UNDERSTANDING FACTORS CONTRIBUTING TO WILDLAND FIREFIGHTER HEALTH, SAFETY, AND PERFORMANCE: A PILOT STUDY ON SMOKEJUMPERS

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AUTHORIZATION TO SUBMIT THESIS

This thesis of Callie N. Collins, submitted for the degree of Master of Science in Natural Resources and titled "UNDERSTANDING FACTORS CONTRIBUTING TO WILDLAND FIREFIGHTER HEALTH, SAFETY, AND PERFORMANCE: A PILOT STUDY ON SMOKEJUMPERS," has been reviewed in final form. Permission, as indicated by the signatures and dates below, is now granted to submit final copies to the College of Graduate Studies for approval.

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ABSTRACT

Wildland firefighters have arduous and hazardous occupations with alarming injury and fatality rates. Thus, improving wildland firefighter health and safety is a national concern. Incident reports typically highlight situational awareness and communication as key factors leading to wildland firefighter injuries and fatalities. However, important factors such as nutrition, hydration, and sleep on the fireline have received limited attention. This research explores factors that may be leading to injuries and fatalities on the fireline. A survey was completed by 428 wildland firefighters to understand what they deem to be common contributing factors that lead to injuries and fatalities on the fireline. After analysis of the survey, additional research was conducted on body composition and sleep quality and quantity to gain an understanding of what was occurring on the fireline as well as gain insight on wildland firefighters sleep quality and quantity while on and off a fire assignment. This research was initiated during the fire season of 2017 (June-September) with the ultimate goal of gaining a stronger understanding of "select" self-reported factors that surveyors identified from which interventions could be applied. Sleep quantity was significantly reduced on the fireline, yet sleep quality improved, likely due to the participants being exhausted at the end of the work day. Body weights did not increase over the fire season, yet, body fat increased significantly, leading researchers to believe that nutrition on the fireline may have played a role in these results.

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DEDICATION

I could not have done this research on wildland firefighter health, safety, and performance if it weren't for the incredible and unwavering support of my family and friends. A special thank you goes to my mom, Jennifer Padian. Without her I would not have made it this far! Her support and encouragement has pushed me to do many things in life, this is one I am most proud of - thanks Moms! I'd also like to thank my friends Kelly Stevenson and Laura Ehlen for all the pep talks, advice, and fun times (PR's!).

With my entire family, many friends, and mentors, I have had the best team behind me, and all the encouragement that helped make this phase of the project successful. I could not have done this without you. It is my hope that this research can be built upon so that interventions will be created to increase wildland firefighter health and safety.

Special thanks to my grandparents Robin and Jay- thank you for everything!

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CHAPTER 1: LITERATURE REVIEW

Understanding Factors Contributing to Wildland Firefighter Health, Safety, and Performance

Smoky the Bear has taught the public we can and should control all fires. Often politicians and the public exert pressure to go all out to save homes in the wildland urban interface (WUI). The WUI is defined by the National Wildland Fire Coordinating Group (NWCG) as "the line, area, or zone where structures and other human development meet or intermingle with undeveloped wildland or vegetative fuels" (Radeloff et. al. 2005). Now there is a perception and expectation to fight all wildfires with people, planes, helicopters, and retardant, while protecting structures and natural resources at all costs. This mentality of protecting structures and natural resources at all costs has also been "ingrained" into those fighting wildfires (Brooks and Collins, 2018). There is a real need to re-educate the public about the issues of fire management which requires a paradigm shift for the public as well as those in the firefighting world. We need to return to a more natural view that all fires are not stoppable in the same sense that we cannot stop hurricanes, earthquakes, floods, and other natural events.

The 2015 wildfire year was epic with over 68,151 fires nationwide. Across the US, over 10.1 million acres burned with suppression costs greater than $2.1 billion. Both of these were the highest numbers ever recorded, until the 2017 fire year, where over 66,100 fires burned 9.8 million acres, which was the costliest on record (NIFC, 2018). Total acres burned across the US in 2015 was 145% of the ten-year average. Alaska burned 420% of its 10-year average. Fifty-two of the fires were over 40,000 acres in size while 4,336

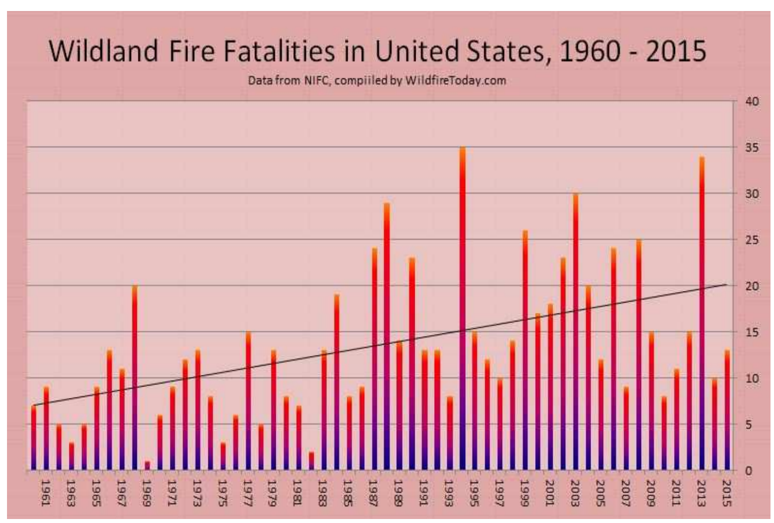

Figure 1. 1. Wildland fire fatalities from 1960-2015. Source NIFC (2015)

structures were destroyed. National Type 1 Incident Commander (IC) teams mobilized 39 times and were on assignment for 572 days in 2015 (data retrieved from National Interagency Fire Center). The majority of these fires are fought by US Forest Service (USFS) seasonal fire hires, referred to as wildland firefighters (WLFFs). Every year in the United States, 100 firefighters die in the line of duty (Britton et al. 2013). From 1997 through 2007, excluding 2001, about 17% of these deaths occurred during wildland firefighting activities which is increasing at an alarming rate (Fig.1). Additionally, during this same time period they also reported that nearly 60,000 injuries happened to WLFFs while on the job. The majority of these deaths are medical related, consisting of cardiac events (Butler et al., 2017; Table 2). However, the number of fatalities reported vary between surveillance system characteristics (Butler et al. 2017). Regardless, an urgent national need exists to improve wildland firefighter health and safety (WFEC, 2014, and Fig. 1).

A factor worth noting is the increased wildfire frequency and intensity (Withen, 2015). Along those same lines, the fire season has increased by over 30 days in the past 20 years (Figure 2, Klos et al., 2015) leading to higher suppression costs, more risk-taking in the sky and on the ground (McLennan and Birch, 2005), and in all likelihood, increase the proportion of injuries and deaths among wildland firefighter (Withen, 2015). This projection is an unsettling fact for WLFFs, especially given part of the work force goes back to college in August or the seasonals reach the end of their contract. This leaves firefighting agencies "spread thin" during the late fire season adding additional stress on firefighters remaining on the fireline. This includes less experienced seasonal and new hires, downsizing laterals, and others who have not worked their way up in the fire organization with a lack of training

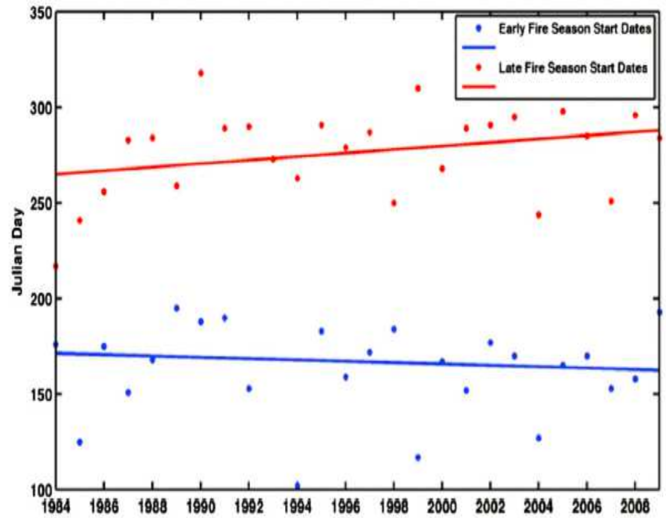

Figure 1. 2. Average US Fire start and end dates, 1984-2010 (Klos et al.)

experience or a combination of the two and.As the name implies, Fire and Aviation Management is a broad field, encompassing firefighters, fire ecologists, fuels specialists, fire managers, administrative personnel, helicopter and fixed wing pilots, aviation and ground safety professionals, radio communications and electronic technicians, dispatchers, fire prevention specialists, and communicators. The logistics of coordinating and communicating, not only within but between these groups can be a logistical nightmare. Generally, the USDA Forest Service workforce reaches its highest numbers during the peak fire season each summer. There are various schedules available to work. Some personnel sign on for a limited number of hours during the summer – called “seasonals”. Others have permanent seasonal positions, and work 26 weeks with 26 weeks off. Others work full time, year-round, but have limited appointments or a “not to exceed” time limit of one to four years. There is also a large permanent, full time workforce as well that have chosen Fire and Aviation Management for their career.

Seasonal jobs in firefighting include working on a local initial attack (IA) hand crew, a helitack/helirappeling crew, a hot shot crew, smokejumper, or on an engine crew. These are tough, stressful jobs (US Dept. of Labor, 2016; Sharkey 2000) usually performed in primitive, backcountry conditions. In addition to specific requirements for each kind of job, it is essential that wildland firefighters be in top physical condition for this demanding work. Employees and prospective employees must pass the Work Capacity Test annually before working on the fireline. The USFS provides Personal Protective Equipment (PPE) clothing, hardhat and fire shelter, but the wildland firefighter must provide their own lug soled, leather eight-inch topped boots. In addition to providing PPE, agencies provide training in many specialty fields designed to enhance health and safety.

Wildland firefighting clearly deserves the definition of arduous work: *"Duties involve field work requiring physical performance calling for above average endurance and superior conditioning. These duties may include an occasional demand for extraordinarily strenuous activities in emergencies under adverse environmental conditions and over extended periods of time. Requirements include running, walking, climbing, jumping, twisting, bending, and lifting more than 50 pounds; the pace of work typically is set by the emergency condition."* (NWCG 310.1)

Even with the PPE and training that is provided, hazards still exist while on the fireline. From 1994-2016 over 1,114 WLFF fatalities have occurred in the line of duty (Table 1). The cause of those fatalities are varied and unique (Table 2; Butler et al., 2017) and underlying circumstances are unknown. The workforce is typically composed of younger people (average age = 25.6) employed by the US Government and many feel invincible and believe that the job is not hazardous and as stated by Desmond (2007):

"*The firefighters report [that while working on actual fires they get only about four to five hours sleep per night. They have trouble sleeping due to other people snoring in locations such as cabins, tents or the floor of school gyms. Some are simply so wired after spending the whole day in emergency-mode that they can't switch off. "Management needs to redefine "success" and "failure" in firefighting, together with priorities and consequences. Evaluate all messages against agency goals especially the goal of safety first. It is easier to modify behavior than attitudes. Changing attitudes occurs after a 3- to 5-year effort. Attitudes need to be exemplified in behaviors.*"

Table 1. 1. Western firefighter fatalities from 1994-2016 by Nation and State (NIFC 2017)

United States Firefighter Fatalities from 1994-2016	1,114
Idaho Wildland Firefighters Fatalities from 1910-2016	137
Washington Wildland Firefighters Fatalities from 1994-2016	41
California Wildland Firefighters Fatalities from 1994-2016	339
Oregon Wildland Firefighters Fatalities from 1994-2016	41
Montana Wildland Firefighters Fatalities from 1994-2016	45
Nevada Wildland Firefighters Fatalities from 1994-2016	15
Wyoming Wildland Firefighters Fatalities from 1936-2016	24
Utah Wildland Firefighters Fatalities from 1994-2016	18
Colorado Wildland Firefighters Fatalities from 1994-2016	40

Table 1. 2. NWCG Risk Management Committees: Fatal accidents related to wildfire by year (NWCG 2017)

	Aviation	**Driving**	**Entrapment & Burnover**	**Hazard Tree & Snag**	**Medical Emergency**	**Vehicle, ATV, & Equipment**	**Other**
2015	2		4	1	6		
2014	2	1			7		
2013	1	3	19	3	8		
2012	6	2		1	6		
2011			4	1	4	1	1
2010		2			4		2
2009	6	3		1	5		
2008	14	2	1	1	3		4
2007	1	3		1	2		2
2006	8	4	7	1	3		1
2005	3	3	1	1	3		1
Total	43	23	36	11	51	1	11

1.2 Body Composition

While cardiac events are the leading cause of death among firefighters (Fig. 3; NIOSH 2015, Butler et al.., 2017), what is unknown are the reasons for these events and if the physiological changes WLFFs possibly undergo throughout the season in regard to body composition is an underlying factor. It is well established that excess body fat can lead to a myriad of chronic and acute health issues, so maintaining a healthy body composition is vital for WLFFs.

According to American College of Sports Medicine (ACSM), *"Body composition reveals the relative proportions of fat and lean mass in the body. Fat mass consist of two types of fat: essential and nonessential fat. The second component of body composition, lean mass, refers to bones, tissues, organs and muscle. Essential fat is the minimal amount of fat necessary for normal physiological function. For males and females, essential fat values are typically considered to be 3% and 12%, respectively. Fat above the minimal amount is referred to as nonessential fat. It is generally accepted that a range of 10-22 percent for men and 20-32 percent for women is considered satisfactory for good health. A body composition within the recommended range suggests you have less risk of developing obesity-related diseases such as diabetes, high blood pressure, and even some cancers. In addition, although we face risks when our body composition is too high, we face another set of risks when our body composition is too low. When we drop below the minimal recommended levels of essential fat, we negatively affect the delivery of vitamins to the organs, the ability of the reproductive system to function, and overall well-being"* (ACSM, 2016).

Chronically, excess body fat located centrally around the abdomen increases risk of hypertension, metabolic syndrome, Type 2 diabetes, stroke, cardiovascular disease, and dyslipidemia (ACSM 2014). While cardiac events appear to be prevalent among WLFFs (Poston et al., 2011) few studies have examined wildland firefighter body composition or body weight across a fire season or longitudinally. Surprisingly, 79% of career (urban and wildland) firefighters are classified as overweight or obese (Poston et al. 2011). Being overweight or obese places a person at risk for a number of health-related issues such as hypertension, abnormal blood lipid panels, continuous weight gain, lower cardiorespiratory fitness, reduced muscular strength, and an increased number of cardiac events. Cardiac events account for many wildland firefighter fatalities in Idaho (Table 3). This is consistent with Stefanos et al. (2003) who found that 45% of US firefighter deaths in the line of duty were related to cardiovascular events, while Butler et al. (2017) noted WLFF deaths related to cardiac events ranged from 17.7% to 25.9%, depending on the surveillance system utilized.

Increased body fat percentage (BF%) is associated with poor performance on most tasks that are crucial to firefighter performance and poor job performance is associated with increased BF% (Michaelides et al., 2008). Sell and Livingston (2012) measured body fat percentage

BF% mid-season on interagency hotshots and found the mean was 12.9% (2.3%) but did not elaborate further. No changes were observed in body composition for paratroopers after seven weeks of training (Vaara, et al. 2015). Roberts et al. (2002) found during a 16-week training program for firefighters that body fat and body weight decreased, while lean tissue increased. Cuddy et al. (2008) measured wildland firefighter body weight before and after a single day shift but this information was only used for water turnover and there were no bodyweight differences among the groups studied. What is unknown are the longitudinal changes in BF% changes or even if changes occur throughout the season for wildland firefighter.

Acutely, body composition is one factor that determines performance, including body size (Boileu and Horswill 2000). Body composition, whether too high or too low percent body fat can have negative health consequences associated with it. Because of these factors, many athletes and athletic teams have their body composition assessed regularly. WLFFs, who are considered 'tactical athletes' should have their body composition monitored for these same reasons (Ebben et al. 2005; Simenz et al. 2005). This information can be useful for an individual wildland firefighter as well as the entire crew in a variety of ways. These include a general overall health assessment, tracking nutritional needs and deficiencies, as well as a possible predictor for future seasons as to when and if longer rest and relaxation periods are needed, (i.e. when shifts should be shortened or crews should be rotated throughout a daily shift.) Tracking body composition changes across a fire season and across multiple years will provide information and help determine interventions that will enhance wildland firefighter health and safety to maintain overall health as well as job performance.

Excess body fat is detrimental while fat-free mass (FFM) is beneficial for athletic performance (Boileu and Horswill 2000). Conversely, a low percentage of body fat also has negative health implications, which predisposes athletes or WLFFs to chronic periods of low energy availability (EA) and poor nutrient support (Sundgot 2013; Sundgot 2011) which could translate to poor performance on the job.

Performance is not the only concern associated with poor body composition. As stated earlier, cardiac events are the leading cause of wildland firefighter deaths (Butler et al.,

2017) and therefore monitoring body composition would be a useful tool to predict underlying health issues before a WLFF is placed in stressful situations. The National Fire Protection Association (NFPA 2003) has guidelines for periodic medical surveillance and there are no requirements to maintain minimal physical capacities or to follow any fitness exercise program. The USFS requires the Work Capacity Test (pack test) consisting of a 4.83 km (3-mile) walk with a 20.5 kg (45 pound) backpack in a 30-minute time frame to assess adequate fitness level for performing fire related tasks, yet cardiac events are still occurring.

Table 1. 3. Fatalities of WLFF in Idaho (NIOSH 2015).

