ALCOHOL USE, EXERCISE, AND PHYSICAL FITNESS AMONG CAREER FIREFIGHTERS

By

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LIST OF ABBREVIATIONS

ACE	American Council on Exercise
ACFR	Alachua County Fire Rescue
ACSM	American College of Sports Medicine
AUC	Area under curve
AUDIT-C	Alcohol Use Disorders Identification Test
BMI	Body mass index
BRFSS	Behavioral Risk Factor Surveillance System
LTEQ	Leisure Time Exercise Questionnaire
MANOVA	Multiple analysis of variance
ROC	Receiver operating characteristics
WFI	Wellness Fitness Initiative

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This paper outlines three studies for the dissertation of Anna Gardner. The research seeks to investigate rates of alcohol use, physical activity, and levels of physical fitness among career firefighters. Additionally, the alcohol-activity association is assessed.

Data were collected from a convenience sample of firefighters from Alachua Country Fire Rescue (ACFR), using a web-delivered, self-administered health assessment designed to assess exercise and drinking behaviors. A comprehensive fitness assessment included measures for cardiovascular fitness, muscular endurance, muscular strength, and flexibility to determine overall fitness levels among the firefighters. Descriptive (i.e. mean, standard deviation, frequencies, percentages) and inferential (i.e. multiple linear regression, hierarchical binary logistic regression, and MANOVA) statistics were used to assess the research questions outlined herein.

Results will add to the current literature on firefighter alcohol consumption. Additionally, results will assist intervention and policy efforts towards reducing alcohol use and abuse among firefighters.

CHAPTER 1
INTRODUCTION

The United States fire service consists of an estimated 1,082,500 firefighters, including 278,300 career and 804,200 volunteers (United States Fire Administration, 2013). The firefighting occupation is characterized by long hours (typically 24-hour shift work), disrupted sleep, high-intensity labor, and exposure to potential dangers, such as blazing fires and thick smoke, hazardous materials (i.e. gas leaks, chemical spills), and structurally unsafe buildings (Murphy et al., 1999). Considering such an intense working environment, firefighters must maintain optimal health status, including physical, emotional, and mental well-being. To better understand the health status of firefighters, more research related to their health behaviors is needed.

While research has investigated several health behaviors and outcomes among firefighters (i.e. obesity, cardiovascular health, and smoking), relatively little is known about quantity and frequency of alcohol consumption among this population. Identifying the alcohol use among firefighters is critical to ensuring optimal levels of job performance and safety. For instance, drinking while on-duty, or intoxication off-duty that lingers into shift work, may impair a firefighter’s job readiness/performance and potentially lead to injury, permanent disability, or even death for themselves or fellow firefighters. While research has assessed alcohol consumption related to stress and trauma (i.e. post-traumatic stress disorder) among firefighters (Murphy, et al., 1999; Bacharach et al., 2008; McFarlane, 1998; Boxer & Wild, 1993), few studies have investigated levels of alcohol consumption among firefighters in general (Haddock et al., 2011; Carey et al., 2011). Among their convenience samples, high levels of alcohol consumption were observed. Among 459 career firefighters, Haddock et al. (2011) documented drinking frequency, on average, of ten days per month, with three or more drinks per occasion.

Also, 56% binge drank (5 or more drinks on one occasion) in the past month. Carey et al. (2011) observed similar drinking levels among 112 career firefighters, where 80% used alcohol (mean of 1.6 ± 1.7 drinks per day), 56% binge drank (4+ drinks for men, 3+ drinks for women), and 14% binge drank two or more times per week. These levels exceed that of the general population, where approximately 55% of adults have had at least one drink in the past 30 days, and 17% binge drank (Centers for Disease Control and Prevention, 2012). Furthermore, alcohol consumption among firefighters surpasses that of college students, a subgroup of the adult population who exhibit the highest drinking rates of any demographic [62% consumed alcohol in the past 30 days and 21% binge drank 1-2 times in the last two weeks] (American College Health Association, 2012). Thus, based on the currently available literature, it appears firefighters represent an at-risk drinking group. One purpose of this dissertation research is to assess the quantity and frequency of alcohol consumption among firefighters, along with the covariates that influence consumption levels. Findings from this study will add to the current literature on firefighter alcohol consumption, as well as inform intervention and policy efforts aimed at reducing alcohol use and abuse among firefighters.

In addition to alcohol consumption, exercise represents a salient health behavior of firefighters, considering the physically-demanding nature of the job. Simply put, firefighters must maintain optimal levels of cardiorespiratory fitness, often achieved by increasing levels of exercise, in order to perform their job well (International Association of Fire Chiefs, 2008). The Wellness Fitness Initiative, a task force dedicated to improving overall health among firefighters, recommends 60-90 minutes of on-duty exercise (International Association of Fire Chiefs, 2008). Off-duty exercise is also promoted due to variability in scheduling, calls, and training that oftentimes limits the on-duty firefighter's ability to complete a full workout (Soteriades et al., 2011).

Interestingly, the aforementioned health behaviors among firefighters (i.e. exercise and alcohol consumption) parallel scientific literature outlining an incongruous, positive association between alcohol consumption and physical activity/exercise. Specifically, those who drink alcohol are more likely to be physically active than non-drinkers (Pate et al., 1996; Dunn & Wang, 2003, Piazza & Barry, 2012; French et al., 2009, Westerterp et al., 2004). In fact, across all age groups, studies document a dose-response relationship between alcohol consumption and physical activity level. In other words, as drinking increases, so does physical activity (Piazza & Barry, 2012). Another purpose of this dissertation research is to examine the association between drinking and exercise among firefighters, a group among which this relationship has not been previously studied.

In line with physical activity, physical fitness, which refers to the ability to perform activities of daily living with vigor and alertness and void of undue fatigue (President's Council on Physical Fitness and Sports, 1971), is also an essential facet of health and job performance for firefighters. Comprised of multiple components (e.g. cardiovascular fitness, muscular strength and endurance, flexibility), physical fitness allows the working firefighter's body to meet the high-intensity demands it faces during rescue calls. Based on the need for high levels of fitness (often achieved through high levels of exercise), one might assume firefighters would maintain a rather lean, muscular build with low levels of adiposity. Typically, adiposity among the general adult population is assessed with the standard measure of body mass index (BMI), as it allows for quick, non-invasive, and inexpensive measurement. However, a limitation of BMI is its likelihood to overestimate obesity in populations with muscular builds (e.g. athletes). Few studies (Jitnarin et al., 2013; Poston et al., 2011a) have assessed the accuracy of BMI in determining overweightness/obesity among firefighters compared to more accepted measures (e.g. body fat percentage). These studies are limited by a) use of male-only samples (Jitnarin et al., 2013; Poston et al., 2011a), b) assessing only overweightness (Jitnarin et al., 2013) *or* obesity (Poston et al., 2011a), and c) use of a wide range of "acceptable" body fat percentages (Jitnarin et al., 2013).

Furthermore, only one study has assessed the impact of body composition on physical fitness among firefighters (Poston et al., 2011a). This study was limited by the lack of a comprehensive measure of fitness, as muscular endurance tests were not included. Therefore, two additional purposes of this dissertation research include a) identifying concurrent validity of BMI and percent body fat as an indicator of body composition among firefighters, and b) investigating differences in physical fitness levels based on adiposity status (i.e. non-overweight/obese, overweight (but not obese), and obese) as estimated by BMI or measured by body fat percentage.

Overall, the proposed research will supplement existing knowledge related to salient health behaviors (i.e. alcohol use and physical activity) and outcomes (i.e. BMI, body fat, and physical fitness) of firefighters. Findings can inform future public health and occupational interventions aimed at decreasing alcohol use and abuse, while increasing physical activity on and off duty. Information related to rates of alcohol consumption and physical activity, along with further research investigating the impact of these behaviors on health and job performance, may also serve as a catalyst changes in fire service policy and procedures. This work will also provide rationale for acceptable measures of obesity within the firefighting occupation, followed by the impact of obesity on firefighter's fitness. Identifying an accurate measure of obesity is the first step in progressing towards established criteria for “acceptable” levels of adiposity among firefighters. Likewise, knowledge related to the effects of obesity on fitness, paired with future research on detriments to job performance, can inform nationwide fire service “fit-for-duty” mandates.

