disagree (Check one box per question):

	Strongly Disagree (1)	**Disagree (2)**	**Agree (3)**	**Strongly Agree (4)**
64. The demands of my work interfere with my home and family life.	❒	❒	❒	❒
65. The amount of time my job takes up makes it difficult to fulfill family responsibilities.	❒	❒	❒	❒
66. Due to work-related duties, I have to make changes to my plans for family activities.	❒	❒	❒	❒
67. The demands of my family or spouse/partner interfere with work-related activities.	❒	❒	❒	❒
68. I have to put off doing things at work because of demands on my time at home.	❒	❒	❒	❒
69. My home life interferes with my responsibilities at work such as getting to work on time, accomplishing daily tasks, and working.	❒	❒	❒	❒

Please continue on the NEXT PAGE:

III. HEALTH BEHAVIORS

The following questions ask about SLEEP quality. If you do not typically work 24 hour shifts, please skip to Q.6

1. **On a 24 HOUR WORK SHIFT**, how many hours of sleep do you typically get at night? _______hours

2. On a 24 HOUR WORK SHIFT, do you sometimes take a nap during the day? ❒Yes ❒No. **If Yes:**

   2a. Total number of minutes of time napping in a day _________

3. On a 24 HOUR WORK SHIFT, do you sometimes fall asleep during the day? ❒Yes ❒No.

4. Is it acceptable at your station, to take a nap during the day, if it doesn't interfere with your job?
   ❒Yes ❒No

5. **ON a 24 HOUR WORK SHIFT, how big do you consider your problems are with**:

	None (1)	Small (2)	Moderate (3)	Very Big (4)
a) Falling asleep at night	❒	❒	❒	❒
b) Waking up during the night	❒	❒	❒	❒
c) Waking up too early	❒	❒	❒	❒
d) Not feeling rested by your sleep	❒	❒	❒	❒

6. **ON A NON-WORK DAY, how many hours of sleep do you typically get at night?** _______hours

   6a. ON A NON-WORK DAY, how big do you consider your problems are with:

	None (1)	Small (2)	Moderate (3)	Very Big (4)
a) Falling asleep at night	❒	❒	❒	❒
b) Waking up during the night	❒	❒	❒	❒
c) Waking up too early	❒	❒	❒	❒
d) Not feeling rested by your sleep	❒	❒	❒	❒

7. **On average during the past year, how many days a week have your aerobic or cardio EXERCISE (work outs) met the following two criteria:**
   - 30 minutes or more in duration
   - Medium (work up a sweat and slight heart rate increase) to vigorous intensity (work up a good sweat and rapid heart rate increase)

   7a. DURING YOUR **LEISURE OR FREE TIME** while NOT at work?
   - ❒ 0 days/week
   - ❒ 1 day/week
   - ❒ 2 days/week
   - ❒ 3 or more days/week

   7b. **AT THE FIRE STATION**?
   - ❒ 0 days/week
   - ❒ 1 day/week
   - ❒ 2 days/week
   - ❒ 3 or more days/week

8. **The following questions are concerned with your dietary habits:**

Questions	**ON-DUTY**			**OFF-DUTY**		
	Never/ Rarely (1)	**Some- times (2)**	**Often/ Always (3)**	**Never/ Rarely (1)**	**Some- times (2)**	**Often/ Always (3)**
a. I have time to eat leisurely.	❒	❒	❒	❒	❒	❒
b. I drink canned soft drinks, energy drinks, sports drinks or nutritional drinks.	❒	❒	❒	❒	❒	❒
c. I eat more of my favorite foods to make me feel better, under stressful events.	❒	❒	❒	❒	❒	❒
d. I eat more than I usually do under stressful events.	❒	❒	❒	❒	❒	❒
d-1. I eat less than I usually do under stressful events.	❒	❒	❒	❒	❒	❒
e. I deliberately eat less in order not to become heavier.	❒	❒	❒	❒	❒	❒
f. I try not to eat between meals because I am watching my weight.	❒	❒	❒	❒	❒	❒
g. I walk past a snack bar or a café, I have the desire to buy something delicious.	❒	❒	❒	❒	❒	❒
h. If food smells and looks good, do you eat more than usual?	❒	❒	❒	❒	❒	❒
i. I eat snacks or sweets when I need to stay awake.	❒	❒	❒	❒	❒	❒
j. I drink coffee when I need to stay awake.	❒	❒	❒	❒	❒	❒
k. I eat snacks when I want to fall asleep.	❒	❒	❒	❒	❒	❒

l. I eat more when I am bored.	❒	❒	❒	❒	❒	❒

The following questions are concerned with your dietary habits (cont.)	**ON-DUTY**			**OFF-DUTY**		
	Never/ Rarely (1)	**Some-times (2)**	**Often/ Always (3)**	**Never/ Rarely (1)**	**Some-times (2)**	**Often/ Always (3)**
m. I eat my meals even if I am not hungry.	❒	❒	❒	❒	❒	❒
n. I skip or miss meals because of work or chores.	❒	❒	❒	❒	❒	❒
o. I eat out at restaurants or fast-food.	❒	❒	❒	❒	❒	❒
o-1. I salt food before tasting it.	❒	❒	❒	❒	❒	❒
p. I eat "family style" group meals at my station.	❒	❒	❒			