Age	Rank	State	Sex	Nature	Date
66	Firefighter	Idaho	Male	Heart attack	NA
33	NA	Idaho	Male	Heart	6/10/2015
40	NA	Idaho	Male	Trauma	9/27/13
65	Equipment operator	Idaho	Male	Heart attack	7/8/2013
20	Firefighter	Idaho	Female	Trauma	8/12/2012
63	Ass't Fire Chief	Idaho	Male	Heart attack	2/8/2010
27	Firefighter	Idaho	Female	Trauma	8/13/2006
37	Firefighter	Idaho	Male	Trauma	8/13/2006
32	Firefighter	Idaho	Female	Trauma	8/13/2006
42	Pilot	Idaho	Male	Trauma	8/13/2006
52	Captain	Idaho	Male	Heart attack	12/14/2004
54	Inmate firefighter	Idaho	Male	Heart attack	8/19/2003

1.3 Sleep

In addition to percentage body fat, inadequate or disrupted sleep is another factor that is correlated with cardiovascular and metabolic diseases (Gangwisch et al, 2006; Hall et al, 2008; Myles 1987; World Health Organization, 2010). WLFFs have reported getting six hours or less of sleep per night while on assignment (Wolkow et al., 2015; Collins and Brooks 2018). A typical assignment, or "roll", lasts up to 14 days consisting of 8-16 hour work days. Research has shown that less than one week of sleep curtailment in healthy young people is associated with striking alterations in metabolic and endocrine function leading to decreased carbohydrate tolerance and increased sympathetic tone, which is a contributing risk factor for obesity (Bosy-Westphal et al. 2008; Knutson et al. 2007; Spiegel et al. 1999).

The National Sleep Foundation (2008) reported that US adults are only sleeping 6 hours/night during the work week. The average adult needs 7-9 hours of sleep (CDC, 2017) every day in order to function at the highest level of effectiveness, and that failure to fulfill this genetically pre-determined sleep quota rapidly leads to substantial cognitive impairments from which full recovery is more slow and difficult than previously thought.

From a performance and safety standpoint, chronic sleep loss is an important concern. Chronic lack of sleep across the season predicts a massively higher risk of injury in athletes (Milewski et al. 2014). In the context of injury there is no better risk- mitigating insurance policy than sleep (Walker 2017). The relationship between sleep and human performance has been well documented where Walker (2017) states that sufficient sleep offers significant improvement to motor skill memory while also restoring benefit of perceived energy and reduces muscle fatigue. Obtaining anything less than 8 hours of sleep, especially less than 6 hours, drops the time to physical exhaustion by 10-30 percent and aerobic output is significantly reduced (Walker 2017). Add to this marked impairments in cardiovascular, metabolic and respiratory capabilities that hampers an under-slept body. This includes faster rates of lactic acid buildup, reductions in blood oxygen saturation, and increases in blood carbon dioxide due to the decreased amount of air the lungs can expire. Lastly, the body's ability to sweat during physical exertion is impaired by sleep loss. Sleep quality predicts the gradual return of motor function (Herron 2008). The role that adequate sleep has on performance is to accelerate physical recovery from common inflammation, stimulate muscle repair, and restore cellular energy in the form of glucose and glycogen.

One brain function that buckles under even the slightest amount of sleep deprivation is concentration (Walker 2017). A major consequence of a lack of concentration due to sleep deprivation is in the form of drowsy driving (Walker 2017). The Center for Sleep Research at the University of South Australia found that driving performance after 17 hours of work is equivalent to driving with a 0.05% blood alcohol content, while driving after 24 hours of work is equivalent to driving at 0.10% blood alcohol content (Aisbett 2012). The research participants were unaware that the lack of sleep had affected them that to this extent. Most vehicular accidents occur on the drive to and from fires (NIOSH 2015). When examining the rest of the United States population, the National Sleep Foundation reported that most vehicle accidents and "near misses" occur from 4:00 – 6:00 a.m.; midnight – 2:00 a.m. and 2:00 to 4:00 pm. This time period of 2:00 to 4:00pm should receive extra mention in the case of wildland firefighting as WLFFs know this time as the "witching hour" where the heat of day has set in, the weather conditions are just right for fires to blow up, and the time of day where fatigue has set in. This time of day is often when the most accidents and fatalities occur (NFIC 2014). Summarily, sleep deprivation and fatigue make lapses of attention more likely to occur, and may play a role in behavior that may lead to crashes attributed to other causes (NSF 2018).

It is also known that the brain does not function efficiently after sleep deprivation (Hoermann et al. 2011) and WLFFs must be cognitively efficient when performing their job tasks. Acutely, missing one night of sleep leads to reductions in audio and visual tracking, especially in combination with the heat of the external temperature due to season and fire (Aisbett et al, 2012).Chronic sleep deprivation leads to lowered work production, decreased cognitive performance and impaired visual function (Hoermann et al. 2011; Alhola and Polo-Kantola 2007; DeGennaro et al 2001), increased work related illnesses and injuries, as well as increased risk for developing depression, alcoholism, drug abuse, and obesity (Dembe et al. 2005).

Aisbett et al. (2012), found that Australian WLFFs averaged 3-6 hours of sleep during a multiday fire. The data reported that those receiving either no sleep or 1.5 to 3 hours of sleep over consecutive days displayed a significant decline in visual vigilance, reaction time, and the speed with which they responded to orders or numerical code substitution tasks. The decline in these cognitive functions poses significant danger for WLFFs while on the fireline since surroundings continuously change which requires constant visual vigilance and quick reaction times in case of a falling crown or a drastic change in winds that send the fire their way. The need for acute alertness to quickly react situationally is critical to avoid injuries and accidents on the fire line.

Lack of sleep does not just affect those on the direct fireline. According to a USDA Forest Service Wildland firefighter Health and Safety Report (USDA FS, n.d.):

"*A sleep log data was collected on members of five incident management teams at fire camps in California and Montana during 2008. Data for 140 team members (36 percent female, 64 percent male) indicated that they averaged 6.1 hours of sleep, ranging from 3.5 to 9.0 hours per night. On average, team members went to bed at 9:30 p.m. They reported being awakened an average of 2.2 times per night, awakening from zero to six times per night. When team members were asked to rate the quality of their sleep, the average was 6.6 on a 10-point scale. Nearly one-fourth (23.8 percent) reported feeling tired when they woke, while 53.6 percent felt somewhat rested, 20.2 percent felt rested, and 2.4 percent felt very rested*"

The end result, unfortunately, is more injuries and fatalities on the fireline will continue to occur with inadequate sleep length and conditions. In combination with lack of sleep, fatigue can be exacerbated by other factors, such as, hydration and nutrition.

More research is needed in order to better understand the predisposing factors of this population who experiences inadequate sleep, and what causes their inadequate sleep (due to long shifts, long travel time to fires, and due to working through the night) is sleep quality and quantity. What is unknown are the hazards associated with inadequate sleep levels that may lead to accidents in-transit to fires in remote regions, loss or reduction of cognitive abilities once on the fire line, and hazards once headed back to camp after long, grueling days. With a lengthening fire season (Klos et al, 2015) we can expect more accidents to occur (Withen 2015).

1.4 Nutrition

Just as wildfires need fuel to burn, WLFFs need fuel themselves to battle the flames. There is evidence suggesting that WLFFs burn upwards of 4,700- 6,000kcals a day while working on the fireline due to the physical demands (Ruby et al. 2002; Heil 2002; USDA n.d.). There is a lack of research on WLFF's energy intake and energy expenditure due to the varying degree of job duties each type of wildland firefighter crew type performs. With the multitude of tasks assigned to WLFFs on various types of terrain and intensities of fire, workloads can increase or decrease significantly (Parker et al., 2017). In verifying wearable technology use on WLFFs, Parker et al. (2017) confirmed that activities of the wildland firefighter depend on both their position within the crew and different terrain, which cause varied physiological workload.

For this reason, much of the current literature regarding wildland firefighter energy expenditure concentrates on hotshots. Hotshot crews are known to hike in to remote areas in order to access fires, and is done while having a full pack and PPE. In the literature data states that hotshot crewmembers expend on average 4700 kcals per day +/- 300 kcals/day (Ruby et al. 2002; Heil 2002; USFS n.d.) They are said to have the most physically demanding job in wildland firefighting due to hiking in and out of the fire while also completing fire suppression tasks. It is also not unusual for a work assignment to keep them on the fireline up to 14 days (National Park Service, n.d.). Performing these tasks for up to 14 days, makes a caloric deficit more likely to occur. Understanding the needs of WLFFs in the worst of circumstances is necessary to maintain a close balance of risk and benefit (Aisbett et al., 2012).

A caloric deficit is when total energy expenditure does not balance with energy intake ACSM 2015). Total energy expenditure is the amount of energy used by the body to perform not only exercise or physical actions but also includes the energy used for resting basal metabolic processes (BMR) (ACSM 2015). Understanding BMR for each and every wildland firefighter would be a daunting task, however, an understanding of the energy expenditure through "exercise" or job duties would be a realistic first step in addressing any nutritional and/ or caloric deficiencies in the WLFFs diet.

Reaching an energy deficit for a duration of time comes with acute as well as chronic consequences. Acutely an energy deficit can decrease athletes (wildland firefighter's) muscular strength, time to fatigue (endurance) decrease glycogen stores. An energy deficit can also impair judgment, decrease coordination and concentration, increase irritability, as well as depression, any of these consequences ultimately increase their risk of injury (Mountjoy et al. 2014). Longer durations of a caloric deficit can be associated with chronic consequences that can be described as Relative Energy Deficiency in Sport (RED-S) (Mountjoy et al. 2014).

RED-S has been associated with an entire cluster of physiological complications in both male and female athletes who don't consume a sufficient energy intake for the body to perform its biological functions optimally (Mountjoy et al. 2014). RED-S has a list of 12 specific health consequences. RED-S may negatively affect menstrual function, bone health, endocrine, metabolic, hematological, growth and development, psychological, cardiovascular, gastrointestinal, and immunological systems (Mountjoy et al. 2014).

In order to monitor caloric intake needs or the ability to maintain an energy balance in WLFFs the only recommendation that the USFS has made is the suggestion that WLFFs weight themselves once every two weeks. They suggest doing this as a means of tracking whether or not caloric needs are being met. There are better ways to do so, such as tracking percent body fat as well. Body fat percentage can provide the individual a lot more information than weight measurements alone.

DXA would be the most accurate method to do so yet not very practical as wildland firefighter bases are spread out and usually a distance away from a University or medical facility that may have this machine. There are other ways that would be more feasible in tracking parentage body fat such as body calipers, though not as accurate, if done consistently it can provide an adequate base of information.

Although the assessment of body composition may assist in athletic performance and health monitoring it cannot fully predicted performance and health based solely on body weight and composition alone. A rigid guideline of "optimal" body composition should also not be recommended for any group of athletes, thus not for WLFF's either. However, there are relationships between body composition and sports performance that are important to consider when monitoring the energy expenditure and energy intake of WLFFs (Sundgot, 2013). Although suggestions for "optimal" body fat content for various sports exists in some textbooks, they are evidence based. There are also critical values for body fat that are also not evidence based either, although 12% and 3% have been suggested as critical values for female and male athletes, respectively (Gropper and Smith 2013). Nonetheless, the critical values stated above may serve as a useful guide in maintaining overall health, job performance and prevention of RED-S.

It is well known that firefighting is a strenuous and taxing job. Previous research has revealed higher than average physical demands during wildland fire suppression (Ruby et al., 2002; Heil, 2002; Cuddy et al., 2011; Robertson et al., 2017), which implies increased caloric/dietary requirements (Williams, 1998) in order for WLFFs to attain an energy balance. Gaining an accurate insight into the diet of WLFFs could help prevent occupational injuries and ultimately fatalities as well as maintain overall health (Cuddy et al., 2011). Having an understanding of WLFFs diet may allow for comprehensive behavioral, exercise, and nutrition counseling that can aid in correcting any deficiencies that may exist (Wolkow et al., 2013).

There is disagreement in the research over whether nutrient distribution/intake for WLFFs are in accordance with health guidelines. Robertson et al. (2017) found that nutrient imbalances exist and this deviates from the work of Cuddy et al. (2007) and Ruby et al. (2002) who found that WLFFs were meeting proper macronutrient distributions and energy intake requirements. WLFFs are considered as tactical athletes. Athletes require additional nutrition in comparison to the general population due to the extra energy spent during exercise, training, and competition this can true for WLFFs as well. (ACSM 2007; ACSM 2013). More research is still needed.

Following an examination of nutrition and its importance to the wildland firefighter, especially while they are on an active fire assignment, the University of Montana determined that the implementation of Shift Food should be applied by all wildland firefighting crews. The Shift Food system is an intermittent feeding system that has the firefighters eating small nutrient rounded meals every 2-3 hours. Doing this as opposed to the typical sack lunch which is eaten around mid-day allows the firefighter to have more energy throughout the day. In fact, it was shown in the study by the University of Montana that the firefighters were able to maintain their work (energy) output even through the later hours of their shift. It was also seen that intermittent feeding helped to maintain blood glucose levels, immune function, as well as maintain an overall positive mood (Cuddy et al. 2007). Besides what has already been mentioned, the food they used for shift meals cost less than the sack lunches and were enjoyed more by the firefighters. This feeding strategy could be easily implemented for all crews and is beneficial in several areas.

Montain et al. (2008) reported that providing food that could be eaten on-the-go promoted increased dietary intake and work-related physical activity among WLFFs. These findings suggest that wildland firefighter physical performance may decrease if dietary intake is inadequate. Research has identified that consuming fluid that contains carbohydrates each hour in addition to meals increased the length of time wildland firefighter were able to work by approximately two hours when compared to those who consumed a placebo (Cuddy et al, 2007).

Carbohydrates (CHO) have rightfully received a great deal of attention in sports nutrition due to a number of special features of its role in the performance of, and adaptation to training (Spriet 2014; Burke et al. 2011; Cox et al. 2010). CHO are an important fuel source as they provide fuel for the brain, central nervous system and working muscles. CHO can support exercise for range of intensities due to its utilization by both anaerobic and oxidative pathways.

The amount of glycogen within the muscle cell during exercise alters the physical, metabolic, and hormonal environment in which the responses to exercise are exerted. There is also significant evidence that the performance of prolonged sustained or intermittent high-intensity exercise is enhanced by diet strategies that maintain high CHO availability. Such as keeping glycogen stores, blood glucose adequate to fuel the physical demands. Maintaining glycogen stores is important as the depletion of these stores is associated with fatigue (i.e reduced work rates, impaired skills and concentration, and increased perception of effort) (Medicine Science in Sports 2014; Spriet 2014).

In the early stages of moderate exercise, CHO provide 40 to 50 percent of the energy requirement. As work intensity increases, CHO utilization increases. Depending on the intensity, duration, and frequency of exercise, athletes should consume 6-10 grams of CHO per kilogram of body weight per day. For continuous activities of three to four hours, it is important that glycogen stores in the muscles and liver are at a maximum to support the energy demands of physical activity. Additionally, CHO during the event in the form of liquid carbohydrate solutions, mixed with electrolytes can be beneficial (Burke et al. 2011). CHO requirements are also affected by the athlete's sex and body mass, as well as total daily energy expenditures and environmental conditions (Rodriguez et al. 2009; Burke et al. 2011; Spriet 2014).

When compared to fat and CHO, protein (PRO) contributes minimally to energy needs for the body. Dietary PRO is digested into amino acids, which are used as the building blocks for the different tissues, enzymes, and hormones that the body needs to function. It is important for muscle building and repair that occurs after exercise, which speeds up the time of muscular recovery (131-134 Van and Gibala 2006; Ivy et al. 2003; Etheridge et al. 2008; Hoffman et al. 2010). The current Recommended Daily Allowance (RDA) for protein is 0.8 grams per kilogram per day for the general population (ACSM).

However, the Academy for Nutrition and Dietetics and the American College of Sports Medicine recommend that endurance athletes eat between 1.2-1.4 grams of PRO per kg of body weight per day (g/kg bodyweight), resistance and strength-trained athletes are recommended to consume 1.2-1.7g/kg body weight, and athletes who participate in continuous training for several hours at a time and/or for consecutive days, is 1.6g/kg bodyweight (Rodriguez et al. (2009). Wildland firefighter fit this last category with the requirement of 1.6g/kg body weight especially when they are on an active fire assignment.

Lastly, the macronutrient fat has a recommendation in terms of percentage according to Rodriguez et al., (2009) the recommended intake for fat is 25-30% of total calories. Fat has several important roles for numerous metabolic activities that promote overall optimal health and cognitive functions (Rodriguez et. al, 2009) Fat is also a significant contributor to energy needs. It supplies 9 kcal/g of fat, making it the most energy dense macronutrient. During endurance events lasting 6-10 hours, fat can contribute anywhere from 60-70% of energy requirements. Fat consumption should be a minimum of 20 percent of total energy intake to preserve athletic performance as well as maintaining overall health. Adequate fat intake is crucial to meeting nutritional needs of essential fatty acids and fat-soluble vitamins, vitamins A, D, E and K (Calder et al. 2010; Cialdella-Kam et al. 2014; Thomas et al. 2016).