CHAPTER 2
COVARIATES OF ALCOHOL CONSUMPTION AMONG FIREFIGHTERS

Background

Research has examined several health behaviors and outcomes among firefighters (i.e. obesity [Poston et al., 2011a; Choi et al., 2011], cardiovascular health [Soteriades et al., 2011; Kales et al., 2007], smoking [Carey et al., 2011; Haddock et al., 2011]), but little is known about rates of alcohol consumption within this occupation. While studies have assessed firefighters' alcohol consumption related to stress and trauma (i.e. post-traumatic stress disorder) (Murphy et al., 1999; Bacharach et al., 2008; McFarlane, 1998; Boxer & Wild, 1993), only two investigations have indentified general levels of alcohol consumption (Haddock et al., 2012: n = 459; Carey et al., 2011: n = 112). Overall, consumption levels, based on frequency and quantity, were high. In both studies, 80% or more of the sample were current drinkers, with the majority (56%) having binge drank in the past 30 days (Haddock et al., 2012; Carey et al., 2011). Additionally, Carey et al. (2011) identified 14% binge drank two or more times per week in the past month. In terms of frequency, firefighters drank, on average, ten days per month (Haddock et al. (2012), with the average quantity of consumption ranging from approximately 1.5 (Carey et al., 2011) to three (Haddock et al., 2012) drinks per occasion. These levels surpass alcohol consumption among the general adult population (55% have had at least one drink in the past 30 days, and 17% binge drank; Centers for Disease Control and Prevention, 2012) and college students - a subgroup of the adult population who exhibit the highest drinking rates of any demographic (62% consumed alcohol in the past 30 days and 21% binge drank 1-2 times in the last two weeks; American College Health Association, 2012).

While it appears firefighters represent an at-risk drinking group, the dearth of literature currently available is limited by geographic region (e.g. one sample from the Northeast and one from the central United States) and also fails to further investigate factors impacting firefighter alcohol consumption. The purpose of this study is to assess the quantity and frequency of alcohol consumption among career firefighters from a department located in the Southeast United States (an area not previously sampled), along with the covariates that influence consumption levels.

Material & Methods

This study was approved by the University of Florida Institutional Review Board. A convenience sample of career firefighters was recruited from a local fire department. This sample was selected due to an ongoing collaboration between the university and fire department. This fire department, located in North Central Florida, serves a county of approximately 250,000 people within 969 square miles (United States Census Bureau, 2012), and provides both medical and fire rescue services.

Data was collected over a 6-week period during the summer of 2013. A self-administered health assessment survey was accessed through a secure, online employee portal. The survey contained 33 total items related to smoking and tobacco use, physical activity, alcohol consumption, sleep habits, nutrition, and demographics. Those wishing to participate in the study indicated their consent prior to beginning the survey. The time to complete the survey was approximately 10-15 minutes and all responses were anonymous.

Survey Items

Self-report measures for alcohol consumption included 7 total items. Three items measuring hazardous drinking were taken directly from the Alcohol Use Disorders Identification Test (AUDIT-C) (Bush et al., 1998). These items included: a) How often do you have a drink containing alcohol? [never, monthly or less, 2-4 times a month, 2-3 times a week, 4 or more times a week], b) How many drinks do you have on a typical day when you are drinking? [1-2 drinks, 3-4 drinks, 5-6 drinks, 7-9 drinks, 10+ drinks], and c) How often do you have 6 or more drinks on one occasion? [never, less than monthly, monthly, weekly, daily or almost daily]. Respondents were informed that one drink is equivalent to a 12-ounce beer, a 5-ounce glass of wine, or a drink with one shot of liquor. The AUDIT-C has not been previously administered among firefighters. However, data from the AUDIT-C has been shown to be valid and reliable among a variety of populations (Bradley et al., 2007; Frank et al., 2008; Rumpf et al., 2003; Dawson et al., 2005).

Three items related to quantity of consumption and intoxication were taken from the Behavioral Risk Factor Surveillance System (Centers for Disease Control and Prevention, 2011). Average quantity was measured according to the item, “During the past 30 days, on the days when you drank, about how many drinks did you drink on average?”, and highest quantity of consumption was measured via the item, “During the past 30 days, what is the largest number of drinks you had on any occasion?” For each item, respondents indicated a number from 0 through 15. Weekly intoxication was measured using the item, “In a typical week, how many days do you get drunk (intoxicated)?” Respondents indicated a number from 0 through 7. The BRFSS has been used in studies among firefighters, but not assessing alcohol consumption (Haddock, et al., 2012). Still, data from the BRFSS has been shown to be valid and reliable among other populations (Link & Mokdad, 2005; Stein et al., 1993; Midthjell et al., 1992).

Lastly, one item was modified from the American College Health Assocation’s National College Health Assessment (American College Health Association, 2008) to assess perception of quantity of alcohol consumption among peer firefighters. Respondents indicated a number from 0 to 15 for the item, “How many drinks do you think the typical firefighter at your station had the last time he/she drank?”

Study Variables

Drinking frequency

The variable drinking frequency was categorized based on response options to "How often do you have a drink containing alcohol?" (e.g. never, monthly or less, 2-4 times a month, 2-3 times a week, 4+ times a week).

Binge drinking status

Binge drinking status was measured according to the question "During the past 30 days, what is the largest number of drinks you had on any occasion?" Based on the proposed cut-offs by Wechsler et al. (1995b), binge drinkers were categorized as males who consumed five or more drinks, or females who consumed four or more drinks, on any occasion over the past 30 days.

AUDIT-C score

AUDIT-C score was calculated according to standard scoring procedures (Bush et al., 1998). Values range from 0 to 12, with a score of 7 or more for men, and 5 or more for women, indicating hazarding drinking behavior (DeMartini & Carey, 2012).

Demographic covariates

Covariates included smoking status, smokeless tobacco use, exercise status, number of hours of sleep (on- and off-duty), diagnosis of sleep disorder, race, sex, time in fire service, and active or light duty status. These covariates were selected based on prior research identifying an association with alcohol consumption (Ma et al., 2000; Reed et al., 2007b; Piazza & Barry, 2012; Carey et al., 2011; Stein & Friedmann, 2005; Wilsnack et al., 2000; Nolen-Hoeksema, 2004; Substance Abuse and Mental Health Services Administration, 2012). Based on the recommended 7-8 hours of sleep for adults (Morgenthaler, 2013; National Sleep Foundation, 2013), the reported number of hours of sleep on-duty and off-duty were categorized as "6 or less hours of sleep" and "7 or more hours of sleep". Due to low frequencies for non-White races, the variable *race* was recoded into "White" and "Non-White". Worth noting, age was not used as a covariate due to the low number of respondents (n = 69) indicating their age.

Statistical Analysis

Statistical analyses were carried out using Predictive Analytics SoftWare Version 21. Descriptive statistics were used to assess the number of current drinkers and rates of hazardous drinking. Exploratory data analysis was used to ensure all assumptions were met. Hierarchical binary logistic regression assessed the ability of several covariates (outlined below) to predict the dependent variable binge drinking status. Additionally, hierarchical multiple linear regression was used to assess the ability of several covariates (outlined below) to predict the dependent variable, AUDIT-C score. For both regression analyses, Block 1 included the personal covariates race and sex. Block 2 included the behavioral covariates smoking status, smokeless tobacco use, exercise status, number of hours of sleep (on- and off-duty), and diagnosis of sleep disorder. Block 3 included the vocational covariates time in service and work status (i.e. active or light duty).

Results

The final sample size included 160 career firefighters. The majority were White (79.8%) males (84.8%), who on average, had worked as a firefighter for 14.3 (± 8.8) years. The mean age was 37.5 (± 9.2) years. It is worth noting, only 69 participants indicated their age. The mean response for the item "How many drinks do you think the typical firefighter at your station had the last time he/she drank?" was 6.04 (± 4.4) drinks. See Table 2-1 for descriptive statistics and health-related behaviors.

The majority of this sample of firefighters consumed alcohol (89.3%), with approximately one-third (33.7%) having binge drank in the past 30 days. The average number of drinks per occasion over the past 30 days was 3.76 (± 3.37), and the largest number of drinks on any occasion in the past 30-days having a mean of 4.9 (± 3.81) drinks. Average AUDIT-C score for the sample was 4.11 (± 2.45) which is below the cut-off indicating hazardous drinking behavior.