	Strongly Disagree (1)	**Disagree (2)**	**Agree (3)**	**Strongly Agree (4)**
q. Since childhood, have you always eaten a lot?	❒	❒	❒	❒

9. How many servings of food do you eat (per day) that are high in fiber, such as whole grain bread, high fiber cereal, fresh fruits or vegetables? (a serving size: 1 slice bread, ½ cup vegetables, 1 medium fruit, ¾ cup cereal)
   - ❒ (1) 5-6 servings/day
   - ❒ (2) 3-4 servings/day
   - ❒ (3) 1-2 servings/day
   - ❒ (4) never/rarely

10. How many servings of food do you eat (per day) that are high in cholesterol or fat such as fatty meat, cheese, fried foods or eggs? (a serving size: 3 ½ oz meat, 1 egg, 1 oz/slice cheese)
   - ❒ (1) 5-6 servings/day
   - ❒ (2) 3-4 servings/day
   - ❒ (3) 1-2 servings/day
   - ❒ (4) never/rarely

The following questions are about health climate at your workplace. Please indicate the extent to which you agree or disagree (Check one box per question):

	Strongly Disagree (1)	**Disagree (2)**	**Agree (3)**	**Strongly Agree (4)**
11. My coworkers encourage me to exercise.	❒	❒	❒	❒
12. My coworkers exercise with me.	❒	❒	❒	❒
13. My coworkers eat foods that are high in cholesterol or fat.	❒	❒	❒	❒

14. My coworkers eat more than 5 servings of fruits (1 serving = 1 medium fruit) and vegetables (1 serving = 1/2 cup) each day.	❒	❒	❒	❒
15. My supervisor...	❒Encourages me to exercise	❒Discourages my exercise	❒Neither encourages me or discourages me	❒N/A

16. Estimate the % of firefighters in my station eating more than 5 servings of fruits (1 serving = 1 medium fruit) and vegetables (1 serving = 1/2 cup) each day.
❒ 0% ❒ 20% ❒ 40% ❒ 60% ❒ 80% ❒ 100%

17. Estimate the % of firefighters in my station eating foods that are high in cholesterol or fat .
❒ 0% ❒ 20% ❒ 40% ❒ 60% ❒ 80% ❒ 100%

18. Do you currently smoke or use tobacco products? ❒Yes ❒No

18b. Have you ever smoked or used tobacco products ❒Yes ❒No

Please indicate how ready you are to make the changes or improvement in your health in the following areas.

	No present interest in making a change (1)	Plan to change in the next 6 months (2)	Plan to change this month (3)	Recently started doing this (4)	Already doing this regularly (5)
19. Practice good eating habits	❒	❒	❒	❒	❒
20. Avoid smoking or using tobacco	❒	❒	❒	❒	❒
21. Lose weight or maintain healthy weight	❒	❒	❒	❒	❒
22. Avoid alcohol or drink in moderation	❒	❒	❒	❒	❒
23. Reduce the amount of stress in your daily life	❒	❒	❒	❒	❒

How certain are you that you could overcome the following barriers?

I can manage to stick to healthful foods …

	Very uncertain (1)	Rather uncertain (2)	Rather certain (3)	Very certain (4)
24. …even if I need a long time to develop the necessary routines.	❒	❒	❒	❒
25. …even if I have to try several times until it works.	❒	❒	❒	❒
26. …even if I have to rethink my entire way of nutrition.	❒	❒	❒	❒
27. …even if I do not receive a great deal of support	❒	❒	❒	❒

from others when making my first attempts.				
28. …even if I have to make a detailed plan.	❒	❒	❒	❒

How certain are you that you could overcome the following barriers?

I can manage to carry out my exercise intentions …

	Very uncertain (1)	Rather uncertain (2)	Rather certain (3)	Very certain (4)
29. …even when I have worries and problems.	❒	❒	❒	❒
30. …even if I feel depressed.	❒	❒	❒	❒
31. …even when I feel tense.	❒	❒	❒	❒
32. …even when I am tired.	❒	❒	❒	❒
33. …even when I am busy.	❒	❒	❒	❒

IV. HEALTH

1. In general, would you say your health is …

- Excellent 1 ❒
- Very good 2 ❒
- Good 3 ❒
- Fair 4 ❒
- Poor 5 ❒

2. **What is your height?** ____________Feet _______Inches

3. **What is your weight?** ____________Lbs.