1.5 Hydration

Dehydration is a risk that WLFFs are continuously faced with. Fire season is typically at its peak during mid to late summer, which means WLFFs are exposed to extreme heat in the required impermeable protective clothing that increases sweat rates to a dangerous level (Raines et al., 2013). A review of 10 studies on wildland firefighter hydration levels (Walker et al, 2016) showed that hypohydration is a major risk to their health and safety (Hendrie et al, 1997). Prescribed fluid intake can help maintain euhydration and decrease core body temperature (Raines et al. 2012), however Cuddy and Ruby (2011) documented a case of heat injury in one wildland firefighter despite higher fluid consumption. Cuddy et al. (2008) confirmed that fluids with added electrolytes resulted in similar hydration levels while requiring less water consumption versus a non-fortified beverage. This is an important discovery since minimizing the amount of water firefighters need to carry and consume may promote improved hydration. Hydration is also a very complicated subject when it comes to WLFFs since the water they drink is also the water they carry on their person to various and sometimes extreme fire locations.

Water is an important nutrient for the general population as well as the athlete. However, due to the physical demands of athletes sweat rate is increased and the water loss during an athletic event or training will need to be monitored and replaced. (ACSM 2007; Steinmuller et al. 2014) Sweat rate can be further increased due to environmental factors such as elevation and ambient temperature and the requirement of excessive clothing (PPE).

Hydration is extremely important when it comes to cognitive and physical functions. Gopinathan et al. (1988) questioned what levels of dehydration would cause mental performance decline or suffer impairment. They discovered that a 2% total body water loss created an impairment in recognition tests, serial addition tests, and tasks that involved motor speed and attention. This loss of total body water can be exacerbated with WLFFs due to extreme work conditions, environment, and tasks. To avoid dehydration, an athlete should drink 5 to 7 mL per kilogram of body mass approximately four hours before an event. During an event its recommended to drink 3-8 fluid ounces of a sports beverage that contains 5-8 percent of a carbohydrate solution and electrolytes. every 15-20 minutes when exercising greater than 60 minutes. After exercise, 16-24 oz of water should be consumed for every pound that was lost during the athletic event. (ACSM 2007; Steinmuller et al. 2014) These guidelines for athlete hydration may be helpful in keeping WLFFs adequately hydrated.

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CHAPTER 2: WILDLAND FIREFIGHTERS SELF-REPORTED FACTORS CONTRIBUTING TO ACCIDENTS ON THE FIRE LINE

2.1 Abstract

From 2005-2015, the United States lost 176 Wildland Firefighters (WLFF) while reported accidents averaged 42 per year. As such, accidents are a noticeable occurrence in the wildland firefighting profession. In order to gain perspective regarding factors and/or situations that may be contributing to accidents on the fireline a survey was designed to determine if any commonalities or trends exist. This study was a web-based survey that included questions that were either closed ended, partially closed ended, ordered categories, completely open-ended, scalar, and closed ended with scalar. The survey was open from December 2016 through March, 2017, collecting responses from 428 wildland firefighters. The following results were analyzed in order to view any trends or commonalities in each response for all questions excluding demographics. Commonalities of factors contributing to accidents/injuries included 1) fatigue, 2) inadequate sleep, and 3) peer pressure to perform. Trends in situations contributing to accidents included 1) slips, trips, and falls, 2) communications, and 3) injuries related to equipment/tools. This information will be helpful in future research and the implementation of interventions that will increase WLFF’s health, safety, and performance. The survey respondents were also allowed to leave any final remarks or question.

2.2 Study Rationale

This survey was designed to gain an understanding of factors that may contribute to injuries and fatalities on the fire line. Gaining insight from wildland firefighters on what they consider to be factors that contribute to accidents is crucial information in advancing their health and safety on the fire line. Understanding these factors will provide a basis of information that will allow for future research.

2.3 Introduction

Every year in the United States, 100 firefighters die in the line of duty (Britton et al. 2013). From 1997 through 2007, excluding 2001, about 17% of these deaths occurred during wildland firefighting activities which is increasing at an alarming rate (NWCG 2017). Additionally, during this same time period they also reported that nearly 60,000 injuries happened to WLFFs while on the job. The majority of these deaths are medical related, consisting of cardiac events (Butler et al., 2017). Regardless, an urgent national need exists to improve wildland firefighter health and safety (WFEC, 2014). To investigate factors that may influence wildland firefighter's health and safety while on fire assignment and throughout the fire season, an online survey was conducted during the winter of 2016. The objective of this survey, along with identifying possible factors that influence wildland firefighter's health and safety, was also to establish a "pilot study" of follow-up research that would then investigate specific health and safety factors in greater detail. The survey was created and based off of a survey (Newman et. al., 2018) that was created for CDC's Health and Safety of northwest loggers. The survey consisted of 17 questions that ranged from demographics, nutrition, sleep, personal protective equipment usage, accident frequency, and other factors contributing to accidents such as personal. The survey also allowed wildland firefighters to add any additional comments or concerns. The results of the survey were all self-reported answers in order to gain preliminary data that would help create a basis for future research of the subject matter.

2.4 Materials and Methods

2.4.1 Survey Design

In order to simplify gathering survey responses, collect and analyze data, and keep responses anonymous, an online host website was used to create and distribute the survey (www.surveymonkey.com). Dr. Randy Brooks and Dr. Rob Keefe reviewed the survey questions. Dr. Brooks provided insight on survey questions and ensured that all topic areas were covered for the purpose and goal of this survey and designed according to Dillman (2000). The University of Idaho International Review Board (IRB) reviewed the questions to ensure they were appropriate for research purposes and for the intended audience of the survey. The survey was open from December, 2016 until March, 2017, collecting responses from 428 wildland firefighters. Questions were either closed ended, partially closed ended, ordered categories, completely open-ended, scalar, and closed ended with scalar.

2.4.2 Survey Questions

Question 1

In order to ascertain who was responding to the survey, the first question asked, *"What is your specific job title?"* This question was asked to gain an understanding what type of wildland firefighter responded and what their wildland firefighting role was. The vast majority of respondents were Type 1 and 2, Engine bosses, and Management personnel (Table 1).

Table 2. 1. Self reported job titles.

Wildland Firefighter Position	Respondents by role (n=428)	Percent of Total
Type 2	71	16.6%
Engine Boss	53	12.4%
Type 1	52	12.1%
Management Officer/Supervisor	49	11.4%
Engine Crew	45	10.5%
Hand Crew	37	8.7%
Hot Shot	29	6.8%
Helitack	23	5.4%
Engine Captain	26	6.0%
Forest	10	2.3%
Retired	8	1.9%
Smoke Jumper	7	1.6%
Fuels	7	1.6%
Forestry Technician	9	2.1%
Type 3	2	.4%

Question 2

From 2005-2015, the United States lost 176 WLFF with reported accidents averaging 42 per year, hence accidents are a noticeable occurrence in the wildland firefighting profession. In order to gain a better understanding of factors contributing to accidents on the fire line the following question was asked. *"Rate (common/uncommon) how much the following factors contribute to accidents during fire operations"* to determine if there were discernible trends that can be addressed in future research. The top 6 responses are listed below in Table 2.

Table 2. 2. Commonality of factors contributing to accidents during fire operations.

How common are the following situations?	***Not at all common***	***Uncommon***	***Neither***	***Common***	***Very common***
Physical fatigue/tiredness due to manual labor	0.7%	7.9%	12.2%	52.7%	26.5%
Mental fatigue- long fire season	1.4%	7.9%	18.0%	51.6%	21.0%
Tunnel Vision	2.1%	11.0%	23.0%	50.7%	13.2%
Inadequate sleep due to long shifts or travel	2.6%	15.2%	13.5%	54.7%	14.0%
Peer pressure from others to perform	2.6%	18.2%	19.4%	45.6%	14.3%
Inadequate sleep due to other factors (sickness, noise, etc.)	2.3%	18.5%	17.8%	48.1%	13.1%

Question 3

Gathering an understanding of whether or not wildland firefighters were taking precautionary measures to ensure their own health and safety seems necessary before challenging any of the current rules, regulations, and PPE requirements. Question 3 *asked "How often do you wear ALL PPE (goggles, hard hat, hearing protection, gloves, etc.) on fire assignment?"* Responses are given in Table 3.

Table 2. 3. How often do you wear ALL PPE on fire assignment?

Response	Percent
Always	31.3%
Often	46.3%
Rarely	20.6%
Never	1.9%

Question 4

Performance on the job can be compromised if dietary needs are insufficient. Little if any data exists on WLFF nutritional habits. Obtaining information on WLFF eating habits and nutritional knowledge is essential for understanding how nutrition is utilized by wildland firefighters and if this could be a contributing factor to health and safety on the fireline. Therefore Question 4 asked *"How often do you monitor the amount of food eaten while on fire assignment?"* Table 4 lists responses.

Table 2. 4. How often do WLFF monitor amount of food eaten?

Response	Percent
Always	21.3%
Often	37.2%
Rarely	35.5%
Never	6.1%

Question 5

Research has shown that the majority of alcohol-related work-performance problems are associated with nondependent drinkers who may occasionally drink too much -- not exclusively by alcohol-dependent employees. Although drinking alcohol is sensitive subject to some, in order to determine behaviors associate with possible accidents, Question 5, with responses shown in Figure 1 and Table 5, asked "*How often do you drink alcohol prior to or after a fire assignment?"*

Table 2. 5. How often do WLFF monitor amount of food eaten.

ANSWER CHOICES	RESPONSES	
Multiple times a day	1.17%	5
Daily	10.28%	44
Weekly	45.33%	194
Never	43.22%	185
TOTAL		428

Question 6

Since WLFF work in an ever changing and hazardous environment, the risk for accidents and injuries is elevated. With the ultimate goal of providing interventions to improve

WLFF's health and safety, Question 6 asked, "*How common or uncommon are the following accident situations during fire operations?*"

Twenty-eight percent of respondents (82.7% responded with common or very common) indicate that slips, trips, and falls are the most common accident on the fire line. Sixty-two percent indicated that communication failures, miscommunications, or no communication at all is the second leading situation that leads to accidents.

Table 2. 6. Commonalities of situations leading to accidents.

How common are the following situations?	***Not at all common***	***Uncommon***	***Neither***	***Common***	***Very common***
Injury while working on/around equipment or vehicles	7.7%	41.7%	23.4%	23.6%	3.5%
Slips, trips, or falls	0.5%	7.7%	9.4%	54.8%	27.9%
Communication failures, miscommunications, or none at all	2.1%	15.0%	20.9%	47.6%	14.3%
Being hit/pinned by branch, snag, or live tree domino effect	12.4%	46.5%	19.4%	17.5%	4.2%
Injury relates to chainsaw or other hand tools/equipment	8.6%	38.8%	23.6%	26.4%	2.6%
Accident related to "horse play" or goofing off	16.6%	40.4%	25.9%	14.2%	2.8%

Question 7

Following up with Questions 2-6, an opportunity was provided for respondents to provide input on additional situations that the survey did not address. Question 7 asked, “Are there common accident situations on fire operations that we did not ask you about in questions 1-5? If so please list them here.” *Text analysis indicate the top 4 words used are injuries, accidents, driving, and common. Quotes from respondents are listed here:*

Injuries

“Sickness camp crud Over use related injuries i.e. Tennis elbow Chemical dependence. Nicotine, sleep pills, caffeine related dehydration”

“Rolling debris, rocks, and logs on steep slopes have contributed to a lot of the injuries I've seen on the fire line.”

“People not wearing appropriate PPE greatly contributes to minor injuries (i.e. cuts on hands while sharpening chainsaws or tools, bruises/hematomas while handling have items)”

Accidents

“That accident prone person that should not be in the fire service, or should get some spec. Training. Ego maniacs trying to look good.”

“While maybe not defined as accident, camp crud or other similar issues can make a huge impact on a person or eventually crew's ability to perform. Also heat related illness. Again maybe not defined as accident.”

Driving

“Driving to/from an incident that Dispatch wants you there at 0600 and they call you late at night.”

Common

"Complacency and normalizing danger to me seems to be the most common denominator."

"Daily Physical Training and it would be Common."

Question 8

Performance on the job can be compromised if hydration is inadequate. Little if any data exists on WLFF hydration habits. Obtaining information on WLFF hydration habits on a fireline is essential for understanding if hydration status could be a contributing factor to health and safety on the fireline. Therefore Question 8 asked "*When on a fire assignment, how much water (or Powerade/Gatorade) do you typically drink in a day? (1 Nalgene bottle holds 32oz)*".

Self reported hydration averaged 134.8 ± 66.5 ounces of fluids per day (Table 8).

Table 2. 7. Descriptive statistics for hydration (oz).

Descriptive Statistics for Hydration (oz)	
Mean	134.7525
Standard Error	3.325326691
Median	128
Mode	128
Standard Deviation	66.50653382
Minimum	16
Maximum	405
Count	400

Questions 9 & 10

Restricted sleep can affect a wildland firefighters cognitive and physical abilities while on the fireline and inadequate sleep has been identified in the literature to be a major factor affecting WLFF's health and safety. For this reason, Question 9 asked, "*How many hours of sleep do you get in a 24-hour period during fire season"* Question 10 provides specific information about WLFF's sleep (quantity) habits while on a fire assignment by asking, *"While on an active fire season assignment specifically how many hours of sleep a night do you get?"*

WLFF reported getting an average of 6.8 hours of sleep during the fire season (Table 9) and average of 5.6 hours of sleep while on active fire assignment (Table 10). These two values are significantly different (Table 10.1).

Table 2. 8. Sleep during fire season.

Descriptive Statistics for Sleep During Season	
Mean	6.81
Standard Error	0.059
Median	7
Mode	7
Standard Deviation	1.22
Sample Variance	1.49
Kurtosis	4.15
Skewness	0.78
Range	11.5
Minimum	2.5
Maximum	14
Sum	2901.6
Count	426

Table 2. 9. Sleep on active fire

Descriptive Statistics for Sleep While on Active Fire	
Mean	5.56
Standard Error	0.056
Median	6
Mode	6
Standard Deviation	1.15
Sample Variance	1.33
Kurtosis	3.87
Skewness	-1.09
Range	8
Minimum	0
Maximum	8
Sum	2369.8
Count	426

Table 2. 10. Hours of Sleep During Fire Season and While on an Active Fire Assignment.

t-Test: Paired Two Sample for Sleep Hour Means During and On Fire

	During fire	***On active fire***
Mean	6.811267606	5.562910798
Variance	1.487684507	1.33000939
Observations	426	426
Pearson Correlation	0.261629877	
Hypothesized Mean Difference	0	
df	425	
t Stat	17.85825582	
P(T<=t) one-tail	6.34886E-54	
t Critical one-tail	1.648446842	
P(T<=t) two-tail	1.26977E-53	
t Critical two-tail	1.965561459	

Question 11, 12 & 13

Demographics

The Following the questions were asked to provide basic demographic information for comparison purposes and to provide information on the average age of wildland firefighters.

Question 11 asked *"Approximately how many seasons have you worked in firefighting?"*

Table 2. 11. Season worked in firefighting.

Descriptive Statistics for Mean of No. Seasons in Fire	
Mean	11.62646
Standard Error	0.433755
Median	10
Mode	3
Standard Deviation	8.963105
Sample Variance	80.33726
Kurtosis	1.028027
Skewness	1.13521
Range	46
Minimum	1
Maximum	47
Sum	4964.5
Count	427

Question 12 asked *"What is your age?"*

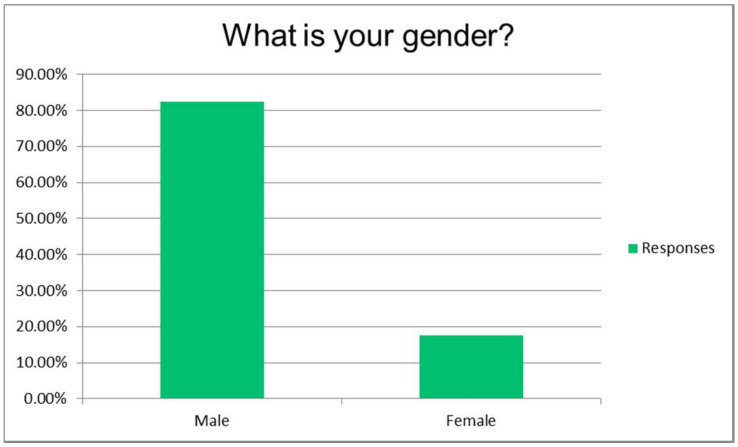
Table 2. 12. Descriptive statistics for age

Descriptive Stats for Age	
Mean	36.32
Standard Error	0.89
Median	33
Mode	31
Standard Deviation	18.32
Sample Variance	335.64
Kurtosis	162.97
Skewness	10.25
Range	317
Minimum	17
Maximum	334
Sum	15544
Count	428

Question 13 asked, *"What is your gender?"*

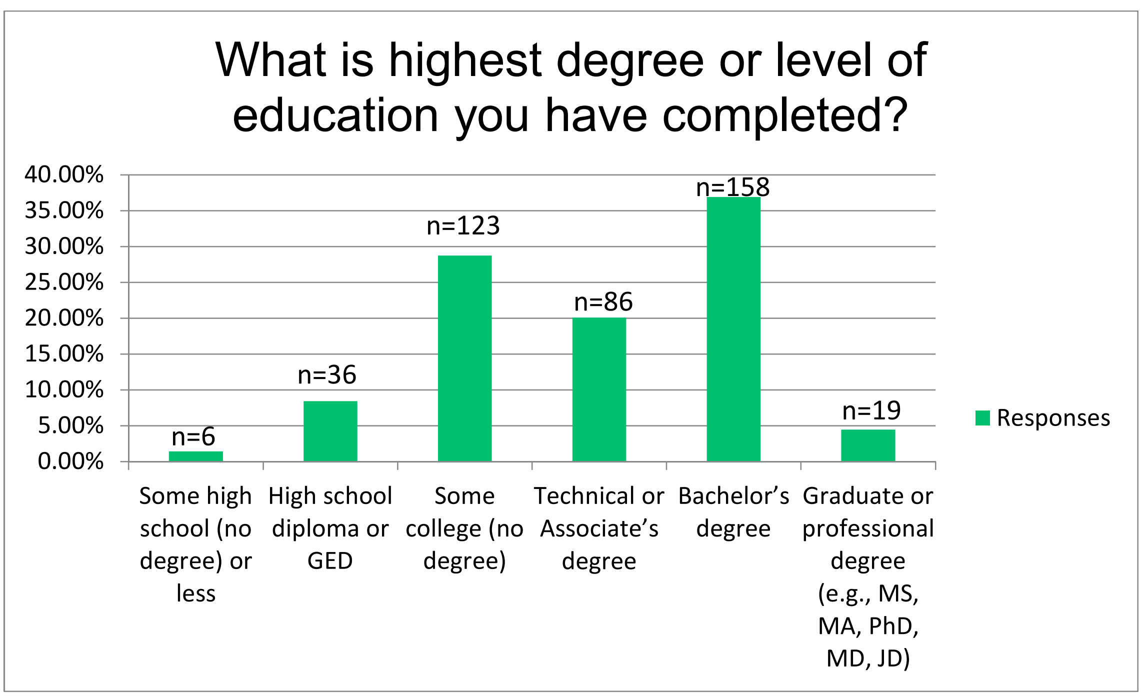
353 males and 75 females responded to the survey (Fig. 2).