For the binary logistic regression, only the full model containing all covariates was statistically significant, χ^2 (10, N = 129) = 18.668, *p* = .045. The model explained between 13.5% (Cox and Snell R square) and 18% (Nagelkerke R squared) of the variance in binge drinking status, and correctly classified 71.3% of cases. Race (*p* = .03) and time of service (*p* = .001) were the only covariates that made a statistically significant contribution to the model. An odds ratio of 4.48 indicated that, after controlling for other factors in the model, White respondents were approximately 4.5 times more likely to binge drink compared to non-White respondents (95% CI [1.15, 17.4]). In addition, an odds ratio of 0.92 indicated that, after controlling for other factors in the model, for each additional year of service, firefighters were 1.08 times less likely to binge drank (95% CI [0.87, 0.97]).

Due to low correlations with the dependent variable (AUDIT-C score), work status (r = .018), smoking status (r = .008), and exercise status (r = -.003) were omitted from the linear regression model. A high correlation existed between time as a firefighter and age (r = .833). Considering this, along with the low number of respondents that indicated age, age was also omitted from the model. The model did not achieve statistical significance; however, time of service was a statistically significant predictor of AUDIT-C score (β = -.244, *p* = .012).

Discussion

This study investigated alcohol use and covariates of consumption among a sample of career firefighters. Average quantity of consumption among this sample (3.76 ± 3.37 drinks) was similar to that observed by Haddock et al. (2012; 3+ drinks per occasion), but rates of binge drinking were lower compared to previous studies among this occupation. For example, approximately one-third of this sample binge drank in the past 30 days, while Haddock et al. (2012) and Carey et al. (2011) identified 56% of the samples binge drank. Drinking levels observed in this study exceed those of the general adult population, including college students.

In assessing the covariates of binge drinking among this sample, White respondents were more likely to binge drink compared to other races/ethnicities. This finding echoes previous literature among college students (Wechsler et al., 1995a; O'Malley & Johnston, 2002), the general population (Substance Abuse and Mental Health Services Administration, 2012; Falk et al., 2006), and adolescents (Vega et al., 1993; Blum et al., 2000), where Caucasians had higher rates of alcohol consumption compared to all other races/ethnicities.

Time of service was also a statistically significant covariate of binge drinking, in that the longer the time of service, the less likely a firefighter was to binge drink. Previous research has not assessed the association between length of service as a firefighter and alcohol use. Two plausible explanations for this relationship stem from a) the association between drinking and age, and b) the concept of "identity" within the firefighting occupation.

Studies among the general adult population (Wilsnack et al., 2000; Nolen-Hoeksema, 2004; Substance Abuse and Mental Health Services Administration, 2012), and one study among career firefighters (Carey et al., 2011), have identified alcohol consumption decreases with age. Wilsnack et al. (2000) reported that as individuals age, they are more likely to abstain from drinking altogether. Considering age was highly correlated with time of service as a firefighter, the association between time of service and binge drinking identified in this study may likely be mediated by age.

While research has not previously assessed the association between length of service as a firefighter and alcohol use, literature regarding Social Identity Theory (Tajfel & Turner, 1979) and college students' alcohol consumption may provide a plausible explanation. Briefly, Social Identity Theory posits that regardless of your personal attitude towards a behavior, you are more likely to partake in the behavior if the key referent group with which you identify yourself supports the behavior, or you perceive this referent group to support the behavior (Tajfel & Turner, 1979). Among 620 undergraduates, Reed et al. (2007a) identified a positive association between alcohol consumption and perception of peer acceptability of heavy drinking. Similarly, Johnston and White (2003; n = 289) and Neighbors et al. (2010; n = 3,752) found that the stronger a student identified with a specific referent group, the stronger the association between perceived norms for drinking among the referent group and their own drinking.

Research has determined that firefighters value identity (Thurnell-Read & Parker, 2008; Olofsson, 2013) and place high importance on group cohesion (Thurnell- Read & Parker, 2008). Specifically, firefighters focus on reliability, trustworthiness, and willingness to commit to the occupation (Olofsson, 2013). A unique social climate exists among firefighters, who often eat, sleep, and socialize with one another for 24 hour periods at a time (Beaton et al., 1997). Therefore, firefighters are likely to identify their peers as a key referent group. Considering their close interaction, along with occupational responsibilities that depend highly on teamwork, the cultural, even somewhat familial, connection among firefighters is not surprising. Social integration is oftentimes a priority for all firefighters, but especially newer recruits (Myers, 2005). Thus, it is likely that newer recruits to the service may enact health behaviors (such as alcohol consumption and binge drinking) perceived to be acceptable in order to assimilate with their colleagues quicker. Firefighters from this sample estimated their peers drank, on average, 6 drinks the last time they consumed alcohol. In actuality, the mean number of drinks (according to the item “How many drinks do you have on a typical day when you are drinking?”) was between one and four. Thus, it appears the firefighters’ perception of peer drinking is overestimated and may factor into the increased likelihood of binge drinking among those with lesser time in the service. Future research should investigate the existence (actual or perceived) of “cultural” acceptance, identity, and norms of alcohol consumption within the firefighter culture, as well as if and how these factors influence differences in alcohol consumption by time spent in the service.

Overall, the observed levels of alcohol consumption among this sample of firefighters are cause for concern, considering the potential for overlap with, and influence on, shift work. While research is needed to assess the effects of alcohol consumption on job performance among firefighters, studies have shown decreases in cognitive functions and psychomotor performance among other professions. For instance, pilots exhibited post-intoxication deficits in flight performance and correctly carried out fewer directives from air traffic controllers eleven hours after reaching a blood alcohol level of 0.10 or greater, (Petros et al., 2003). Among surgeons, previous day intoxication inhibited cognitive, perceptual, and psychomotor aspects of surgical performance the following morning, even after blood alcohol levels had returned to zero (Kocher et al., 2006). Furthermore, such detriments to performance among surgeons have been reported to persist as late as 4 pm the day after drinking (Gallagher et al., 2011). Studies assessing alcohol consumption among active military personnel have prompted concern regarding force readiness- one’s level of physical and mental preparedness/alertness (Blume et al., 2010; Servies et al., 2012; Kline et al., 2010). The concept of force readiness also applies to firefighters, as the nature of their job demands them to be alert and prepared at a moment’s notice. It is likely that alcohol use on duty, or lingering effects from consumption that occurred while off duty, would inhibit force readiness among firefighters. Thus, investigations into off-duty drinking rates among firefighters are warranted to identify and address alcohol use and abuse and to thwart any potential impact of on-duty performance.

It is important to note this study is not without limitations. The use of self-report data presents an inherent limitation, as participants may not have responded honestly or accurately. To inhibit the influence of this limitation on study findings, all responses were kept anonymous, and only instruments previously shown to result in valid and reliable data were used. The proportions for sex and race/ethnicity were representative of the overall population of firefighters (Bureau of Labor Statistics, 2011). However, the use of a convenience sample, which resulted in relatively low frequencies for female and non-White participants, decreases the ability to generalize study findings. Thus, future investigations should include larger, more representative samples of career firefighters. The cross-sectional nature of this study also limits the ability to accurately identify changes in alcohol use over time.

Findings from this study suggest alcohol consumption represents a noteworthy health behavior among career firefighters. Further investigations addressing reasons for alcohol use and abuse among firefighters are warranted. Additionally, the current study along with subsequent research can provide salient information necessary for the development and testing of tailored interventions aimed at reducing firefighter alcohol consumption.