4. How much did you weigh one year ago? (Your best estimate is fine.) ______________ # Pounds

5. How much did you weigh ten years ago? (Your best estimate is fine.) ______________ # Pounds

6. During the past 12 months, did you … **(Check all that apply.)**

- ❒ lose 10 pounds or more because of illness or health problems?
- ❒ lose 10 pounds or more by diet, exercise or change of lifestyle?
- ❒ lose 10 pounds or more for other reasons?
- ❒ None of the above

Please specify: ____

7. **In the past year, I suffered a severe accident, injury, or illness that resulted in more than 4 shifts off.**

❒ **Yes** ❒ **No (If NO: please go to Q.8)**

If YES: They made it difficult to do required physical tasks on duty in the past year

7a. ❒ **Yes** ❒ **No**

They made it difficult to do your exercise on or off-duty in the past year

7b. ❒ **Yes** ❒ **No**

Please read the following items and decide if you ever feel this way about your job. If you have never had this feeling, check box for "Never." If you have had this feeling, indicate how often you feel this way:

	Never (1)	A few times a year (2)	Once a month (3)	A few times a month (4)	Once a week (5)	A few times a week (6)	Every day (7)
8. I feel emotionally drained from my work.	❒	❒	❒	❒	❒	❒	❒
9. I feel used up at the end of the workday.	❒	❒	❒	❒	❒	❒	❒
10. I feel tired when I get up in the morning and have to face another day on the job.	❒	❒	❒	❒	❒	❒	❒
11. Working all day is really a strain for me.	❒	❒	❒	❒	❒	❒	❒
12. I feel burned out from my work.	❒	❒	❒	❒	❒	❒	❒

During your work as a firefighter, have you ever had any experience that was so frightening, horrible, or upsetting that, in the past month, you:

	Yes (1)	No (0)
13. Have had nightmares about it or thought about it when you did not want to?	❒	❒
14. Tried hard not to think about it or went out of your way to avoid situations that reminded you of it?	❒	❒
15. Were constantly on guard, watchful, or easily startled?	❒	❒
16. Felt numb or detached from others, activities, or your surroundings?	❒	❒

We want to know how your health has been in general <u>over the last few weeks</u>. Please read the questions below and each of the four possible answers. Check the response that best applies to you.

Have you recently:	**Not at all (0)**	**No more than usual (1)**	**Rather more than usual (2)**	**Much more than usual (3)**
17. Lost much sleep over worry?	❒	❒	❒	❒
18. Felt constantly under strain?	❒	❒	❒	❒
19. Felt you couldn't overcome your difficulties?	❒	❒	❒	❒
20. Been feeling unhappy or depressed?	❒	❒	❒	❒
21. Been losing confidence in yourself?	❒	❒	❒	❒
22. Been thinking of yourself as a worthless person?	❒	❒	❒	❒

Have you recently:	**More than usual (0)**	**Same as usual (1)**	**Less than usual (2)**	**Much less than usual (3)**
23. Been able to concentrate on what you're doing?	❒	❒	❒	❒
24. Felt that you are playing a useful part in things?	❒	❒	❒	❒
25. Felt capable of making decisions about things?	❒	❒	❒	❒
26. Been able to enjoy your normal day to day activities?	❒	❒	❒	❒
27. Been able to face up to your problems?	❒	❒	❒	❒
28. Been feeling reasonably happy, all things considered?	❒	❒	❒	❒

<u>V. PERSONAL BACKGROUND</u>

The following information will be used to identify group differences, it will NOT be used to compare or identify individuals.

1. **Age:** __________

2. **Gender:** ❒ Male ❒ Female

3. **Please specify your race/ethnicity:**

   ❒ 1) Black

   ❒ 2) Hispanic/Latino/a

   ❒ 3) White/Non-Hispanic

   ❒ 4) Asian

   ❒ 5) Native American

   ❒ 6) Pacific Islander

❒ 7) Other →6a. *Please specify:* ________________________

4. **What is the highest level of education you have completed?**

❒ 1) Some high school
❒ 2) High School diploma or GED
❒ 3) Some college or associate's degree
❒ 4) Bachelor's degree
❒ 5) Graduate degree

5. **What is your marital status?**

❒ 1) Married/Living with partner
❒ 2) Divorced or separated
❒ 3) Widowed
❒ 4) Never married/single

6. **If married or living with a partner, does your partner/spouse work outside the home?**
❒ Full-time ❒ Part-time ❒ Does not work outside the home

7. **Number of children living with you at home:** Under 5 years __________ Over 5 years_________

8. **How many hours/week, on average, do you engage in:**	Number of Hours/Week
a) Domestic tasks (e.g. repairs, laundry, cleaning, shopping, meals etc.)	____________
b) Caring for children or elderly relatives	____________

9. **What was your total <u>household</u> income in the last 12 months?** (*This item is only to allow a comparison with national statistics on obesity prevalence by household income level*).

❒ 1) Less than $50 K
❒ 2) $50,000-$99,999
❒ 3) $100,000-$149,999
❒ 4) $150,000-$199,999
❒ 5) $200,000+

Please continue on the NEXTPAGE…

Please take a moment to answer the following questions about your work:

1. What is the best part(s) about your job?

____

____

____

____

2. What is the most difficult aspect of your job?

____

____

____

____

3. What are some actions that could be taken to improve working life at your current job?

____

____

____

____

4. Additional comments about your work:

____

____

____

THANK YOU FOR TAKING THE TIME TO COMPLETE THIS QUESTIONNAIRE. PLEASE RETURN IT TO JAVIER GARCIA BEFORE YOU LEAVE.