Figure 2. 1. Gender of survey respondents.



Question 14 asked, *"What is the highest level of education you have completed?"*

Figure 2. 2. Education levels of WLFF survey respondents.



Question 15 asked, *"What is the zip where you grew up?"* 36% from 9, 30% from 8, 2% from 7, 3% from 6, 13% from 5, 4.3 % from 4, 2.4% from 3, 1.4% from 2, 2.6% from 1, and 3.6% from 0, 1 from Australia and 2 from Canada

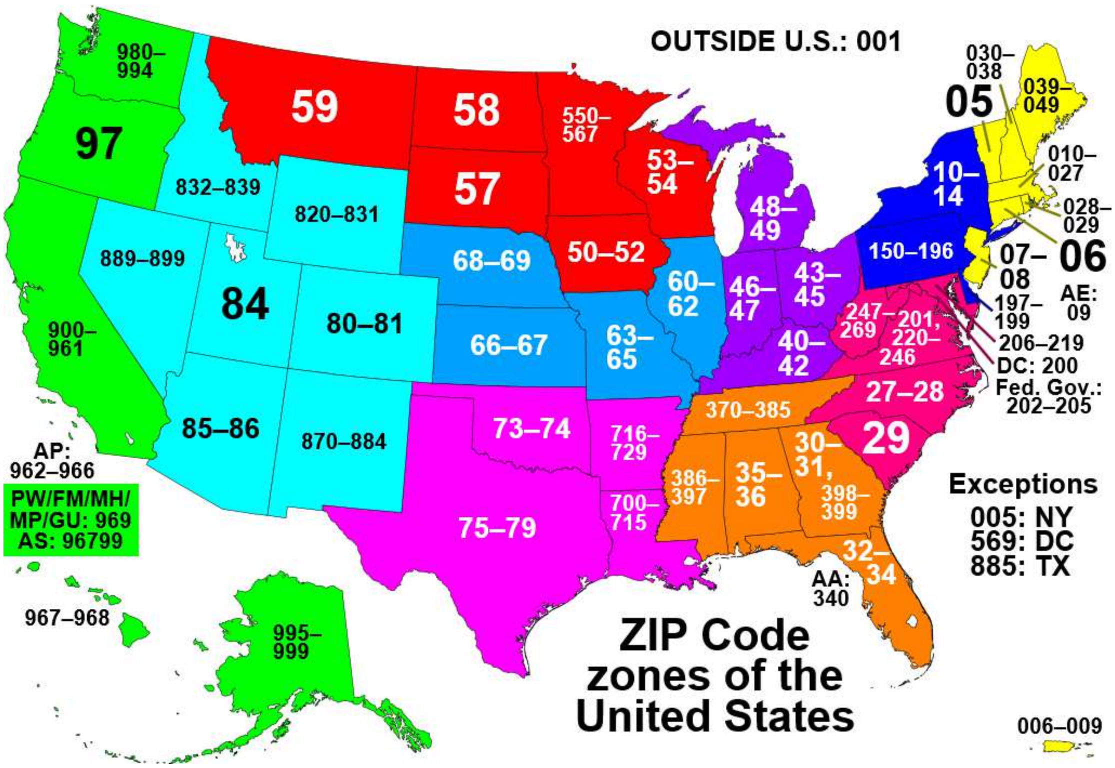


Figure 2. 3. Zip code areas of the U.S. (taken from Wikipedia)

Question 16

Often, respondents will have additional thoughts or comments about a survey or have personal experiences relative to the issue. Question 16 asked respondents *"Do you have any additional comments about any of the above topics or the survey itself?"* 93 of those surveyed responded. Some of the responses were as follows:

"Maybe the Hyper adrenaline drive to seek adventure do the job well and make enough money to live and enjoy some family life. It is a little Manic depressive cycle. Many friends crashed and burned out with family as casualty"

"Fatigue seems to be a major factor. During IA crew can work 36 hours with no rest"

"It seems the most ineffective time of the day to fight fire is at 1400. More deaths have occurred at this same time. Every fire I was on working at night we contained. Every fire we were not allowed to engage at night doubled in size. We should fight at night more"!

Question 17

Additional Questions or Comments

Lastly, survey participants often want to be informed of the research outcomes. Therefore, Question 17 asked, *"If you would like to be informed of the results of the results of this study or participate in follow up research, please leave contact info below."*

195 (45.6%) respondents provided an email address, 190 (44.4%) provided their name, and 132 (30.8%) provided a phone number.

2.5 Results and Discussion

The following results were analyzed in order to view any trends or commonalities in each response for all questions excluding demographics. To view analyzed data, results were filtered by how respondents answered each question: (not at all common, uncommon, neither common nor uncommon, common, very common). The surveyors were also allowed to leave any final remarks or question, this open answer question was filtered for (common words). Although some incidents on the fireline are termed "freak accidents" and are unavoidable, the discussion below is concentrated on factors identified in the survey that can be manipulated, prevented, or changed to influence future accidents on the fireline

2.5.1 Demographics

The individuals that participate in wildland fire operations are as varied as the terrain and fuel types that they work in: they include females and males of all racial backgrounds (Mangan, 1999). Although they must meet the physical fitness requirements of their agencies, they often come to the wildland fire environment with the same physical conditions as the general population: allergies to smoke and dust, bad backs, and trick knees. They may be out of shape and have other preexisting conditions that may surface on the fireline (Mangan 1999). The survey participants also had a wide range in age and wildland firefighting experience and come from all zip code zones in the United States as well as Canada, and Australia. The average age reported by wildland firefighters was 35 years old with a range from 17- 68 years old. Firefighters (n=428) ranged in age from 17-68 years with an average of 35.8 ± 11.2 years. The majority of the wildland firefighter population who took this survey were male, 82.7% (n=349) and 17.3% (n=73) were female. Firefighters (n=428) report working 1 to 41 seasons, with an average of 11.7±8.9 seasons worked so far. Educational backgrounds consisted of some high school or less (n=6, 1.4%), high school or GED (n=36, 8.5%), some college (n=119, 28%), college degree (n=243, 57.6%), and graduate degree (n=18, 4.27%) with 89.8% of firefighters having attended college.

Thirty-six percent of respondents were from zip code zone beginning with 9 (Figure 4), 30% from zone 8, 2% from zone 7, 3% from zone 6, 13% from zone 5, 4.3 % from zone 4, 2.4% from zone 3, 1.4% from zone 2, 2.6% from 1, and 3.6% from 0, 1 from Australia and 2 from Canada.

There are many variables that serve as underlying causes for factors and situations that lead to accidents. Trends identified from the survey for contributing factors that lead to accidents range from fatigue, inadequate sleep, tunnel vision, and peer pressure to perform (Table 2). Situational themes identified from the survey include slips, trips, and falls, communication (or lack thereof), and injuries related to equipment and vehicles (Table 6). To begin to understand the underlying causes of factors and situations that lead to accidents on the fireline, several variables or preventable measures must be examined. Each underlying variable can be manipulated in that interventions are possible.

2.5.2 Sleep

Inadequate sleep was identified a major contributing factor to accidents, second only to fatigue (Table 2). WLFF reported getting an average of 5.5 hours of sleep on active fire assignment while getting 6.8 hours of sleep during the fire season (Table 11). Australian firefighters have reported getting six hours or less of sleep per night while on assignment (Wolkow et al., 2015). Lack of sleep leads to fatigue and review of the literature finds that long arduous work hours increases the risk for sleep deprivation, sleepiness, sleep lapses, and poor sleep behavior. It is known that the brain does not function efficiently after sleep deprivation (Hoermann et al. 2011) and wild land firefighters must be cognitively efficient when conducting their job. Sleep deprivation leads to lowered work production, decreased cognitive performance and impaired visual function (Hoermann et al., 2011; Alhola and Polo-Kantola, 2007; DeGennaro et al., 2001). For example, after missing one night of sleep, audio and visual tracking are reduced, especially in combination with the heat of the external temperature due to season and fire (Aisbett et al, 2012). The decline in these cognitive functions poses significant danger for WLFF's while on the fire line since surroundings continuously change which requires constant visual vigilance and quick reaction times in case of a falling crown or a drastic change in winds that send the fire their way.) The need for acute alertness to quickly react to a situation is critical. The Center for Sleep Research at the University of South Australia (Aisbett, 2012) found that driving performance after 17 hours of work is equivalent to driving with a 0.05% blood alcohol content while driving after 24 hours of work is equivalent to driving at 0.10% blood alcohol content. In combination with lack of sleep, fatigue is then exacerbated by other factors, such as, hydration and nutrition.

2.5.3 Fatigue

Fatigue is a factor that is closely associated with inadequate sleep due to prolonged sleep deprivation and/or chronic sleep restriction that affects health, mental alertness, and performance (Sadeh and Acebo, 2002). Worker fatigue is an increasing area of concern for many occupations including wildland firefighting, especially during an active fire assignment where work days are typically longer than 14 hours. Occupational injuries are 61% higher with overtime (Dembe et al., 2005) and research shows that annually over 100,000 auto accidents, 1,357 fatalities, and 71,000 injuries are a result of drowsy (fatigued) driving (NHTSA, 2005). Additionally, a 12-hour day increases in hazard rate by 37% while a 60-hour work week also increases work related injury and illness by 23% (Dembe et al., 2005).

Fatigue makes lapses of attention more likely to occur, and may play a role in behavior that may lead to crashes attributed to other accidents (NSF 2018). Inadequate sleep is not the only contributor to fatigue as energy deficit can also decrease athletes (wildland firefighter's) muscular strength, time to fatigue (endurance) decrease glycogen stores. Maintaining glycogen stores is important since depletion of these are associated with fatigue (i.e reduced work rates, impaired skills and concentration, and increased perception of effort) (Medicine Science in Sports, 2016; Spriet 2014). Fatigue is a hazard in the work place and is likely a contributor in the arduous profession of wildland firefighting. As an intervention for adequate sleep and rest environment, plan to provide 1 hour of sleep or rest for every 2 hours worked and monitor individuals for elevated levels of fatigue. When WLFF deviate from work/rest guidelines, the Agency Administrator or Incident Commander (IC) must give approval in writing (USDA Forest Service, 2003).

2.5.4 Personal Protective Equipment

A closer look at wildland firefighter's proper usage of PPE can be helpful information as to what could be contributing to injuries on the fireline. Only 31% of those surveyed reported that they always wear all required PPE while 23% reported rarely or never wearing all required PPE. One surveyor responded to the question with "Burns to hands and wrists from not wearing PPE". This may be a frequent occurrence that can be preventable if all PPE is worn regularly and properly. WLFF's are required to wear standardized personal protective equipment during fire assignments to maximize their health and safety and performance on the fireline.

In 1993, National Fire Protection Association (NFPA) 1977, created the Standard on Protective Clothing and Equipment for Wildland Firefighting with the goal to "specify the minimum design, performance, testing, and certification requirements for protective clothing, helmets, gloves, and footwear that are designed to protect firefighters against adverse environmental effects during wildland firefighting operations" (NFPA, 1977).

PPE may vary across different WLFF job positions; however, some common PPE items may include: flame-resistant clothing, yellow long-sleeved aramid shirts, hard hat, leather gloves, 8-inch-high, laced-type exterior work boots with Vibram-type, melt-resistant soles, and eye and face protection. (USFS 1999)

2.5.5 Nutrition

Just as wildfires need fuel to burn, wildland firefighters need fuel themselves to battle the flames. Wildland firefighters are considered tactical athletes (Gabbert, 2015) and while wildland firefighting may not be considered a sport, the physical and nutritional demands can be compared to those of athletes who compete in sports. There is evidence suggesting that wildland firefighter's burn upwards of 4,700- 6,000 kcals a day while working on the fire line due to the physical demands (Ruby et al. 2002; Heil 2002; USDA n.d; Gabbert, 2015).

These calories must be replaced to help avoid an energy deficit. An energy deficit can impair judgment, decrease coordination and concentration, increase irritability, as well as depression, any of these consequences ultimately increase their risk of injury (Mountjoy et. al. 2014).

2.5.6 Hydration

Almost 26% of WLFF surveyed indicated that distraction due to thirst was a factor contributing to accidents (Table 8) while admitting they only consume an average of 135 ± 66 ounces (Table 8). Dehydration is a risk that wildland firefighters are continuously faced with. Fire season is typically at its peak during mid to late summer, which means wildland firefighters are exposed to extreme heat in the required impermeable protective clothing that increases sweat rates to a dangerous level (Raines et al., 2013). A review of 10 studies on wildland firefighter hydration levels (Walker et al, 2016) showed that hypohydration is a major risk to their health and safety (Hendrie et al, 1997).

Hydration is extremely important when it comes to cognitive and physical functions. Gopinathan et al. (1988) questioned what levels of dehydration would cause mental performance decline or suffer impairment. They discovered that a 2% total body water loss created an impairment in recognition tests, serial addition tests, and tasks that involved motor speed and attention. This loss of total body water can be exacerbated with wildland firefighters due to extreme work conditions, environment, and tasks.

On a normal fireline assignment, firefighters may need to replace 160-192 ounces of fluids a day and Joe Domitrovich, exercise physiologist with the USDA Forest Service, recommends that front-line firefighters need 237-338 ounces of water each day (Gabbert, 2015).

2.5.7 Alcohol

Fifty seven percent (57%) of WLFF report consuming alcohol on a weekly basis or more frequently (Table 5) yet only 8.5% report reduced alertness due to alcohol as a contributing factor leading to accidents (Table 2). The consumption of alcohol around working hours may be detrimental to health, safety, and performance of/at any profession. However due to the conditions and environment of wildland firefighting the risks/repercussions may be greater. This is especially crucial for wildland firefighters because data from the National Interagency Fire Committee shows that wildland firefighter fatalities are steadily increasing, along with the length of the fire season (NIFC, n.d).

Two specific kinds of drinking behavior significantly contribute to the level of work-performance problems: drinking right before or during working hours (including drinking at lunch and at company functions), and heavy drinking the night before that causes hangovers during work the next day. Analyses of workplace fatalities showed that at least 11% of the victims had been drinking, breathalyzer tests detected alcohol in 16% of emergency room patients injured at work and large federal surveys show that 24% of workers report drinking during the workday at least once in the past year. One-fifth of workers and managers across a wide range of industries and company sizes report that a coworker's on- or off-the-job drinking jeopardized their own productivity and safety (NCADD, 2015).

2.6 Summary

Health, safety, and performance are the goal for the majority of occupations and wildland firefighting is one that requires a mixture of more components and higher standards in order to increase each of these things. Studying WLFF's sleep, nutrition, hydration, PPE, and alcohol use is a start in understanding factors and situations that contribute to injuries and fatalities on the fireline. In the literature on each of these topics (sleep, nutrition, hydration, PPE, and alcohol use) there are supporting research on “standards”, however, it is important to remember that each individual is different, and there are no recommendations/standards that can apply to everyone exactly.

2.7 Future Research

Results from the survey indicate a need for sleep monitoring, both quality and quantity, as well as body composition testing across a fire season to gain an understanding of what is occurring on the fire line. The common responses indicating inadequate sleep has been self-reported /demonstrated by majority of the survey participants. Not only has inadequate sleep been reported by those who took the survey but also in other wildland firefighter sleep research/studies (Aisbett et al., 2012; Cuddy et al., 2011; Sharkey, 2000). Future research on sleep will include objective measures such as the use of the Fatigue Science ReadiBand to monitor quality and quantity of sleep of wildland firefighters throughout a fire season.

Monitoring body composition will also be the next step of our continued research as result of the data collected from the nutrition related questions of the survey as well as the comments section of the survey. The nutrition section of the survey indicated that the majority of wildland firefighters were distracted due to thirst and/or hunger. Monitoring body composition will provide insight as to how well the wildland firefighters are fueling themselves to fight the flames. Food journaling/logging has also been considered. However, at this point having wildland firefighter’s record all food and beverages consumed daily, or even at weekly intervals would create difficultly in participation as well as accuracy due to time constraints on the fireline.