Table 2-1. Participant characteristics

Demographic	N	Percent
Sex		
Male	151	84.8
Female	8	4.5
Race		
White	142	79.8
Non-White	15	8.4
Hours of Sleep: Off-Duty		
6 or less	75	42.1
7 or more	82	46.1
Hours of Sleep: On-Duty		
6 or less	140	78.7
7 or more	18	10.1
Diagnosis of Sleep Disorder		
Yes	17	9.6
No	141	79.2
Exercise Status		
Exerciser	152	85.4
Non-exerciser	11	6.2
Work Status		
Active duty	140	78.7
Light duty	19	10.7
Smokeless Tobacco Use		
Yes	32	18
No	128	71.9
Smoking Status		
Smoker	12	6.7
Non-smoker	149	83.7
Drinking Frequency		
Never	19	10.7
Monthly or less	44	24.7
2-4 times a month	43	24.2
2-3 times a week	37	20.8
4 or more times a week	13	7.3
AUDIT-C Score	Mean	SD
Overall	4.11	2.476
Males	4.16	2.508
Female	3.5	1.761

CHAPTER 3
ASSESSING THE ALCOHOL-ACTIVITY ASSOCIATION AMONG A SAMPLE OF CAREER FIREFIGHTERS

Background

While the harmful effects of alcohol consumption are well-established (Nelson et al., 2009; Wechsler et al., 1995c), ironically, superior health has been observed among drinkers compared to non-drinkers (Green & Polen, 2001; Bridevaux et al., 2004). While the exact relationship and mediating factors of alcohol consumption and positive health outcomes are currently unknown, recent research highlights physical activity as a plausible explanation (Piazza & Barry, 2012).

Across all age classifications (i.e. youth, college students, general adult population, and older adults), scholarly investigations have consistently documented a positive relationship between physical activity level and alcohol consumption (Piazza & Barry, 2012), a relationship coined as "the incongruous alcohol-activity association" (Musselman & Rutledge, 2010). Furthermore, results suggest a dose-response relationship between alcohol consumption and physical activity level. While prospective studies are needed, current published literature suggests that as drinking increases, so does physical activity.

The alcohol-activity association has not previously been investigated among career firefighters. Given the physically-intense nature of the job and subsequent fitness recommendations for employees (International Association of Fire Chiefs, 2008), along with previous studies reporting high rates of alcohol consumption within the occupation (Haddock et al., 2012; Carey et al., 2011), it seems logical to examine the alcohol-activity association among firefighters. Hence, the purpose of this study is to assess the association between alcohol consumption and physical activity level among a sample of career firefighters. Based on previous literature, I hypothesize that alcohol consumption will have a positive linear association with physical activity.

Material & Methods

This study was approved by the University of Florida Institutional Review Board. Participants were recruited from a convenience sample of career firefighters who work for a county fire and rescue service in North Central Florida. This fire department provides both medical and fire rescue to approximately 250,000 people within 969 square miles (United States Census Bureau, 2012).

Data on self-report alcohol consumption and exercise behaviors was collected using a self-administered health assessment survey. Firefighters wishing to participate in the study accessed the survey through a secure, online employee portal. Consent was given prior to beginning the survey. Survey duration was approximately 10-15 minutes, and participants were assured that all responses would remain anonymous.

Survey Items

Alcohol consumption

Three items taken from the AUDIT-C (Bush et al., 1998) were used to assess drinking status, drinking frequency, and AUDIT-C score. The AUDIT-C is a screening tool used to identify hazardous drinking, as well as individuals with active alcohol use disorders. Items included: a) How often do you have a drink containing alcohol? [never, monthly or less, 2-4 times a month, 2-3 times a week, 4 or more times a week], b) How many drinks do you have on a typical day when you are drinking? [1-2 drinks, 3-4 drinks, 5-6 drinks, 7-9 drinks, 10+ drinks], and c) How often do you have 6 or more drinks on one occasion? [never, less than monthly, monthly, weekly, daily or almost daily]. Respondents were informed that one drink is equivalent to a 12-ounce beer, a 5-ounce glass of wine, or a drink with one shot of liquor. While the

AUDIT-C has not been previously administered among firefighters, valid and reliable data has been shown among a variety of other populations (Bradley et al., 2007; Frank et al., 2008; Rumpf et al., 2003; Dawson et al., 2005).

Physical activity/exercise

Measures for exercise included status, frequency (times per week), duration (minutes per session), and type (aerobic or strength). Items were drawn from the BRFSS and Godin Leisure-Time Exercise Questionnaire (LTEQ) (Godin & Shephard, 1985). While the BRFSS has not previously been used to assess exercise among firefighters, data has been shown to be valid and reliable among other populations (Yore et al., 2007; Ainsworth et al., 2006; Brown et al., 2004; Evenson et al., 2004). The LTEQ has been used among firefighters, but reliability and validity were not established (Tamers et al., 2011). Still, the LTEQ has been shown to produce valid and reliable data among other populations (Sallis, 1991; Sallis et al., 1993; Jacobs et al., 1993; McIntyre & Rhodes, 2009).

Study Variables

Drinking status

The variable drinking status included responses for "How often do you have a drink containing alcohol?" recoded into "drinker" (answers other than "never") and "non-drinker" ("never" response).

AUDIT-C score

AUDIT-C score was calculated according to standard scoring procedures (Bush et al., 1998). Values range from 0 to 12, with a score of 7 or more for men, and 5 or more for women, indicating hazarding drinking behavior (DeMartini & Carey, 2012).

Exercise status

The variable exercise status was drawn from responses to the item “During the past month, other than your job, did you participate in any physical activities or exercises?”, where “exerciser” was anyone responding “yes”, and “non-exerciser” was anyone responding “no”.

Typical weekly exercise

In order to determine typical weekly exercise, a composite variable was created from frequency and duration of each type of exercise. Response options for frequency were coded as follows: 1 = 1 time per week, 2 = twice per week, 3 = 3 times per week, 4 = 4 or more times per week. Response options for duration were coded: 1 = 30 minutes or less, 2 = less than an hour but more than 30 minutes, 3 = one hour, 4 = more than an hour. The coded values for frequency and duration were then multiplied together to get a separate score for aerobic exercise and strength exercise. The scores for aerobic and strength exercise were then added together to determine the variable of interest, typical weekly exercise, with scores ranging from 0 to 32.

Control variables

Control variables included sex and race. Due to low frequencies for non-White races, the variable race was recoded into “White” and “Non-White”. Age was omitted as a control due to the low frequency of responses (n = 69).

Statistical Analysis

Statistical analyses were carried out using Predictive Analytics SoftWare Version 21. Descriptive statistics were used to assess drinking status, AUDIT-C score, exercise status, and typical weekly exercise. Exploratory data analysis was used to ensure all assumptions were met. Hierarchical multiple linear regression was used to assess the ability of AUDIT-C score to predict the dependent variable, typical weekly exercise, while controlling for sex and race. For the analysis, only AUDIT-C score was entered into Block 1. Block 2 added the control variables sex and race.

Results

The final sample size included 160 career firefighters. The majority were White (79.8%) and male (84.8%), who, on average, had worked as a firefighter for 14.3 (± 8.8) years. The mean age (n = 69) was 37.5 (± 9.2) years. Descriptive statistics were used to assess drinking status, drinking frequency, and exercise status (See Table 3-1). Overall, a majority of the sample exercised (85.4%), with a mean typical weekly exercise score of 12.5 (± 7.5). Likewise, 89.3% of the sample drank, with an average AUDIT-C score of 4.11 (± 2.5).

For the regression analysis, both models were statistically significant. For model 1, AUDIT-C score explained 6% of the variance in typical weekly exercise [F (1, 103) = 6.55, p = .012]. In model 2, the control measures, race and sex, explained an additional 1.9% of the variance in typical weekly exercise [F (3, 101) = 2.88, p = .04]. However, only AUDIT-C score was a statistically significant predictor (B = -0.78, p = .009), indicating that, for each unit increase in AUDIT-C score, typical weekly exercise decreased 0.78. See Table 3-2 for complete regression results.

Discussion

This is the first study to assess the alcohol-activity association among career firefighters. When controlling for sex and race, findings suggest an inverse relationship between alcohol consumption (as measured by AUDIT-C score) and physical activity (as measured by total weekly exercise) among career firefighters, in that, as drinking level increases, physical activity decreases. Results run contrary to the initial hypothesis and also contradict previous scientific literature showing a positive linear relationship between alcohol and physical activity across varying age groups.

One plausible explanation for this finding stems from the sample characteristics. While a majority (85.4%) of the sample reported exercising, the mean total weekly exercise score was approximately 12 out of a maximum score of 32. This indicates that, although they exercised, the average *level* of exercise (based on frequency and duration) among this group of firefighters was rather low, thus, resulting in the inverse alcohol-activity relationship. Furthermore, considering the body composition and fitness findings from Study 3 (see Chapter 4), where 43.7% of the sample was obese and 13.1% overweight based on body fat percentage, in addition to obesity being associated with subpar fitness, it seems logical to suspect that this group of firefighters is not partaking in an appropriate amount of physical activity.