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CHAPTER 3: BODY COMPOSITION CHANGES OF SMOKEJUMPER'S ACROSS A FIRE SEASON

3.1 Abstract:

The purpose of this study was to determine if Wildland Firefighter Smokejumper's body composition changed throughout the fire season of 2017. Subjects for the study included 10 smokejumpers in the age range of 24-49 from the Northwest. Demographic data of each subject (age 30.1 ± 8.28 yrs., weight 81.32 ± 6.39 kg.) was recorded during the initial body composition testing. Subjects participated in pre-season and post-season body fat caliper testing. Outcomes are described as means and standard deviation (mean ± standard deviation). A paired t-test was performed to examine differences in mean pre-season and post-season changes in a body fat percentage and body weight. Body fat percentage differed across pre and post-season (average body fat percentage = 1.31%) and was significant at the set alpha level of a = .05 (t= 2.30, p= .04). Body weight differed across pre and post-season (average increase in body weight: .17 kg) but was not significant at the set alpha level of a = .05 (t= 2.30, p= 0.78). A significant relationship was found in change in body fat percentage however there was not a significant change in body weight.

3.2 Introduction

Health and performance can be affected by body composition (Heyward and Walsh, 2004). In light of this, studying body composition has received considerable research attention when examining physical performance (Hirsch et al., 2017; Clark et al., 2003; Williford et al., and Scharff-Olson, 1998; Gardener et al., 1996). Terms such as body fat percentage (BF%) and lean body mass are of interest by both coaches and athletes as they become aware of their applications in sports (Heyward and Walsh, 2004; Fleck, 1983). The relationship between nutrition and performance is well established in the literature thus optimum nutrition is widely accepted as a means to enhance performance and recovery (ACSM, 2000). The intensity and duration of certain sports impacts the amount of calories burned and research reflects that sports with higher physical activity influences body composition (Bird, 2008; Gibson et al., 2009; Fleck, 1983; Ramana et al., 2004).

Wildland firefighters (WLFFs) are considered tactical athletes (Gabbert, 2015) and while wildland firefighting may not be considered a sport, the performance demands coupled with the physical and nutritional demands can be comparable to, or even exceed those of athletes who compete in sports. “Perhaps the top 10-15 percent of the average population can do this job based on fitness levels” said Joe Domitrovich, an exercise physiologist with the USDA Forest Service, as such, “front-line firefighters burn between 4,000 and 6,500 calories each day and need 7-10 liters of water each day”, said Brent Ruby, director of the University of Montana’s work physiology department (Gabbert, 2015). Their duties require them to fight fires in all types of landscapes and terrain. The topography and weather varies greatly, especially in the western United States, which means WLFFs need to be in excellent physical shape and able to adapt to ever changing conditions.

Wildland firefighting provides a wide range of jobs and positions like hand crews, fuels crews, engine crews, hotshot crews, and aviation crews such as Helitack and smoke jumper crews. Many are seasonal and the ages of WLFF’s vary (Brooks and Collins, 2018). All WLFFs are required to pass a Work Capacity Test at the light, moderate, or arduous level (USDA Forest Service, 2002). These requirements vary depending on the position of the WLFF. NWCG (2015) defines the arduous level as:

“*Duties involve fieldwork requiring physical performance calling for above-average endurance and superior conditioning. These duties may include an occasional demand for extraordinarily strenuous activities in emergencies under adverse environmental conditions and over extended periods of time. Requirements include running, walking, climbing, jumping, twisting, bending, and lifting more than 50 pounds; the pace of work typically is set by the emergency situation.”*

Smokejumpers must pass the arduous level of the pack test and in addition be able to do, at the minimum, seven pull-ups, 45 sit-ups, 25 push-ups, and a 1.5 mile run in less than 11 minutes. They must be able to perform a gear pack-out with 110 pound pack over 3 miles in 90 minutes or less (USDA Forest Service, 2008).

Smokejumpers are considered a national resource that travel all over the country, including Alaska, to provide highly trained, experienced firefighters with great leadership skills for quick initial attacks on wildfires in remote areas (USDA Forest Service, n.d.). They must be in excellent physical condition and possess a high degree of emotional wellbeing and mental alertness and go where help is needed (USDA Forest Service, n.d.). A typical work season is June through October, however, research shows that the fire season has grown by 30 days in the last 20 years with the fire season starting earlier in the spring and ending later in the fall (Klos et al., 2015). This is concerning since WLFF's commitment of continuous physical job demands will increase in duration and ultimately test the physical and nutritional components that are essential for health and performance.

Many factors such as body size and composition can determine performance (Boileu and Horswill, 2000). For reference, either too high or too low of a BF% can have negative impacts on health. Because of these factors, many athletes and athletic teams have their body composition assessed on a regular basis (Ebben et al., 2005; Simenz et al., 2005). WLFFs are tactical athletes (Gabbert, 2015) and as such their body composition should be monitored for the same reasons. Body composition information can be used with the individual athlete or WLFF and the crew in a variety of ways, including part of a general overall health assessment and to monitor periods throughout the fire season where nutritional needs are insufficient and/or where deficiencies in nutrition are occurring based of body composition changes across a season, a year, and multiple years.

Inactivity during a WLFF's off season can lead to accumulation of body fat which can affect performance and fitness levels (Dempsey, 1966). Having a higher BF% lowers the amount of endurance an individual will have, which allows fatigue to set in quicker than those who have a healthy lower BF%. The National Interagency Fire Center (NIFC, 2017) has guidelines for periodic medical surveillance, although there are no requirements to maintain minimal physical capacities or to follow any specific fitness exercise program.

In general, excess body fat is detrimental to overall health and performance while fat-free mass (FFM) is beneficial for physical performance. Too little body fat has negative health implications as well and subjecting athletes or WLFFs to chronic periods of low energy availability (EA) in conjunction with poor nutritional support can be detrimental (Sundgot, 2013; Sundgot 2011).

It is known that low EA in male and female athletes may compromise athletic performance acutely, such as decreased endurance and power output (Volek et al., 2006). Low EA also has chronic health related issues associated with it as well therefore screening and treatment guidelines have been established for managing low EA in athletes (Sundgot, 2013; Sundgot 2011; De Souza, 2013).

When carrying extra body fat there is no compensatory need for increased maximal oxygen intake versus if the extra weight was due to an increase in muscle mass. Oxygen transport is often not as efficient in an individual with higher BF% compare to those with appropriate amounts of body fat. Consequently, performance and endurance is limited, correspondingly, between the higher and appropriate body fat individuals (Dempsey et al., 1966).

It has been demonstrated that a 5kg accumulation of fat may add 1.5 mm to the subcutaneous fat layer of a man and 2.5 mm to that of a woman (Pugh et al. 1960). At rest, the thermal gradient across a layer of superficial fat is approximately 0.15ºC/mm, but the insulating effect also has an increased heat influx during work. When an individual is working at a moderate to intense pace (5-8 rate of perceived exertion) a reaction of a 10-fold increase of internal body temperature is equal to approximately 1.5º C per mm of superficial fat (Pugh et al, 1960). The U.S. Institute of Medicine (1992) suggests that with an initial thermal gradient of 7º C from the body core to the environment, the core temperature would rise by an additional 0.8 to 2.0º C if a person with an additional 2 mm of subcutaneous fat worked at a moderate rate (Shephard, 1987). Conversely, if the rise of core temperature were to be avoided by a reduced intensity of working, it would be necessary to decrease the work intensity by 11-28 percent (IMUS, 1992).

WLFF duties are performed in the mandatory personal protective equipment (PPE), in the heat of summer alongside blazing fires and any added heat due to less than ideal body composition could increase the risk of heat related illness or other medical conditions such as heat stroke (Fire Rescue, 2008). Seventy nine percent (79%) of career firefighters are classified as overweight or obese (Poston et al, 2011) and consequently 45% of firefighter deaths in the line of duty are related to cardiovascular disease (Stefanos et al, 2003). While the study by Stefanos et al., (2003) focused exclusively on city firemen, these findings are also reflected in WLFFs (Wildfire Today, 2016).

Being overweight or obese places a person at risk for a number of health-related issues such as, hypertension, abnormal blood lipid panels, continuous weight gain, lower cardiorespiratory fitness, reduced muscular strength, and an increased number of cardiac events (NIH, 2015). Cardiac events are the leading cause of WLFF deaths and in Idaho during 2003-2015, six out of twelve WLFF deaths were due to heart related complications on the job (CDC, n.d.) and is further corroborated by Butler et al. (2017) in Table 1.

Table 3. 1. Number of reported medical and heart related deaths by agency (adapted from Butler et al., 2017).

Characteristics	National Fire Association	United States Fire Administration	National Wildfire Coordinating Group	Cases included in all three sources	Cases included in at least one source
Medical	47	61	54	37	74
Medical non Heart Attack	6	7	7	5	10
Medical Heart Attack	41	54	47	32	64

Monitoring body composition could be a useful tool to predict underlying health issues before a firefighter is placed in less than ideal situations (NIFC, 2017) therefore in 2017 a pilot study was initiated with USFS Smokejumpers to assess possible changes in body composition across a fire season. The aim of this study was to measure body composition of Wildland Firefighter Smokejumpers before and after the fire season of 2017 to assess any body composition changes that occur throughout the season.

3.3 Methods

3.31 Participants

A convenience sample of USDA Forest Service Smokejumpers were used for this study. Participants were recruited on a voluntary basis. There were 10 volunteer WLFFs at this particular base, however one was excluded at the end of the study. Nine (n=9) United States Forest Service Smokejumpers between the ages of 24-49 completed the research study. Approval was obtained from the University of Idaho's Institutional Review Board prior to conducting research (See Appendix A). Each participant was given a folder of materials containing study directions and rational, researcher's contact information, a consent waiver to sign prior to participation, as well as a revocation of consent form. Any participant unable to meet all the requirements for the study (pre-season and post-season body composition testing) was excluded.

Few interactions with the participants were needed as the predictability of when the Smoke Jumpers might return to base was limited. Primary visits to the base were pre-season and post-season with 4 visits in-between to check on volunteers who happened to be at the base. It was understood by researchers and participants that it was unrealistic to test more than pre-season and post-season.

3.3.2 Protocol

Body composition measurements and body weight were taken pre-season and post-season using Lange skinfold calipers and weight scale (Salter Brecknell PS1000) at the jump base that was calibrated each time. Jackson and Pollock three-site skinfold testing was utilized (triceps, abdomen, and thigh). Weight was also recorded for each participant at the time of skin-fold testing. Skinfold readings and weight were then calculated in Excel using the Siri equation to provide BF% for each participant. The Siri equation is a two-compartment model that only measures fat mass and fat free mass (Jackson, et al., 1980).

Jackson and Pollock Body Density Equation (Male) =1.10938-(0.0008267*(sum of three skin folds) + (0.0000016*(sum of three skinfolds^2)) - (0.0002574*age)

Siri Body Density to Body Fat Equation = ((4.95/Body Density)-4.5)

The best use of skinfold thickness data is as raw values, where they act as reliable indices of regional fatness. They can be converted into standard deviation score (SDS) formatted for longitudinal evaluations (Wells and Fewtrell, 2006). Lange skinfold calipers are a "precision instrument" specifically designed for simple and accurate measurements of subcutaneous fat. Lange skinfold calipers are manufactured by Beta Technologies (Cambridge, MD) and widely used by medical and physical health care professionals and allows for efficient and practical measurements for valid testing (Beta Technology, 2008).

All pre-season measurements were taken June 8th, after participants had previously passed the Work Capacity Test. Post-season testing was performed September 21st. Each test was performed by a certified personal trainer with 11 years of experience and had previously performed over 1,000 accurate caliper tests.

Participant's weights and ages were recorded and then body fat was tested by skinfold caliper. Skinfolds were measured in a rotational manner to allow testing sites to regain normal texture and thickness before testing the site again. This was repeated until a total of 3 caliper readings per site were collected. Measurements started with the triceps followed by abdomen, and thigh respectively. All measurements were taken on the right side of the body which was marked on the skin with a marker for consistency and adherence for site specific guidelines. All repeated measurements are required to be within 2mm of each other or re-measured. Skinfold calipers have a +/-3.5% error largely due to participant's hydration status, whether or not their body is inflamed (as it may be after a workout or other physical activity), and the researchers level of experience completing the skinfold testing (ACSM, 2014).

3.3.3 Statistical Analyses

The outcomes are described as means and standard deviation (mean ± standard deviation). A paired t-test (Table 1) was performed to examine differences in mean pre-season and post-season changes in BF% among the WLFF 2017 fire season. This was also repeated for pre-season and post-season body weight. An alpha level of $p < 0.05$ was used for significance.

Table 3. 2. Statistical analysis for body fat means.

t-Test: Paired Two Sample for Body Fat Means	Pre-season	Post-season
Mean	7.633333333	8.941111
Variance	3.57315	8.431736
Observations	9	9
Pearson Correlation	0.847195448	
Hypothesized Mean Difference	0	
df	8	
t Stat	-2.38564676	
P(T<=t) one-tail	0.022077405	
t Critical one-tail	1.859548038	
P(T<=t) two-tail	0.044154809	
t Critical two-tail	2.306004135	

3.4 Results

3.4.1 Body Fat

The study consisted of 9 U.S.F.S smokejumpers from a base of 24 smokejumpers. Ten (10) smokejumpers volunteered to participate in the study and one was later excluded due to failure to meet the study's requirements of both pre-season and post-season testing within the given time frames. Descriptive statistics from the participants are summarized in Table 2. All subjects were Caucasian males, healthy, and eligible for the job of wildland firefighting, thus making them eligible for the study.

The Jackson and Pollock and Siri equations were used to evaluate participant's BF%. BF% (Figure 1) differed across pre-season and post-season (average increase BF%: 1.31%) and was significant at the set alpha level of $\alpha = .05$ ($t= 2.30$, $p= .04$) (Table 2).

Table 3. 3. Descriptive statistics for participants.

Dependent Variables	Mean	Std. Deviation	Range
Age (years)	30.1	8.28	24 - 49
Pre Weight (kg)	81.32	6.39	69.85 - 89.36
Post Weight (kg)	81.50	6.98	69.85 - 91.17
Change Pre- Post weight	0.17	6.36	69.91-89.43
Pre BF%	7.63	1.89	4.83 – 11.11
Post BF%	8.94	2.90	5.25 – 14.29
Change Pre- Post%	1.31	1.64	-1.5 – 3.18

The mean pre-season BF% was 7.63± 1.89 and the mean post-season BF% was 8.94±2.90 (Figure 1). When fat mass (anything that is not muscle, bone, or ligaments) was examined from pre-season to post season, 78% (7/9) of the smokejumpers gained body fat (Figure 2).

3.4.2 Body Weight

Descriptive statistics for body weight is shown in Table 2. Body weight differed across pre and post-season but was not significant (Table 3) at the set alpha level of a = .05 (t= 2.30, p= 0.78). The mean pre-season body weight was 81.32 ± 6.39 kg and the mean post-season body weight was 81.50 ± 6.98 kg (Figure 1). When body weight was observed from pre-season to post-season, 44.4% (4/9) did not have a significant change in bodyweight, 33.3% (3/9) gained weight, and 22.2% (2/9) lost body weight (Figure 3). Participants SJ1 and SJ5 had a decrease in BF% and a slightly fluctuating body weight, the reasons for this is unknown and demonstrates a need for further research with a larger sample size.

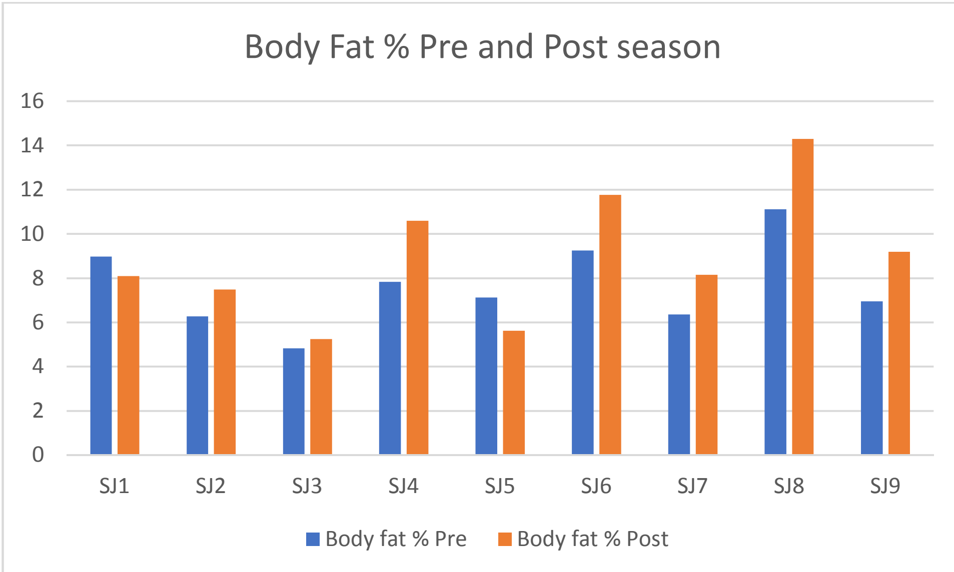

Figure 3. 1. Pre and post season BF%.

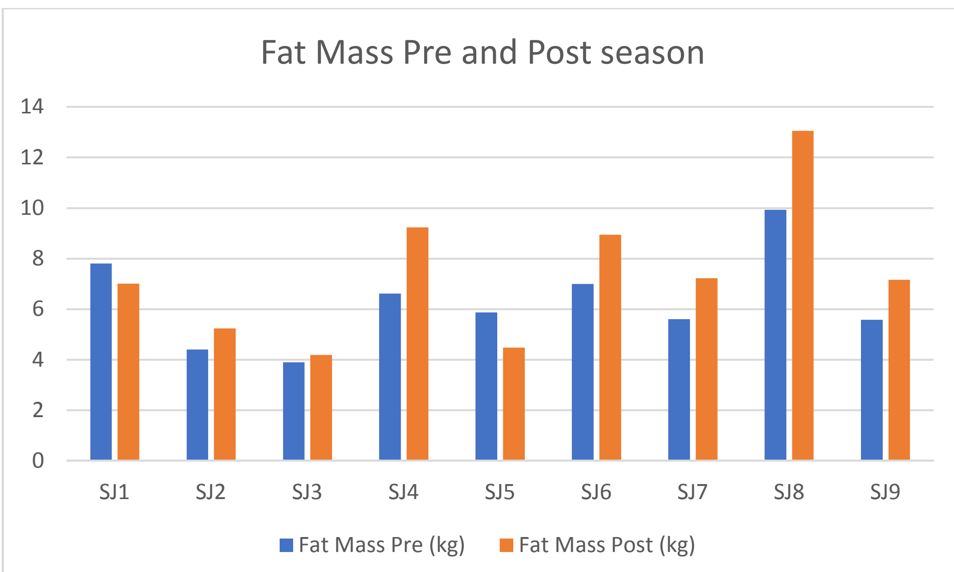

Figure 3. 2. Pre and post season fat mass (kg).

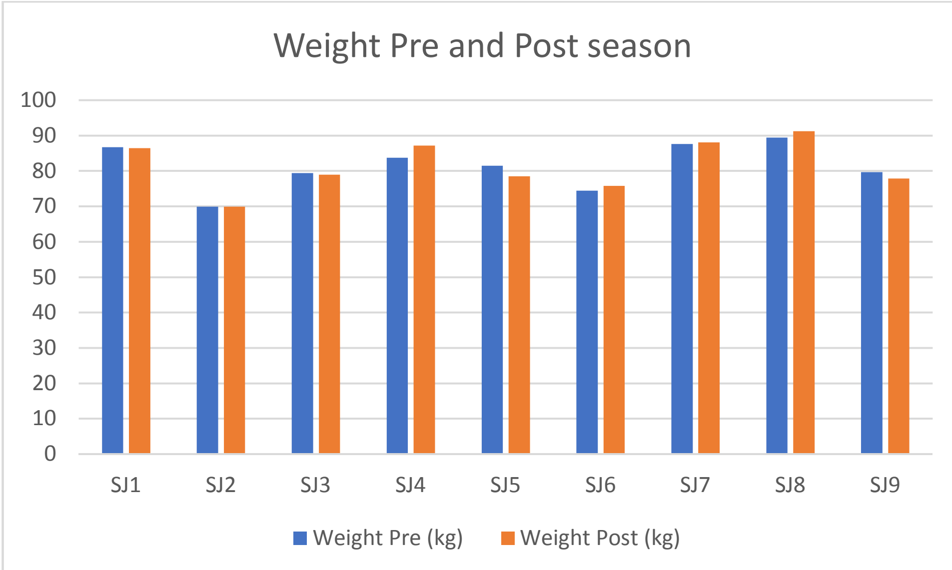

Figure 3. 3. Pre and post season weight (kg).

Table 3. 4. Statistical analysis for body weight means.

t-Test: Paired Two Sample for Body Weight Means	Weight pre (kg)	Weight post (kg)
Mean	81.31903211	81.49542914
Variance	40.43052528	48.67179714
Observations	9	9
Pearson Correlation	0.963609129	
Hypothesized Mean Difference	0	
df	8	
t Stat	-0.27850013	
P(T<=t) one-tail	0.393845797	
t Critical one-tail	1.859548038	
P(T<=t) two-tail	0.787691594	
t Critical two-tail	2.306004135	

3.5 Discussion:

It was anticipated that smokejumpers would undergo body composition changes throughout the season simply due to the arduous and physical demands of the job. It was hypothesized smokejumpers would see an increase in fat mass, a decrease in lean mass, and body weight would remain unchanged due to physical job demands, lack of sleep and recovery between shifts, and the reported nutritional habits that were documented from an earlier survey (Brooks and Collins, 2017). The data does support each hypothesis and indicates 78% underwent what could be construed as an unfavorable body composition change - meaning body weight remained the same or increased while body fat increased - indicating there was a loss of lean mass (Figure 4). However, none of the changes in body composition would be classified as "unhealthy".

Research focused on body composition changes in WLFFs is lacking. One study conducted by Roberts et al. (2002) found during a 16 week firefighter training program that fat mass and body weight decreased, while lean mass increased. Another study conducted by Sell and Livingston (2012) found BF% of interagency hotshots to be 12.9%± 2.3% at mid-season but did not elaborate further. This research is incomplete as a baseline of BF% was not measured and further BF% data was not collected. Cuddy et al. (2008) measured WLFF body weight before and after a single day shift but this information was only measured for water turnover. There were no bodyweight differences among the groups studied.

Vaara et al. (2015) observed no changes on paratrooper's body composition after eleven weeks of training. These findings contradict the results of this study. However, those were facilitated trainings for city firemen and paratroopers and it can be assumed that these participants had a training schedule that allowed for regular meal breaks as well as a set time for training start and dismissal.

A study by Gardener et al. (1996) evaluated Marine recruits (n=88,000) and found those with a high body mass index (body weight in relation to height) that ran 1.5 miles in a time greater than 12 minutes had a larger incidence of exertional heat-related injuries (Gardener et al., 1996). From 1988 to 1992, 528 cases of heat-related illness occurred during training. The recruits exhibiting a high body mass index had an eightfold greater risk for developing exertional heat illness. Overweight individuals tend to produce a greater amount of heat during exercise and suffer from a reduction of the body`s ability to dissipate heat (Gardener et al., 1996). This may help explain the cardiovascular events observed in the firefighting profession.

In athletics, pre-season and post-season BF%s have been monitored in several different sports, leagues, and age groups. Ladwig et al, (2013) found that collegiate female athletes did not undergo significant changes in body fat over a season. Conversely, Carbuhn et al. (2010) did discover a significant difference in BF% from pre-season to post-season readings of female collegiate athletes. However, the studies mentioned above differ from this research due to the set schedule of practices, competitions, and training routines. These schedules provide set recovery times, meal/snack breaks, and allow participants to go home after a day of practice or competition. WLFFs are not afforded this luxury and such factors may play a role in the research that has been conducted in body composition among those on a scheduled regimen.

Williford et al (1996) researched the relationship between simulated job performance tasks and body fat percent and lean body mass on firefighters. They examined 100 individuals to determine their body fat percent and ability to perform a simulated job task. Results showed a statistically significant relationship between BF% and the time to perform the simulated fire line job tasks. As BF% increased, time to perform the simulated job tasks increased. They also found a negative relationship between lean mass and job-related performance. As the amount of muscle mass increased, the time to perform the job tasks decreased. The study concluded that percent of body fat and lean body mass were important predictors of job performance. Firefighters with greater fat-free weight and less fat tended to perform the simulated job tasks in less time. With a lengthening fire season, what remains to be seen is if body composition changes are significant enough to decrease job performance in the WLFF population.

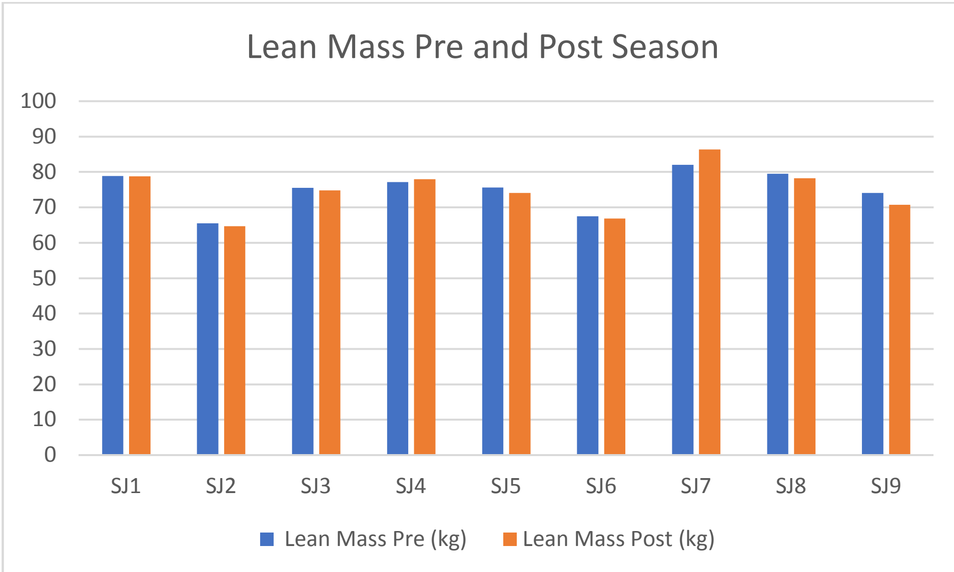

Figure 3. 4. Pre and post season lean mass.

Implications of this present study suggest that the nutritional requirements of each WLFF may not be satisfactory in terms of meeting the energy demands and nutritional requirements of the job. This is possibly due to the patterns in the data, overall, participants maintained body weight, increased fat mass, and loss lean mass from the beginning of the season to the end of the season. This suggests that caloric/energy demands are not being met, and potentially inadequate consumption of protein is occurring during the fire season. As discussed previously, protein has an important role in the recovery of, and repairing of damaged muscle fibers which occurs on the job due to the physical demands of wildland firefighting. If protein is not consumed in sufficient quantities this may be contributing to the patterns discovered in the research on the participants body composition. However, this study may have limitations. One limitation may be the use of skinfold calipers which have a ± 3.5% error associated with BF% readings. To ensure consistency throughout the study, body fat caliper testing was performed by an ACE certified researcher who has performed thousands of measurements. The measurements were conducted at the same time of day and the participants were instructed to follow the same guidelines each time.

Other limitations of this study could be the participant group. All nine participants were smokejumpers from the same base. This may have been a limiting factor as smokejumpers (unless transitioned to square chutes) have a weight limit of 200 pounds which may have had an impact on possible weight gain throughout the study. Lastly, all participants were males which limits further implications/suggestions for female WLFFs. Baseline data is needed there and is a goal for future research.

There are gaps in body composition research on the WLFF population. The power of the study, due to the small sample size and limited population being studied, was not very large. Further research, especially longitudinal data, with a larger sample size may yield stronger power and is needed to better understand our findings and relationships and how these are related to fatalities and injuries.

Table 3 demonstrates the sample size requirement for different effect sizes with an emphasis on what effect size we expect to find based on preliminary data. Statistical power was calculated (Table 3) and sample size calculations were based off body composition data collected from the smokejumpers. To be conservative, a sample size of 24 per group was selected, which will enable detection of a smaller than estimated effect size at 80% power. It is anticipated that the sample size of 24 for the next phase of this research project will be large enough to enable detection of all but the smallest effect sizes at 80% power across all future research.

Table 3. 5. Sample size based on estimated effect sizes and statistical power.

		Statistical Power	
Effect size	0.7	0.8	0.9
d = 0.4	42 (per group)	52 (per group)	68 (per group)
d = 0.6	20 (per group)	24 (per group)	32 (per group)
Estimated d = 0.8	12 (per group)	15 (per group)	19 (per group)

The results of this study suggest that the participants were in adequate physical condition to meet the performance demands of the job. It should be mentioned/reiterated that physical changes in the body causes physiological changes as well and the body must adapt. The depth of physiological changes, longitudinally, is one area of WLFF research that needs addressed due to the high number of cardiovascular related deaths that have occurred in a “physically fit” and “healthy” population. Monitoring variables such as sleep, training, nutrition, hydration, and recovery, both on and off fire assignments, is recommended in order to determine which variable(s) are contributing factors affecting body composition changes.

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CHAPTER 4: SLEEP QUALITY AND QUANTITY OF SMOKEJUMPER'S ACROSS A FIRE SEASON

4.1 Abstract

The objective of this study was to assess longitudinal data on sleep quality, quantity, and fatigue levels of U.S.F.S. Smokejumpers throughout the active fire season of 2017. Participants (n=9) were monitored for the duration of the 2017 active fire season. Objective sleep measures were recorded using an actigraphy device that was worn on the wrist of participants 24/7 (except to charge the battery of the device) and data was recorded continuously in one minute epochs throughout the season, providing sleep data. The Actigraph ReadiBand by Fatigue Science is validated device used in this research. Analyses revealed that sleep quantity and alertness scores were significantly reduced when wildland firefighters were On-Fire compared to Off-Fire assignment. Sleep quality, latency, efficiency, and time awake after sleep onset, did demonstrate significant differences between sleep quality on and off a fire assignment.

4.2 Introduction

The 2017 fire year was epic with over 66,100 fires burning over 9.8 million acres and was the costliest on record, second only in other statistics to the 2015 fire year with over 68,000 fires burning over 10.1 million acres (NIFC, 2018). However, the true cost of wildland fires is not captured by area burned, structures lost, and dollars spent. It is marked by the loss of human life, particularly of the wildland fire fighters who are tasked with protecting communities and natural resources. The average number of wildland fire fighter deaths has exceeded 17/18 per year over the last decade and is increasing in line with larger and more extreme wildfires and increasing numbers of occupationally related firefighter suicides. Most fire line fatalities are attributed to poor individual decision making, lack of situational awareness, or communication breakdowns under hazardous conditions. However, the underlying causes associated with individual health and wellbeing that facilitate these human failures are not well understood in wildland fire fighting. There is a critical need to understand physical fitness, sleep patterns, and mental health factors that facilitate minimizing firefighting injuries and fatalities while maximizing occupational safety and health. Many scientists see the record 2017 fire season as the new norm, making it urgent to understand how we can rapidly improve WLFF safety now and reduce likely increased fatalities and losses under future and even more severe conditions.

Improving WLFF health and safety is a National priority (WFEC, 2014; NSTC, 2015; Fig. 4.1). During the 2015 fire season, the United States experienced over 68,000 wildland fires that burned over 10 million acres and cost the taxpayer over $2.1 billion to suppress. Fifty-two of these fires were over 40,000 acres in size and over 4,300 homes and buildings were destroyed. These were the highest numbers ever recorded, until the 2017 fire year, where over 66,100 fires burned 9.8 million acres, which was the costliest on record (NIFC, 2018). Recent years have indicated that these staggering numbers are becoming the new norm for the United States (Abatzoglou and Williams, 2016). The majority of these fires are fought by USDA Forest Service seasonal fire hires, hereafter referred to as WLFFs. However, the true cost of wildland fires is not captured by area burned, structures lost, and dollars spent. It is marked by the loss of human life in affected communities and those tasked with protecting them. This is brought into sharp focus by the mortality figures; between 1994 and 2016, 1,114 WLFFs were killed while on assignment (NIFC, 2017). In 2015 alone, 11 WLFFs were killed (US Fire Administration 2016). In addition, countless more WLFFs suffer serious injuries while on assignment that are not widely reported.

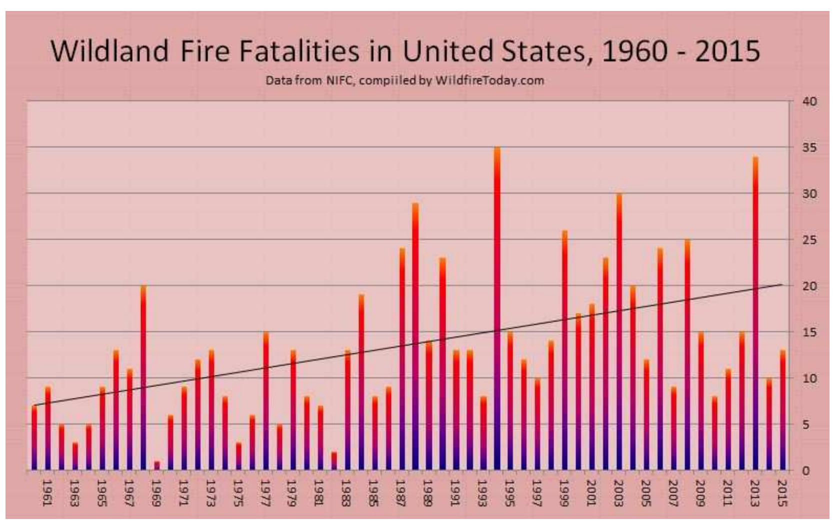

Figure 4. 1. U.S. Wildland fire fatalities from 1960-2015. Source: NIFC

The reasons behind these injuries and deaths are not well understood. Even with the required personal protection equipment (PPE), WLFFs continue to be injured and lose their lives. Incident reports typically highlight situational awareness and communication as key factors leading to WLFF injuries and deaths (DHS, 2014). However, important factors such as nutrition, hydration, and sleep on the fireline as well as overall fitness at other times of the year, have had limited research conducted. Addressing this information gap is an urgent national priority. Indeed, the 2014 National Cohesive Wildland Fire Management Strategy (DHS, 2014) highlighted that "The first rule is that safe and effective response to wildfires **must be the highest priority** of the National Strategy". Importantly, although the National Strategy provided detailed maps and information on how to reduce risk of ignitions, specifics on how to improve firefighter health and safety were lacking, suggesting a critical research need.

Wildland firefighting provides a wide range of jobs and positions, some of those being hand crews, fuels crews, engine crews, hotshot crews, and aviation crews such as helitack and smoke jumper crews (SJ's). In Idaho, many of our communities are made up of wildland firefighters (WLFFs) and their duties have them fighting fires in all types of varying landscapes and terrain. The topography as well as the weather varies greatly in Idaho. WLFFs need to be in great physical shape and be able to adapt to different physical demanding tasks and terrain. It should also be mentioned that many WLFFs are seasonal and the age of WLFFs vary. All WLFF are required to pass a PT test all the same, these PT tests may vary depending on the position of the WLFF.