Another explanation for the reported inverse alcohol-activity association relates to how physical activity was measured. Previous studies assessing the alcohol-activity association (see Piazza & Barry, 2012) use measures for physical activity encompassing frequency, duration, *and* intensity of exercise. For this study, the total weekly exercise score was based only on duration and frequency. Thus, it is possible the more complete measures used in other studies provides a more accurate picture of physical activity level, and therefore, influences the significance and direction of the alcohol-activity association.

It is important to note, this study is not without limitations. First, the measures used to examine physical activity level were void of intensity, providing an incomplete assessment of this variable. Additionally, the categorical response options for frequency and duration of exercise limited analysis capabilities and provided a rather vague interpretation of actual levels of exercise (compared to results using a continuous measure for frequency and duration). This study is also limited by the use of self-report data, as participants may not have responded honestly or accurately. To minimize the likelihood of inaccurate responses, all information was kept anonymous, and only instruments previously shown to result in valid and reliable data were used. Another limitation stemmed from the use of a convenience sample. Hence, the sample was rather homogenous, lacking variability in demographics as well as drinking and exercise behaviors. Thus, results may not be representative of, or generalizable to, the overall population of career firefighters within the United States.

Findings from this study contribute to the current body of scientific literature, and suggest firefighters represent a unique population with which to study the alcohol-activity association. Although an inverse relationship was identified, further investigations are warranted. Specifically, future studies should focus on acquiring a more diverse sample of career firefighters based on demographics (i.e. age, race, size of department, geographic location) and health behaviors. Specific attention should also be given to the measures used for physical activity and alcohol consumption, ensuring an accurate depiction of each variable is provided, along with opportunities for robust statistical analyses. Lastly, once the alcohol-activity association is established within this occupation, further studies should address *why* the association exists and what factors serve as primary contributors.

Table 3-1. Participant characteristics

Demographic	N	Percent
Sex		
Male	151	84.8
Female	8	4.5
Race		
White	142	79.8
Non-White	15	8.4
Exercise status		
Exerciser	152	85.4
Non-exerciser	11	6.2
Drinking frequency		
Never	19	10.7
Monthly or less	44	24.7
2-4 times a month	43	24.2
2-3 times a week	37	20.8
4 or more times a week	13	7.3

Table 3-2. Linear regression predicting AUDIT-C score

Model	B	SE B	β	t	p
1					
Variable					
Constant	15.55	1.39		11.19	0.000
AUDIT-C score	-.742	0.29	-.244	-2.558	0.012
R^2	.060				
F	6.55				.012
2					
Variable	9.97	4.10		2.43	0.017
Constant	-.780	0.291	-.257	-2.679	0.009
AUDIT-C score	2.164	2.447	0.085	0.885	0.378
Race	3.974	3.287	0.116	1.209	0.229
Sex	9.97	4.10		2.43	0.017
R^2	.075				
F	2.88				.040

CHAPTER 4
BODY MASS INDEX VERSUS PERCENT BODY FAT AS AN INDICATOR OF OVERWEIGHT/OBESITY AND PHYSICAL FITNESS AMONG CAREER FIREFIGHTERS

Background

Excess adiposity is associated with increased risk of diabetes, hypertension, heart disease, and several types of cancer (Pi-Sunyer, 2002). Considering the number of deleterious health consequences associated with overfatness, in addition to the growing percentage of obese adults in America (35.7% from 2009-2010; Centers for Disease Control and Prevention, 2011), it is no surprise the United States has set forth mandates to increase the proportion of adults at a healthy weight (Objective NWS-8) and reduce the proportion of adults who are obese (Objective NWS-9; U.S. Department of Health & Human Services, 2010).

The standard measure of overweight and obesity recommended for individual use and clinical practice (Seidell et al., 2001; Ricciardi & Talbot, 2007) is body mass index (BMI). BMI represents an estimate of body fat and is used to gauge one's risk of disease associated with overfatness (National Institutes of Health, n.d.a.). However, concern over the accuracy of BMI in estimating adiposity has risen, considering the inability of BMI to discern between lean versus adipose tissue. While BMI is an accepted measure of adiposity in large-scale epidemiological studies among the general adult population, research has highlighted a severe diagnostic inaccuracy of BMI based on age (Gallagher et al., 1996; Rankinen et al., 1999) sex (Gallagher et al., 1996; Rankinen et al., 1999), ethnicity (Fernandez et al., 2003; Pan et al., 2004), and athletic status (Ode et al., 2007; Nevill et al., 2006). Specifically regarding athletic status, BMI has high sensitivity (accurately identifies obesity among those who are in fact obese) but low specificity (classifies those who are not obese as obese) among athletic populations (Ode et al., 2007). Because athletes tend to have higher amounts of lean muscle mass compared to the general population (from whom BMI cut-points were established), this discrepancy is likely due to the inability of BMI to differentiate between lean and adipose tissue. In other words, these athletes may have higher body mass but are not overfat. The National Institutes of Health (n.d.b) states that while BMI can be used to estimate obesity among most men and women, “it may overestimate body fat in athletes and others who have a muscular build”.

Considering the intense nature of the occupation, it is recommended that firefighters maintain optimal levels of physical fitness, often achieved by increasing levels of exercise (International Association of Fire Chiefs, 2008). Based on the recommended fitness levels and high-intensity nature of the job, it is likely firefighters would possess a more muscular build compared to the general population. Therefore, according to the National Institutes of Health recommendation, BMI may not be an accurate assessment of overweight/obesity among the firefighting occupation.

To date, only two studies have assessed the accuracy of BMI versus body fat percentage in determining overweightness among firefighters (Jitnarin et al., 2013; Poston et al., 2011a). Jitnarin et al. (2013) used a sample of 293 male career and volunteer firefighters, and body fat categories included “acceptable” (body fat = 18-52%) and “fit or below” (body fat < 18%). Thus, the study was limited by a) a lack of female firefighter participants, b) only assessing overweightness and not obesity status, and c) using a wide range of “acceptable” body fat percentages. Poston et al. (2011a) also used a sample of male career and volunteer firefighters (n = 677) and only assessed the accuracy of BMI in predicting obesity, not overweightness, based on body fat percentage. The study by Poston et al. (2011a) is also the only study to assess differences in physical fitness based on obesity status. However, this study did not use a comprehensive assessment of physical fitness, as muscular endurance tests were not included. In addition, as opposed to estimating VO_{2max} using submaximal or maximal quantitative aerobic capacity tests, an estimate of VO_{2max} was calculated based on subjective, self-report exercise habits.

A primary aim of this study is to assess the concurrent validity of BMI and percent body fat as an indicator of body composition. In addition, this study also seeks to identify differences in physical fitness levels based on adiposity status (i.e. non-overweight/obese, overweight (but not obese), and obese) as estimated by BMI or measured by body fat percentage. To account for previous limitations in the literature, BMI and percent body fat categories for overweightness *and* obesity will be compared among a sample including *both* male and female firefighters. Additionally, muscular endurance tests will be included to form a comprehensive assessment of physical fitness, and an objective estimate of VO_{2max} will be used to measure aerobic capacity.

Material & Methods

This study was approved by the University of Florida Institutional Review Board. A convenience sample of career firefighters was recruited from a department located in North Central Florida. This fire department provides both medical and fire rescue services to a county of approximately 250,000 people within 969 square miles (United States Census Bureau, 2012).

All firefighters within the department were recruited for participation. Data collection included a comprehensive battery of physical fitness tests that were administered by firefighter peer-fitness trainers. One firefighter peer-fitness trainer was assigned to each participant and responsible for administering all fitness assessments to that participant. Each of these firefighter peer-fitness trainers completed a week-long certification, including hands-on learning of fitness assessments. This type of training has been used in previous research collaborations with firefighters (Delisle et al., 2013). To ensure confidence, knowledge, and skill towards administering the assessments, an in-service training with all firefighter peer-fitness trainers occurred one week prior to fitness assessment data collection. In addition, an exercise physiologist supervised administration and completion of all fitness testing.

Study Measures

Blood pressure, resting heart rate, height, weight, and body composition (using bioelectrical impedance analysis) were assessed prior to fitness testing. Specific fitness tests are listed below in order of completion, as recommended by the American College of Sports Medicine (2014), and follow protocols recommended by the Wellness Fitness Initiative (WFI).

Cardiovascular fitness

Cardiovascular fitness was measured using a submaximal treadmill test following the Bruce protocol. For those (n = 2) with musculoskeletal limitations, a submaximal stepmill test was used following the protocol recommended by the Fire Service Joint Labor Management WFI. Equipment included the True Fitness M30 model treadmill (True Fitness: St. Louis, MO), Stairmaster 7000PT (Stairmaster: Vancouver, WA), and Polar FS2c heart rate monitor (Polar Electro: Kempele, Finland). Standard calculations from the ACSM (for treadmill) and WFI (for stepmill) were used to estimate each firefighter's maximal aerobic capacity (VO_{2max}).

Muscular strength

Three tests were used to assess muscular strength: hand grip dynamometer, static arm strength (bicep curl), and static leg strength (dead lift). To measure grip strength, the participant's hand was sized for appropriate fit with the hand dynamometer (Hand Grip Dynamometer Model 78011; Lafayette Instrument Company; Lafayette, IN), ensuring that the dynamometer fit snugly in the first proximal interphalangeal joint. With the dynamometer dial set to "0", the participant was instructed to stand upright, with elbows adducted and flexed at a 90º angle. The participant was to squeeze the dynamometer with maximum force for approximately 3 seconds. Upon releasing their grip, the needle measurement was recorded.

Three trials were completed on each hand, alternating hands between trials. The highest score for each hand was recorded as the final score.

The Jackson Strength Evaluation System Model 32628CTL (Lafayette Instrument Company: Lafayette, IN), which has been used previously among firefighters (Poston et al., 2011a), was used with a bicep curl bar (for static arm) and v-grip handlebar (for static leg) to measure muscular strength. Following the WFI protocol, the participant stood upon a level and secure dynamometer base plate, with a chain and bar attached. For the static arm test, the participant stood erect with knees straight and elbows bent at a 90º angle in the sagittal plane (traditional bicep curl form). With the participant gripping the bar, the chain was adjusted to a taut position. The participant was instructed to ease into the isometric contraction, without moving the arms, shrugging shoulders, or arching the back, and hold for a maximum of 3 seconds. For the static leg strength test, the participant stood erect with knees straight on the dynamometer base plate. The chain attached to the base plate was adjusted so the inside edge of the bottom cross-member of the v-grip handlebar was at the top of the patella. Once the chain was taut and secure, the participant was instructed to flex at the knees and hips in order to reach the handlebar. Holding the bar, looking straight ahead with neck in the neutral position, the participant was to fully extend arms, maintain a neutral back, and ease into the isometric leg contraction without bending at the waist, rounding the back, or flexing the arms. A 30-second rest period occurred between each of three 3 trials for both the arm and leg strength tests. The maximum force exerted out of 3 trials was recorded as the final score.

Muscular endurance

Two tests of muscular endurance included the prone static plank and maximum push-up test. For the prone static plank, the participant was instructed to lay prone on a mat, keeping upper body elevated and supported by the elbows. The stopwatch began when the participant raised their hips and legs off the floor, supporting the body on forearms and toes. The participant was to hold this position for the maximum amount of time possible, with the test terminated if a) the participant failed to maintain straight body alignment from the shoulder to hip, knee and ankle after 2 verbal warnings, or b) the participant returned to a prone position with hips and legs resting on the floor. Time was recorded in seconds. For the push-up test, the participant was to perform the maximum number of standard push-ups (on hands and toes with back in neutral position) in a two-minute time frame to the cadence of a metronome set at 80 beats per minute (80 push-up maximum). The test was terminated if the participant a) reached 80 push-ups, b) performed three consecutive incorrect push-ups, or c) failed to maintain continuous motion with the metronome cadence. The highest number of successfully completed push-ups was recorded as the final score.

Lower back and hamstring flexibility

The sit-and-reach test was conducted to measure lower back and hamstring flexibility (Figure Finder Flex-Tester; Novel Products Inc.: Rockton, IL). With shoes removed, the participant was instructed to sit on the floor, with legs together and fully extended so the feet sat flat against the sit-and-reach box. With arms fully extended in front of the body, and one hand over the other, the participant was to exhale and use a slow, fluid movement to stretch forward, bend at the waist, and push the measuring device as far as possible with the tip of their middle fingers. The best of 3 trials was recorded as the final score (in centimeters).

Body composition

BMI (kg/m^2) was used as an estimate of overall body fatness, and calculated based on height and weight measurements. Participants' BMI were categorized into the following classifications (National Institutes of Health, n.d.a.): *underweight* (BMI <18.5), *normal* (BMI

18.5-24.9), *overweight* (BMI 25-29.9), *obese I* (BMI 30-34.9), *obese II* (BMI 35-39.9), and *extreme obesity/obese III* (BMI $\geq$ 40).

Body fat percentage was measured using bioelectrical impedance analysis (Tanita Body Composition Analyzer Model TBF-300A; Tanita Coporation of America, Inc.: Arlington Heights, IL). BIA has been recommended as a valid assessment of body composition, and shown just as accurate and precise in determining percent fat as skinfold, densitometry, and air-displacement plethysmography, and dual-energy X-ray absorptiometry (Rubiano et al., 2000; Kushner et al., 1990; Jackson et al., 1988; Houtkooper et al., 1996; Segal et al., 1988; Biaggi et al., 1999; Boneva-Asiova & Boyanov, 2008).

Classifications for normal and overweight adiposity were taken from the American College of Sports Medicine (ACSM, 2014) due to the specificity of ranges based on age and sex. Because the ACSM does not include body fat percentages indicating obesity, the American Council on Exercise's (ACE, 2013) obesity classifications were used (male: body fat $\geq$ 25%; female: body fat $\geq$ 32%). Table 4-1 provides the ACSM recommended percent body fat. Overweightness was categorized as body fat percentage that exceeded the ACSM recommendations but was lower than the ACE cut-offs for obesity.

Statistical Analysis

To assess the concurrent validity of BMI as a diagnostic tool for overweight and obesity, receiver operating characteristics (ROC) curves were created. Area under the curve (AUC) was generated to identify sensitivity and specificity of BMI in predicting a) obesity, and b) overweightness, without the presence of obesity.

Multivariate analysis of variance (MANOVA) was used to determine differences in fitness levels based on overweightness or obesity, as determined by body fat percentage or BMI. The dependent variable included a composite of scores from the physical fitness tests (e.g.

VO_{2max}, static arm curl, static leg press, push-ups, plank, hand dynamometer [sum of right and left scores], and sit and reach). Two MANOVA models were analyzed with the independent variable adiposity status (non-overweight/obese, overweight but not obese, and obese) categorized by body fat percentage (model 1) or BMI (model 2). Tests for outliers (univariate and multivariate), normality (Mahalanobis distances), linearity (matrix of scatterplots), multicollinearity (correlation matrix), equality of variance (Levene's test), and homogeneity of variance-covariance (Box's M Test of Equality of Covariance Matrices) were conducted. Upon violation of homogeneity of variance-covariance, Pillai's Trace was used in place of Wilks' Lambda. For any violation in equality of variance (Levene's test), a more conservative alpha of .025 was used for follow-up analyses. Upon statistically significant results from the MANOVA, follow-up ANOVA with Tukey honest significant difference was conducted to determine group differences based on the statistically significant fitness tests. When determining between-group effects, Bonferroni adjustment was applied to reduce the chance of Type I error. An alpha of .05 was divided by the number of statistically significant fitness tests and this new alpha was used to determine statistically significant p-values for the ANOVA. In the case homogeneity of variance for the ANOVA was violated, Brown-Forsythe was used to determine significance of the F-value.

Results

Participant characteristics are outlined in Table 4-2. Overall, the sample (n = 177) was comprised primarily of males (n = 168; 95%) with a mean age of 39 years (± 9.3). Body composition classifications based on BMI and body fat are presented in Table 4-3. The majority of participants were considered obese (n = 80; 45%) or overweight but not obese (n = 76; 43%) based on BMI classifications. Based on body fat percentage, 13% of participants were overweight but not obese, while 44% were obese. Table 4-4 provides average fitness test scores among all firefighters sampled.