Smokejumpers are a nationwide resource force that may travel all over the country to provide highly trained, experienced firefighters that also have great leadership skills that are needed for quick initial attacks on wildfires in remote areas. Smokejumper duties can be hazardous and extremely arduous, because of this they must be in excellent physical condition and possess a high degree of emotional wellbeing and mental alertness. A typical work season for an Idaho smokejumper is June - October. However, a factor worth noting is that climate change has increased wildfire frequency and intensity (Withen, 2015). Along those same lines, the fire season has increased by over 30 days in the past 20 years (Figure 4.2, Klos et al. 2015) leading to more risk-taking in the sky and on the ground (McLennan and Birch, 2005), and in all likelihood, increase the proportion of injuries and deaths among wildland firefighter (Withen, 2015). This projection is an unsettling fact for WLFFs.

In a recent survey by Brooks and Collins (2018), fatigue due to lack of sleep was the number one self-reported factor leading to accidents and injuries, while fatigue due to long work days and longer fire season was reported as the second leading contributor. Fatigue is a factor that is closely associated with inadequate sleep due to prolonged sleep deprivation and/or chronic sleep restriction that affects health, mental alertness, and performance (Sadeh and Acebo, 2002).

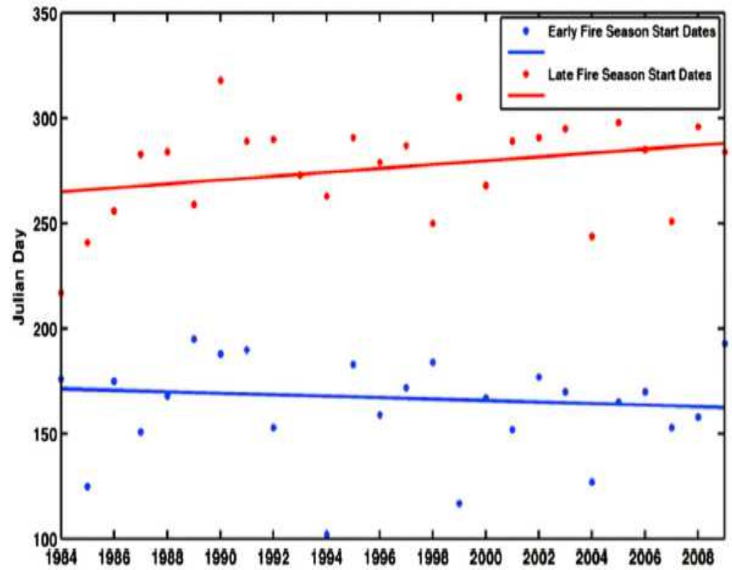

Figure 4.2. U.S. Fire season beginning and end dates (Klos et al., 2015.)

Chronically sleep deprivation creates what is referred to as "sleep debt". As sleep debt is accumulated, vigilance, attention, short term memory, and mental cognition all slow or deteriorate. Lastly, due to sleep debt the frontal lobe functions are decreased which increases the involuntary sleep onset, and impairs waking cognition and performance. (Banks and Dinges, 2007; Bonnet, 1994; Dinges, 1992; Horne, 1993; Koslowsky and Babkoff, 1992; Naithoh, 1975; McCann et al, 1993).

A study by Aisbett et al. (2012), investigated the amount of sleep that Australian WLFFs received each night and found that an average 3-6 hours of sleep was being met each night during a multiday fire. In this study they also reported that those receiving no (0 hours) sleep or 1.5 to 3 hours of sleep over a consecutive 24-hour period displayed a significant decline in visual vigilance, reaction time, and the speed in which they responded to orders or numerical code substitution tasks. (Aisbett et al. (2012). These findings were confirmed when surveying WLFF in the United States (Brooks and Collins, 2018). In the survey, WLFF's report getting 6 hours or less of sleep per night while on assignment which was significantly different from what was reported while for off-fire assignment. A typical assignment, or "roll" usually lasts 14 days. Research shows that less than one week of sleep curtailment in healthy young people is associated with striking alterations in metabolic and endocrine function leading to decreased carbohydrate tolerance and increased sympathetic tone which also leads to risk factors for obesity/increased fat accumulation (Bosy-Westphal et al. 2008; Knutson et al. 2007; Spiegel et al. 1999).

A decline in these cognitive functions poses significant danger for WLFF's while on the fire line as surroundings are continuously changing which requires constant visual vigilance and quick reaction times in case of a falling tree or crown or a drastic change in winds that send fire their way. The need for acute alertness to quickly react to a situation is critical.

It is known that the brain does not function efficiently after sleep deprivation (Hoermann et al. 2011) and wild land firefighters must be cognitively efficient when conducting their job. Sleep deprivation leads to lowered work production, decreased cognitive performance and impaired visual function (Hoermann et al. 2011; Alhola and Polo-Kantola 2007; DeGennaro et al 2001). For example, after missing one night of sleep, audio and visual tracking are reduced, especially in combination with the heat of the external temperature due to season and fire (Aisbett et al, 2012). The end result, unfortunately, can be that more injuries and fatalities on the fireline will continue to occur with inadequate sleep length and conditions.

In 2016, important research that emphasized fatigue and its effects on job health, safety, and performance showed that occupational injuries were 61% higher with overtime (Dembe et al., 2005). This research also shows that 100,000 auto accidents, 1,357 fatalities, 71K injuries are a result of fatigued driving. Additionally, a 12 hour day increases in hazard rate by 37% while a 60 hour work week also increases work related injury and or illness by 23% (Dembe et al., 2005).

Due to the recent heightened recognition of fatigue being a safety issue, scientific knowledge has advanced on this matter and this project is one of many that will bring positive results in regard to safety while on the job. This is especially crucial for WLFFs because data from the National Interagency Fire Committee shows that WLFF fatalities are steadily increasing, along with the length of the fire season.

In summer of 2017, a pilot study was conducted on USFS Smoke Jumper's - one of the WLFF crews that is the most advanced yet possibly put into the most dangerous types of fires during an initial attack.

4.3 Materials and Methods

4.3.1 Participant Recruitment

During the beginning of fire season (June 8^{th}) of 2017, 10 United States Forest Service (U.S.F.S) from Grangeville, Idaho were recruited for the study. Two participants were excluded due to poor sleep measurements and/or following directions of the sleep monitoring. Each participant was given a folder of materials containing study directions and rational, researcher's contact information, a consent wavier to sign prior to participation, as well as a revocation of consent form. An IRB was obtained prior to research being conducted (See Appendix).

4.3.2 Study design

A convenience sample was used for this study. Participants were recruited on a voluntary basis (10 volunteer's out of 24) at their base. Participants were assigned an actigraphy ReadiBand, an on the go charger, along with the packet of instructions and forms (See Appendix).

Few interactions with the participants were needed as the ReadiBand is capable of holding its charge for about 30+ days and requires no special attention for uploading data. The Readiband syncs with an IPad left on 24/7 at the fire base. The Fatigue Science App is on continuously and is Bluetooth capable. Each time a participant walks into the firebase the sleep data is automatically uploaded. If a smokejumper is out on an assignment for weeks at a time the Readiband is able to record and keep data for up to 90 days. Our primary visits were pre- and post- season (June and October) with four other visits scattered through June 12th and September 21st to check on volunteer's who were at the base and not out on an assignment.

4.3.3 Sleep Assessment

The ReadiBand accuracy of measuring and monitoring fatigue is reliant in the fact that 1) fatigue is known to start primarily from inadequate and insufficient sleep in combination with circadian rhythm factors; 2) the impact of fatigue due to different sleep/wake cycles and different sleep quality and quantity have been established for over 100 years of scientific research; 3) wrist actigraphy is able to accurately and unobtrusively monitor sleep information as well as sleep aspects such as circadian rhythm to accurately predict fatigue stages. (Sadeh and Acebo, 2002). Lastly, 4) sleep and circadian rhythm information can be processed with the use of computerized mechanical models that translate the collected information into scientifically accurate predictions of alertness, performance, and fatigue stages/risk (Von Dongen, 2004; Hursh et al., 2004)

When it comes to monitoring sleep the "gold standard" is polysomnography which is a procedure that monitors the electroencephalographic, electromyographic, and electrooculography activity of humans. This sleep monitoring can be done unobtrusively using wrist actigraphy. Activity monitoring through actigraphy provides an object, non-invasive assessment of sleep (Ancoli-Israel et al., 2003) and has been validated against polysomnography in the laboratory (De Souza et al., 2003) and in field settings (Signal et al., 2005). Wrist actigraphy monitors rest/activity cycles as well as sleep by tracking wrist movement that is then processed by a series of algorithms to establish sleep/wake and sleep quality measures. (Russell et al., FS). Participants were instructed to keep the ReadiBand on wrist day and night unless it needed to be charged, which was indicated by a small red light that turns blue when it was charged

The Fatigue Science ReadiBand is a noninvasive device worn on the wrist and collects wrist movement data. From the data collected Fatigue Science is able to calculate the quality and quantity of sleep during the night, as well as the activity levels during the day. This computing bio-mathematical modeling and computer algorithms that uses the data that is converted into an objective fatigue level and then quantify the wearer's effectiveness score, reaction times and relative accident risk. The Fatigue Science ReadiBand has been validated (Russell, n.d.) and is roughly 93% accurate at determining when the user is asleep (Fatigue Science, 2018). From this information, the wearable device uses an algorithm model called the Sleep Activity and Task Effectiveness (SAFTE) Model Alertness Score and is a validated metric for assessing the impact of human fatigue at any moment (Fatigue Science, 2018). The score is a scientific measure of the effects one's body experiences with a lack of good and consistent sleep. This fatigue influences things like judgement and reaction times.

The SAFTE Fatigue Model was developed by the US Army Research Lab with over 25 years and $37 million in research. It has been extensively validated by the US Department of Transportation, Federal Aviation Administration, and numerous other organizations (Fatigue Science, 2018). Accordingly, the SAFTE Fatigue Model accounts for a robust array of relevant sleep factors, including acute sleep interruptions, cumulative sleep debt, and the consistency of sleep onset and wake times, and circadian disruptions that influence a change in cognitive function. At a score of 100, no loss in alertness or performance is expected on account of sleep loss. A score of 70 or below indicates a state known as "fatigue impairment" that correlates sleep and fatigue levels to determine the point at which someone's fatigue levels will reach the equivalent of having a 0.08 blood alcohol level. This is achieved by comparing a person's fatigue levels to the number of human errors and delayed reaction time of an impaired person. By finding a correlation, Fatigue Science is able to accurately compare the risk of a fatigued worker. A score approaching 70% indicates the person is fatigue impaired with reaction times slowed by as much at 34% and an elevated risk of accident and serious error.

Hypotheses to be tested:

H1: Smokejumpers will see a decrease in sleep quantity during fire season.

H2: Smokejumpers will see a decrease in sleep quality during fire season.

H3: Smokejumpers will see a decrease in alertness on a fire vs off fire.

4.4 Data Analysis:

Data were analyzed using Excel and R Statistical Software. Dependent variables included alertness, WASO, (wake after sleep onset), sleep duration, sleep onset, and wake time. Data were assessed according to whether or not the participant was on or off an active fire assignment: (0) off fire assignment and (1) on an active fire assignment. Data collected while on and off a fire assignment was analyzed and compared to one another, this was done for each individual as well as the participant group as a whole.

The Fatigue Science Readiband also utilizes the scientifically validated biomathematical fatigue model, SAFTE™ (Sleep, Activity, Fatigue, and Task Effectiveness), the Readiband processes actigraphy data to predict cognitive effectiveness (Alertness Scores) as a result of sleep and time of day circadian factors. Alertness score data was assessed according to whether or not the participant was on or off an active fire assignment or boosting: (0) off fire assignment, (1) on an active fire assignment, and (2) boosting. A two-tailed t-test was ran to determine whether or not there was significance in Alertness scores on and off an active fire assignment.

4.5 Results

The study consisted of 10 U.S.F.S smokejumpers from a base of 24 smokejumpers. Ten (10) smokejumpers volunteered to participate in the study and one was later excluded due to failure to meet the study's requirements and one was dropped from the study due to poor data quality collected. Between June 13th and September 21st, 2017, eight smoke jumpers collected sleep and fatigue data using Readiband. The eight individuals collected a range of valid data ('On-Wrist Sleep Periods'), from 24 to 98 days, totaling to 518 days of sleep and fatigue data. The following tables and charts provide a summary of the average daily

Alertness, sleep quantity, sleep quality, and timing of sleep while Off Fire, On Fire, and during Boosting.

4.5.1 Sleep quantity

Sleep quantity was measured as sleep duration (hrs), sleep onset, and wake time (Table 4.1). Average alertness (Table 4.2) and sleep minutes/duration (Table 4.3) were significantly lower On Fire versus Off Fire as well as Boosting. WLFF was 91/100 Off Fire, and 86/100 On Fire and Boosting. Average sleep quantity was 6.8 hours Off Fire, and 6.1 hours On Fire and Boosting. Average sleep onset did not differ between On and Off Fire, but Boosting average sleep onset was one hour later. Average wake time was an hour earlier On Fire versus Off and Boosting.

Table 4. 1. Summary of sleep quality.

	Average Sleep Duration (hrs)	Average Sleep Onset	Average Wake Time
Off Fire	6.8	22:40	6:13
On Fire	6.1	22:32	5:09
Boosting	6.1	23:29	6:17
Overall	**6.6**	**22:40**	**5:55**

Table 4. 2. t-Test results for Alertness means.

t-Test: Paired Two Sample for Alertness Means

	Off fire	*On Fire*
Mean	4485.7875	2027.725
Variance	1665052.804	1019016
Observations	8	8
Pearson Correlation	0.564683915	
Hypothesized Mean Difference	0	
df	7	
t Stat	6.312650345	
P(T<=t) one-tail	0.000199639	
t Critical one-tail	1.894578605	
P(T<=t) two-tail	0.000399278	
t Critical two-tail	2.364624252	

Table 4. 3. t Test results for sleep minutes.

t-Test: Paired Two Sample for Sleep Minutes Means

Fire	*Off*	*On*
Mean	430.59	377.37
Variance	2405.92	764.51
Observations	8	8
Pearson Correlation	0.78	
Hypothesized Mean Difference	0	
df	7	
t Stat	4.66	
P(T<=t) one-tail	0.001	
t Critical one-tail	1.89	
P(T<=t) two-tail	0.002	
t Critical two-tail	2.36	

4.5.2 Sleep quality

Sleep quality, for this study, was measured by wake after sleep onset (WASO), sleep latency (how many minutes to fall asleep), and sleep efficiency (percentage of time in bed sleeping). There was a significant difference between On Fire versus Off Fire and Boosting for WASO, sleep efficiency and latency (Table 4.4). WLFF had less WASO and lower sleep latency and higher sleep efficiency while On Fire and Boosting compared to Off Fire.

Table 4. 4. Summary of sleep quality.

	Average WASO* (mins)	Average Sleep Latency	Average Sleep Efficiency
Off Fire	44	26	83%
On Fire	29	16	87%
Boosting	39	14	84%
Overall	**40**	**22**	**84%**

**Wake After Sleep Onset.* The sum of minutes spent awake between sleep onset and wake time.

Figure 4.3 depicts sleep quality and indicates WLFF have higher sleep efficiency while on fire. Sleep latency, or time to fall asleep, was also lower On Fire and Boosting than Off Fire.

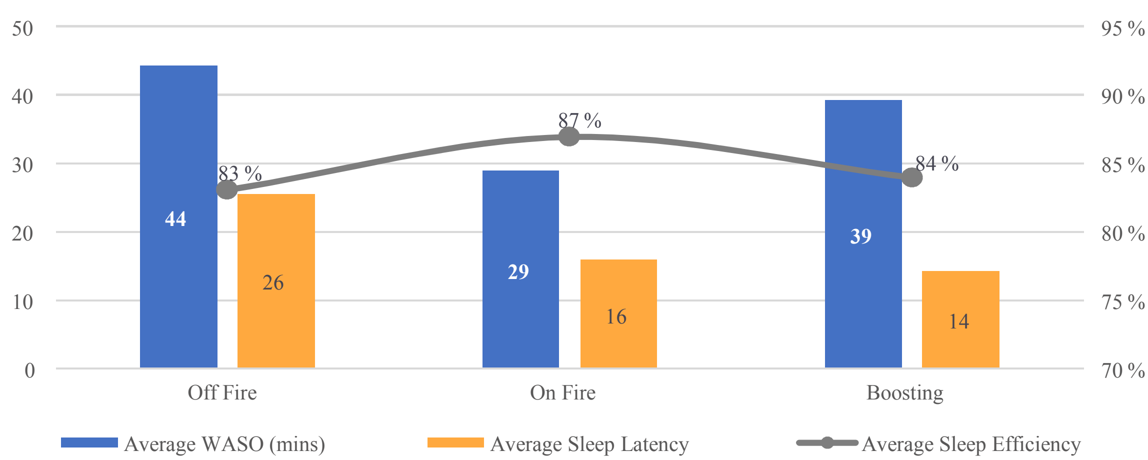

Figure 4. 3. Comparison of average sleep quality

Average alertness scores are calculated by the SAFTE model from all awake minutes. Alertness can predict mental fatigue, or risk of accident or serious error, and is represented as a score out of 100 that predicts sleep restriction on subjective fatigue rating and objectively measures performance and shows the impact of sleep on human factors such as risk of accident or serious error. The score quantifies the expected impact of recent sleep on cognitive performance and safety. Table 4.5 defines alertness scores and levels along with reaction time reduction, lapse index, blood alcohol equivalence, and risk of accident or serious error. An alertness score below 90 indicates reduced reaction times as much as 18%, and a score below 80 represents elevated risk of accident or error, and is correlated to a blood alcohol equivalency of 0.05%.