Using a ROC curve to assess BMI's predictive ability to determine obesity (based on body fat percentage), the AUC was .9 (± .024; p = .000; 95% CI [.854, .947]), indicating high sensitivity and specificity (Kumar & Indrayan, 2011). The AUC for BMI in determining overweightness (without the presence of obesity) was .778 (± .054; p = .000; 95% CI [.672, .884]), indicating fair sensitivity and specificity (Kumar & Indrayan, 2011).

Results indicated a statistically significant difference in fitness level based on adiposity status when using percent body fat [F (14, 320) = 7.927, p = .000; Pillai's Trace = .515; partial eta squared = .258]. Statistically significant between subjects effects were observed for $VO_{2\ max}$ [F (2, 165) = 25.988, p = .000 , partial eta square =.24], push-ups [F (2, 165) = 36.466, p = .000 , partial eta square =.307], plank time [F (2, 165) = 19.455, p = .000 , partial eta square =.191], and sit and reach [F (2, 165) = 13.609, p = .000 , partial eta square =.142]. Follow-up analyses revealed statistically significant mean differences in VO_{2max} between non-overweight/obese and obese participants [M = 6.84 ± 1.01, p = .000] and between overweight but not obese and obese participants [M = 5.72 ± 1.51, p = .000]. Similarly, non-overweight/obese and overweight but not obese participants completed, on average, a higher number of push-ups compared to those who were obese [M = 11.73 ± 1.39, p = .000; M = 9.79 ± 2.06, p = .000, respectively]. Non-overweight/obese participants also scored higher, on average, on plank time [M = 55.65 ± 8.68, p = .000] and sit-and-reach [M = 6.91 ± 1.40, p = .000] compared to obese participants.

A statistically significant difference in fitness level based on adiposity status when using BMI [F (14, 322) = 5.213, p = .000; Pillai's Trace = .37; partial eta squared = .185]. Similar to the previous model, statistically significant between subjects differences were observed on

VO_{2max} [F (2, 166) = 13.452, p = .000, partial eta square =.139], push-ups [F (2, 166) = 13.515, p = .000 , partial eta square =.14], plank time [F (2, 166) = 9.709, p = .000 , partial eta square =.105], and sit-and-reach [F (2, 166) = 8.028, p = .000, partial eta square =.088]. Participants who were overweight but not obese scored higher, on average, on VO_{2max} [M = 5.6832 ± 1.04, p = .000] and sit-and-reach [M = 5.542 ± 1.42, p = .000] compared to obese participants. Participants who were not overweight/obese and overweight but not obese completed, on average, a higher number of push-ups [M = 7.087 ± 2.32, p = .002; M = 7.87 ± 1.53, p = .000, respectively] and a longer plank time [M = 40.03 ± 13.85, p = .003; M = 39.82 ± 9.11, p = .000, respectively] compared to obese participants.

Discussion

Results of this study suggest BMI represents an appropriate diagnostic tool when determining obesity among firefighters, but lacks predictive ability in identifying those at risk for obesity. Thus, BMI should be used with discretion when determining overweightness (or obesity risk) among firefighters. Based on the frequencies for classifications by body fat percentage and BMI, it appears that BMI overestimates overweightness but is accurate at estimating obesity. This is evidenced by the discrepancy in percentages of overweight and obese individuals when comparing classification based on BMI versus body fat percentage. The majority of participants were considered obese (n = 80; 45%) or overweight but not obese (n = 76; 43%) based on BMI classifications. Based on body fat percentage, 13% of participants were overweight but not obese, while 44% were obese. This is also evidenced by the AUC when assessing the ability of BMI to predict overweightness. Thus, there is a large discrepancy when identifying individuals who are overweight but not obese when using BMI compared to body fat percentage. Therefore, BMI does not appear to be a useful diagnostic tool in assessing overweightness among firefighters.

When assessing fitness levels, results were the same regardless of using BMI or body fat percentage to classify obese individuals or overweight but not obese individuals. Findings indicated significant differences among four indicators of physical fitness (e.g. VO_{2max}, push-ups, plank time, and sit and reach) for non-obese versus obese individuals, while no significant differences were observed between non-overweight versus overweight but not obese individuals. The findings of this study are cause for concern, especially considering the number of negative health outcomes associated with poor body composition and physical fitness.

Cardiac events are the number one cause of fatality among firefighters, accounting for 45% of all on-duty deaths (Fahy, 2005). Consequently, research has shown cardiorespiratory fitness (as measured by VO_{2max}) is a particularly salient health indicator (Donovan et al., 2009; Davis et al., 2002) and that low cardiorespiratory fitness is associated with increased cardiovascular disease risk among firefighters (Baur et al., 2011). Thus, decrements in VO_{2max} among obese firefighters represents cause for concern considering the increased risk of on-duty cardiovascular events that may result in death.

Research has also highlighted an increased incidence of injury among firefighters with poorer body composition. Among a sample of 347 career firefighters, those who were obese (BMI $\geq$ 30) were 5.2 times more likely to suffer a musculoskeletal injury compared to their normal weight (BMI 18.5-24.9) counterparts (Jahnke et al., 2013). In a similar study among 478 career male firefighters, each unit increase in BMI corresponded with a 9% increase in absenteeism due to injury (Poston et al., 2011b). Decrements in physical fitness are also associated with injury complaints, where increased aerobic fitness and strength are associated with decreased incidence of injury among firefighters (Beaton et al., 2002; Rodriguez &

Eldridge, 2003). Because injury and decreased fitness levels are likely to hinder job performance, considerable attention should be given to these factors specifically among obese firefighters.

While this study adds to current literature, it is not without limitations. The use of a convenience sample of career firefighters limits the ability to generalize findings outside of those who were studied. Thus, future investigations should include larger, more representative samples of career firefighters. While air-displacement plethysmography and dual-energy X-ray absorptiometry may be considered the gold standards for assessing body composition, financial and feasibility purposes did not allow for body composition measurement using such equipment. Additionally, considering the technical limitations of obtaining consistent skinfold measurements across observers (even with standardized training; Kuczmarski, 1996), bioelectrical impedance analysis was used to assess body composition due to the quickness and ease of use. Bioelectrical impedance analysis, including use of the specific brand and model used in this study (Poston et al., 2011a; Ozcelik et al., 2004; Tunay et al., 2009; Gimenez-Palop et al., 2005), has been used to measure body fat percentage in multiple scientific studies (Poston et al., 2011a; Romero-Corral et al., 2008; Tunay et al., 2009; Ozcelik et al., 2004; Gimenez-Palop et al., 2005).

Among other physical fitness and health measures, BMI is used as the standard for entry into firefighting as it is quick, non-invasive, and cost-effective (Gledhill & Jamnik, 1992; Gallagher et al., 2000; Prentice & Jebb, 2001). Based on the findings of this study, body fat percentage should be used in place of BMI for assessment among entry-level and veteran firefighters, as it offers a more accurate depiction of body composition. In addition, methods of measurement for body fat percentage, such as BIA and skinfold, are still quick and relatively cheap.

While the firefighting occupation places high demands on one's physical capabilities, an estimated 80% of fire departments neglect to incorporate basic health and fitness programs (National Institute of Standards and Technology, 2004). Considering that body composition and increased fitness directly relate to improved performance within this occupation (Henderson et al., 2007), public health and fire service efforts should seek to enhance overall health and physical functioning of firefighters. Specifically, recommendations for off-duty exercise, as well as mandates for on-duty workouts, should be incorporated into interventions aimed at improving fitness levels and body composition. Likewise, interventions should focus on the importance of comprehensive fitness training, as opposed to emphasis solely on strength or aerobic exercise (Rhea et al., 2004).

Table 4-1. ACSM recommendations for percent body fat

Age	20-29	30-39	40-49	50-59	60+
Female	16-24%	17-25%	19-28%	22-31%	22-33%
Male	7-17%	12-21%	14-23%	16-24%	17-25%

Table 4-2. Participant characteristics

	N	Percent	
Sex			
Male	168	94.9	
Female	9	5.1	
BMI classification			
Normal	21	11.9	
Overweight	76	42.9	
Class I Obese	55	31.1	
Class II Obese	20	11.3	
Class III Obese	5	2.8	
Age (years)	N	Mean	SD
Overall	177	38.97	9.314
Male	168	38.76	9.35
Female	9	42.89	7.99
Body Mass Index (kg/m^2)	177	29.75	4.66
Male	168	29.8	4.68
Female	9	28.8	4.49
Body Fat (%)	176	23.56	9.81
Male	167	22.89	9.55
Female	9	35.9	5.62
Systolic Blood Pressure (mmHg)	177	126.2	13.04
Diastolic Blood Pressure (mmHg)	177	78.8	8.89
Resting Heart Rate (bpm)	177	75.96	11.68

Table 4-3. Body composition classification by body fat versus BMI

Classification by	Frequency	Percentage
Body fat		
Non-overweight/obese	76	43.2
Overweight, not obese	23	13.1
Obese	77	43.7
BMI		
Non-overweight/obese	21	11.9
Overweight, not obese	76	43.1
Obese	80	45.0

Table 4-4. Average fitness test scores

Fitness test	N	Mean	SD
Cardiovascular fitness (ml/kg/min)	177	40.7	7.03
Hand grip dynamometer (lbs; right and left)	176	216.7	45.1
Static arm (lbs)	174	108.7	25.9
Static leg (lbs)	176	338.3	81.4
Static plank (sec)	174	98.1	59.4
Push-up	173	23.4	10.1
Sit and reach (cm)	175	34.5	9.2

CHAPTER 5
CONCLUSIONS

Overall, results from this research suggest firefighters represent a salient population among which to study alcohol use, physical activity, and fitness. Rates of alcohol consumption within this occupation are higher compared to the general population, as well as college students. While the majority of firefighters reported partaking in exercise, the overall level of exercise (based on average frequency and duration) was low. Considering exercise plays a key factor in maintaining a lean body composition, it was not surprising to identify over half of the firefighter sample as overweight or obese. Furthermore, those identified as obese had subpar fitness levels compared to non-obese firefighters. These findings are particularly alarming considering the potential detriments to job performance and safety. For instance, firefighters who drink on-duty or report for duty still intoxicated are likely to suffer from cognitive and motor deficits that would impair their ability to respond to rescue calls. This not only places themselves at increased risk for injury and death, but also comprises the safety of their colleagues and the individuals being rescued. Insufficient levels of physical activity, and subsequent low levels of physical fitness, are also likely to impair a firefighter's job performance and safety. Unfit firefighters may not be able to withstand the physical stress encountered on-duty, once again, placing themselves, their colleagues, and the public at increased risk for harm.

As a whole, this research can be used to increase public health and occupational awareness specifically towards firefighter drinking and fitness. Because the job is highly dependent on alertness, readiness, and physical functioning, primary goals for nationwide adoption of policies and mandates should include a) decreasing overall alcohol consumption (as well as consumption in close time proximity to shift work), in addition to b) establishing fit-for-duty standards. In the meantime, individual fire departments should take the initiative to monitor fitness levels among employees with annual or bi-annual fitness testing, followed by tailored interventions for those employees deemed unfit for duty. For instance, peer fitness trainers can be paired with unfit firefighters to provide a) education related to the importance of a healthy lifestyle, b) goal-setting techniques, c) exercise and wellness programming (e.g. weekly workout schedules, healthy eating menus), and d) accountability. Incentives can also be offered for improvement and maintenance of physical fitness and health biomarkers (e.g. blood pressure, cholesterol). For instance, firefighters could be given a monetary bonus for passing quarterly health screenings or completing annual fitness testing with satisfactory scores. Fire services may also establish monthly or quarterly workshops and employee seminars focused on a variety of health behaviors. For instance, a nutritionist and/or alcohol abuse counselor may speak with employees on the physiological effects of alcohol and how lingering effects of consumption can impair job safety and performance. Firefighters should also learn typical warning signs of intoxication in order to address potential issues with intoxicated colleagues reporting for duty. Similarly, the use of wellness coaches or peer-fitness counselors can assist firefighters in establishing and maintaining active lifestyles off-duty, in order to improve overall health, body composition, and physical fitness.

It is important to note, several limitations are inherent throughout this work. The use of self-report data for alcohol consumption and exercise behavior increases the likelihood that participants may not have responded honestly or accurately. To inhibit the influence of this limitation on findings, a) participants were ensured that all data would be kept anonymous, and b) only instruments previously shown to result in valid and reliable data were used. In addition, recruiting a convenience sample of firefighters resulted in low frequencies for sex and race/ethnicity, specifically female and non-White participants. While the demographic characteristics of the sample included proportions representative of the overall population of firefighters (Bureau of Labor Statistics, 2011), the small number of females and non-White participants may still decrease the ability to generalize study findings. The use of firefighter peer-fitness trainers to administer fitness tests might have resulted in inconsistencies across trainers, thereby potentially decreasing validity and reliability of the results. To decrease the likelihood of this limitation, all peer-fitness trainers were certified through a week-long workshop, re-assessed for proper test administration one week prior to department-wide testing, and supervised by student assistants from the University of Florida and a mastered exercise physiologist. The rigor of the research, specifically for Study 2 (Chapter 3), was inhibited by incomplete measures of physical activity, as intensity was not assessed. While frequency and duration are key components of physical activity and can provide a glimpse at overall activity level, an *accurate* depiction (to facilitate comparison to national recommendations) cannot be calculated without knowing intensity. Additionally, items used to assess frequency and duration of exercise were vague in wording and response options, further inhibiting the accuracy in measuring overall activity level, as well as limiting options for statistical analysis.

Throughout the course of conducting this research, multiple lessons were learned. First, in academic/research collaborations, all involved parties must work to ensure the highest standard of rigor. Maintaining open lines of communication, establishing accountability, and double-checking each other's work is key to developing and implementing studies appropriately, feasibly, and efficiently. Second, when using self-report measures, always pilot your materials. For survey instruments, this will ensure proper logistics, skip patterns, etc., and also identify potential limitations in administering the survey to your population of interest. Third, special considerations must be taken into account when working in academic-community partnerships.

As researchers/academicians, we are programmed to uphold high scientific rigor. We study the literature and devote our time to crafting research to answer questions in the best way possible. However, when working with individuals outside the realms of research and academia, we must be cognizant that what we deem as “the best” may not always be feasible or fitting for our population of interest. Case in point, among firefighters recruited for participation in this research, high levels of apprehension ensued due to fear that survey responses and fitness data would be reported to the fire department administration, potentially placing them at risk of losing their jobs or being demoted. Therefore, as a researcher, it was my responsibility to clearly communicate to the firefighters that all data would be kept confidential and only accessible to the research team at the University of Florida, not fire department administration. Still, many of the firefighters voiced their concern and stated that, although responses were anonymous, the demographic questions asked in the survey (e.g. age, rank, station number, years of service) could potentially be used to identify specific employees. Therefore, in an attempt to further decrease apprehension, as well as increase participation and decrease the likelihood of skipped/missing responses, select questions were omitted from the draft survey. Participation rates were high; however, as noted in Chapters 2 and 3, less than half of respondents indicated their age. Thus, while precautions were taken, the research was still affected by the amount of missing data, as age could no longer be used as a covariate/control.

Although the aforementioned factors created obstacles throughout the course of this work, the wisdom gained as a result of these lessons will enhance judgment and rigor with future research and involvement in collaborations. Additionally, working in close proximity to the population of interest provided key insights that otherwise would not have been identified.

Research findings will be disseminated through four primary methods. Manuscript submission and scholarly presentations are two avenues that will focus on communication of results to researchers, academicians, and practitioners. Each study (Chapters 2-4) will be submitted for publication. While the final outlets have not been determined, *Occupational Medicine, Addictive Behaviors, Preventive Medicine*, the *Journal of Obesity*, and *Medicine and Science in Sport and Exercise* are journals currently under consideration. Presentation of research findings will also be given at national, state, and/or local conferences. Focusing on the population of interest, results will be compiled into a brief summary to be presented as a newsletter posted on *Target Solutions* for all ACFR firefighters to read. Lastly, a meeting will be scheduled with ACFR and county administration to discuss results and future plans. At this meeting, a research presentation will be given on research findings, as well as suggestions for future research, health behavior programming, and fire service policy.

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BIOGRAPHICAL SKETCH

In the spring of 2014, Anna received her doctoral degree in Health and Human Performance. She majored in health education and behavior and also served as a research assistant.