Table 4. 5. Alertness score defined.

Alertness Score	Reaction Time Reduction	Lapse Index*	Blood Alcohol Equivalence	Risk of Accident or Serious Error
91 - 100	5%	0.9x	0%	Very Low
81 - 90	18%	2.3x	0%	Low
71 - 80	34%	4x	0.05%	Elevated
61 - 70	55%	6.6x	≥0.08%	High
0 - 60	100%	10x	≥0.11%	Very High

*lapse index is a measure of likelihood of an individual suffering a lapse (or “micro-sleep”) versus a well rested person

Table 4.6 provides average daily Alertness Scores for On Fire, Off Fire, and during Boosting for the population. Alertness levels On Fire and Boosting were significantly lower than Off Fire. Participants spent twice as much time (69%) in high alertness zone compared to On Fire (34%) and Boosting (40%). Indeed, collectively, the group spent 4.4% of their time below 70%, which is high to very high risk of accident or serious error with a blood alcohol equivalency greater than .08%.

Table 4. 6. Summary of alertness scores.

	Average Alertness
Off Fire	91
On Fire	86
Boosting	86
Overall	**89**

Figure 4.4 summarizes the percentage of waking time spent with each range of alertness levels. WLFF spent 69% of their waking time OFF fire in the high alertness level, compared to 31% in the reduced alertness levels. However, when On Fire, they only spent 34% of their time in the high alertness level with 66% of their waking time On Fire spent in a reduced alertness level. While Boosting, 40% of their time was in the high alertness, while 60% of their time was spent in a reduced alertness level.

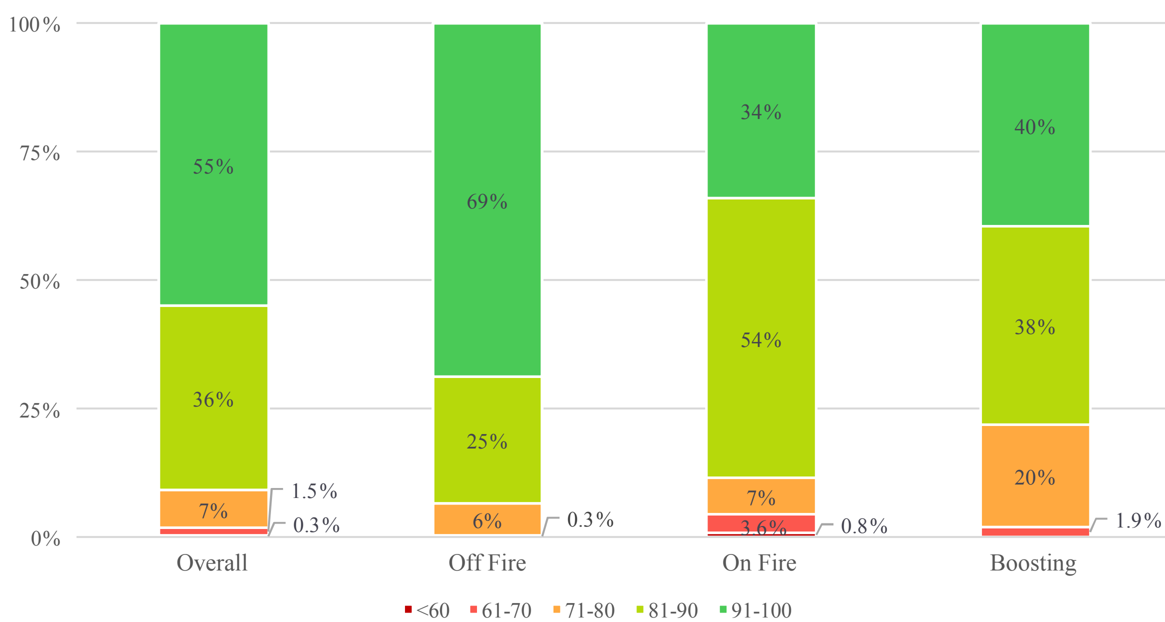

Figure 4. 4. Summary of percentage of waking time spent within each range of alertness

During the 518 days of valid Readiband data, 7,797 hours of fatigue data (Alertness Scores) during waking hours was recorded (Table 4.7).

4.5.4 Average Recovery

During the 518 days of valid Readiband data, 36 “On Fire periods” with sleep and fatigue data were recorded between June 13th and September 21st, 2017. The periods following On Fire duties required an average of 1.8 days rest/recovery for Alertness Scores to normalize (>90). Hence the two days required after a 14 day roll seemed adequate for this group. However, this was a group average and individual results varied.

Table 4. 7. Summary of waking hours spent within each range of alertness.

Alertness Score	Overall	Off Fire	On Fire	Boosting
91 - 100	4287	3184	919	184
81 - 90	2793	1144	1470	179
71 - 80	575	290	192	93
61 - 70	120	13	98	9
0 - 60	22	0	22	0

4.6 Discussion

4.6.1 Sleep Quantity and Quality

In the current study sleep quantity and quality differed significantly, depending on whether participants were On or Off Fire or Boosting. The data between Boosting and On Fire assignment was not significantly different.

On average participants slept an average 6.8 hrs ± .75 Off Fire, while averaging 6.1 ± .40 On Fire sleep. This was significant at the P=0.002 level. Average sleep onset was different for Off Fire (22:40) versus On Fire (22:32) but was for Boosting (23:29). However, when participants were On Fire, the average wake time was 05:09 compared to 06:13 Off fire and 06:17 Boosting.

This limited sleep duration of 6.8 hours of sleep is consistent with other research (Vincent et al., 2015; Gaskill and Ruby, 2004; Carter et al., 2007). As previously mentioned, one concern with inadequate sleep in wildland firefighting is the health, safety, and performance of the WLFF's. Consecutive days of inadequate sleep accumulates as "sleep debt" or sleep curtailment that may jeopardize the safety of job tasks on the fireline as cognitive and physical functions decline due to inadequate sleep (Hayes et al., 2013).

Sleep efficiency, as measured by percentage of time spent in bed sleeping, increased slightly, but not significantly, during On Fire verses Off Fire and Boosting. Sleep efficiency while On Fire was 87% while Off Fire and Boosting was 83% and 84% respectively. These findings are supported by the USDA Forest Service Wildland firefighter Health and Safety Report (USDA FS, n.d.) which stated:

"A sleep log data was collected on members of five incident management teams (n= 140; 36% female, 64% male) at fire camps in California and Montana during 2008. Participants reported being awakened an average of 2.2 times per night, awakening from zero to six times per night. When team members were asked to rate the quality of their sleep, the average was 6.6 on a 10-point scale. Nearly one-fourth (23.8%) reported feeling tired when they woke, while 53.6 percent felt somewhat rested, 20.2 percent felt rested, and 2.4 percent felt very rested".

Aisbett et al. (2012), found that Australian WLFFs averaged 3-6 hours of sleep during a multiday fire. The data reported that those receiving either no sleep or 1.5 to 3 hours of sleep over consecutive days displayed a significant decline in visual vigilance, reaction time, and the speed with which they responded to orders or numerical code substitution tasks. The decline in these cognitive functions poses significant danger for WLFFs while on the fireline since surroundings continuously change which requires constant visual vigilance and quick reaction times in case of a falling crown or a drastic change in winds that send the fire their way. The need for acute alertness to quickly react situationally is critical to avoid injuries and accidents on the fire line.

The national sleep foundation (2008) reported that US adults are only sleeping 6 hours/night during the work week. The average adult needs 7-9 hours of sleep (CDC, 2017) every day in order to function at the highest level of effectiveness, and that failure to fulfill this genetically pre-determined sleep quota rapidly leads to substantial cognitive impairments from which full recovery is more slow and difficult than previously thought.

It is well known by sleep experts and recognized by the CDC that the majority of adults require 8 hours of sleep per night to ensure optimal functionality in terms of alertness, performance, and vigilance. In the population of wildland firefighting, optimal sleep is seemingly hard to get due to spontaneous shifts, and shift durations in terms of hourly and consecutive days of work (Balkin et al., 2000; Carskadon, and Roth, 1991) and WLFFs do not obtain adequate sleep needed to perform optimally (Vincent et al., 2015; Aisbett et al., 2012).

It was noted that participants as a group did not meet the recommended 7-9 hours (CDC, 2017) of sleep On or Off Fire assignment. A typical assignment, or "roll" usually lasts 14 days. Research shows that less than one week of sleep curtailment in healthy young people is associated with striking alterations in metabolic and endocrine function leading to decreased carbohydrate tolerance and increased sympathetic tone which also leads to risk factors for obesity/increased fat accumulation (Bosy-Westphal et al. 2008; Knutson et al. 2007; Spiegel et al. 1999).

From a performance and safety standpoint, chronic sleep loss is an important concern. Chronic lack of sleep across the season predicts a massively higher risk of injury in athletes (Milewski et al. 2014). In the context of injury there is no better risk- mitigating insurance policy than sleep (Walker 2017). The relationship between sleep and human performance has been well documented in that sufficient sleep offers significant improvement to motor skill memory while also restoring benefit of perceived energy and reduces muscle fatigue (Walker 2017). Obtaining anything less than 8 hours of sleep, especially less than 6 hours, drops the time to physical exhaustion by 10-30 percent and aerobic output is significantly reduced (Walker 2017). Add to this marked impairments in cardiovascular, metabolic and respiratory capabilities that hampers an under-slept body (Herron 2008). This includes faster rates of lactic acid buildup, reductions in blood oxygen saturation, and increases in blood carbon dioxide due to the decreased amount of air the lungs can expire. Lastly, the body's ability to sweat during physical exertion is impaired by sleep loss. Sleep quality predicts the gradual return of motor function and the role adequate sleep has on performance is to accelerate physical recovery from common inflammation, stimulate muscle repair, and restore cellular energy in the form of glucose and glycogen (Herron 2008).

Factors that restrict sleep duration while On Fire may include shift length, shift start time location, and environmental conditions, to include smoke. Shift lengths while on a fire assignment can vary greatly and longer shifts have a negative influence on sleep duration. This in combination with early start times (05:09) restricts sleep duration while on a fire assignment which can result in upwards of two weeks of sleep debt. The sleep locations of smokejumpers vary as well, this is dependent on where the fire is located and how long they are on the fire assignment. However, making sleep a priority is vital according to Walker (2017) who states "in the context of injury there is no better risk- mitigating insurance policy than sleep". In order to improve sleep duration, other factors may need to be addressed such as sleeping environment and locations which could improve sleep duration, as well as quality.

4.6.2 Alertness

Although WLFF's sleep efficiency was higher On Fire, Alertness Scores were significantly decreased while On Fire and Boosting, indicating that even with better quality sleep WLFF's were not getting enough sleep to recover, thus leading to increased risk of injury. While on fire, SJ spent 66% of their in a reduced state of alertness. This reduced state of alertness results from lack of sleep and recovery leading to fatigue.

While fatigue is generally caused by lack of sleep or poor-quality sleep (Sadeh and Acebo, 2012), there are several work-related and non-work related factors that can contribute to its development. This sleep deprivation creates what is referred to as "sleep debt" and manifests itself as fatigue. As sleep debt is accumulated, vigilance, attention, short term memory, and mental cognition all slow or deteriorate. Lastly, due to sleep debt the frontal lobe functions are decreased which increases the involuntary sleep onset, and impairs waking cognition and performance. (Banks and Dinges, 2007; Bonnet, 1994;

Dinges, 1992; Horne, 1993; Koslowsky and Babkoff, 1992; Naithoh, 1975; McCann et al, 1993) and can ultimately lead to accidents on the fireline.

Little research has been conducted on alertness levels, and none in the WLFF population. James and Vila (2015) found that fatigue levels in day shift versus night shift police officers affected cooperative outcomes instead of deadly force. Roma et al. (2012) found that as SAFTE model effectiveness (alertness scores) decreased, reaction times decreased, speed decreased, and lapses increased in flight attendants. Fox et al. (2015) found effectiveness/fatigue in emergency medical residence workers decreased as the week progressed with effectiveness scores of 70 (equivalent to blood alcohol content of 0.08%) by weeks end. To compensate, sleeping longer on weekends and non workdays has become common (National Sleep Foundation, 2002), however our WLFF population does not seem to fit this trend as their Off Fire sleep times only average 6.8 hours, well below the 7-9 hours recommended.

4.7 Conclusions

This research indicates that WLFF's sleep quality is increased when on a fire assignment and decreased while off a fire assignment. However, sleep quantity is decreased while On Fire and Boosting. Average sleep onset while on fire was 22:32 and 22:40 while off a fire assignment. Their average wake time of 05:09 while on a fire and 06:13 while off a fire assignment. Average sleep duration while on a fire is 6.1hrs while off a fire their average is 6.8hrs. SAFTE Alertness scores overall decline while on a fire assignment compared to off a fire assignment. Further data is needed to corroborate these findings in an effort to create interventions that will reduce the risk of accident or serious injury. Thus this pilot study is the beginning of a longitudinal research project designed to monitor sleep and fatigue in WLFF's.

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APPENDIX A: IRB OUTCOME LETTER

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To: Randy H. Brooks
Cc: Callie Collins
From: Jennifer Walker, IRB Coordinator
Approval Date: August 11, 2016
Title: Wildland Firefighter Safety and Health
Project: 16-048
Certified: Certified as exempt under category 2 at 45 CFR 46.101(b)(2).

On behalf of the Institutional Review Board at the University of Idaho, I am pleased to inform you that the protocol for the research project Wildland Firefighter Safety and Health has been certified as exempt under the category and reference number listed above.

This certification is valid only for the study protocol as it was submitted. Studies certified as Exempt are not subject to continuing review and this certification does not expire. However, if changes are made to the study protocol, you must submit the changes through VERAS for review before implementing the changes. Amendments may include but are not limited to, changes in study population, study personnel, study instruments, consent documents, recruitment materials, sites of research, etc. If you have any additional questions, please contact me through the VERAS messaging system by clicking the ‘Reply’ button.

As Principal Investigator, you are responsible for ensuring compliance with all applicable FERPA regulations, University of Idaho policies, state and federal regulations. Every effort should be made to ensure that the project is conducted in a manner consistent with the three fundamental principles identified in the Belmont Report: respect for persons; beneficence; and justice. The Principal Investigator is responsible for ensuring that all study personnel have completed the online human subjects training requirement.

You are required to timely notify the IRB if any unanticipated or adverse events occur during the study, if you experience and increased risk to the participants, or if you have participants withdraw or register complaints about the study.

APPENDIX B: PLAIN LANGUAGE AND CONSENT FORM

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PLAIN LANGUAGE STATEMENT AND CONSENT FORM

TO: Participant

Plain Language Statement

Date: 25 September 2017

Full Project Title: *Identifying Physiological and Nutritional Related Factors Affecting Wild Land Firefighters Health and Safety*

Principal Researchers: Dr. Randy Brooks, Dr. Ann Brown

Associate Researchers: Ms. Callie Collins, Ms. Samantha Worden

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Thank-you for expressing interest in this project. You are invited to participate in a study investigating sleep habits, changes in body composition, and hydration status across the fire season.

Purpose:

The aim of this study is to identify wildland firefighters' (WLFF) sleep quantity and quality, body composition and hydration status across a fire season. Additionally, we would like you to fill out a post-traumatic stress syndrome (PTSD) survey.

Methods:

Participation in this project will involve three separate physical components:

1) Wearing an activity monitor on your wrist (exactly like a wristwatch) for the period of May 15, 2018 through October 15, 2018, or until fire season is over. Activity monitors are small lightweight devices (weigh 17.5g, size 2.8x2.7x1.0 cm) that monitor human movement. This device will determine the quantity of your sleep and work during fire suppression.

Sleep data will be collected using Fatigue Science ReadiBands (Vandrico, Inc.). The ReadiBand is a wearable device worn on the wrist and designed to collect wrist movement data. From this data, Fatigue Science is able to calculate the quality and quantity of sleep during the night, as well as the activity levels during the day. This computing data can be converted into an objective fatigue level and then quantify the wearer's effectiveness score, reaction times and relative accident risk. The ReadiBands is roughly 93% accurate at determining when the user is asleep. From this information, the wearable device uses an algorithm that correlates sleep and fatigue.

This descriptive field study will recruit 40 WLFF who are employed with the USDA Forest Service. You will wear the Actigraph to provide information on time in bed, total sleep time, sleep efficiency and work activity. A greater understanding of firefighters' sleep behavior could eventually be used to inform agencies of the risks associated with work hours and sleep/wake patterns. We do not anticipate any additional risks to your normal working conditions by wearing this monitor.

2) Providing a urine specimen at various but convenient times (before going out to a fire and upon returning). Participants will be provided cups to urinate in and then samples will be disposed of on-site immediately after testing.

If feasible, each participant will be asked to provide a urine sample before and after a fire shift assignment. Each time a participant provides a sample, urine specific gravity (USG) will be measured using an ATAGO refractometer (Bellevue, WA). Fire season is typically at its peak during summer, which means WLFFs are exposed to extreme heat in the required impermeable protective clothing that increase sweat rates to a dangerous level. Dehydration is a risk facing WLFFs. A review of 10 studies on WLFF hydration levels showed that dehydration is a major risk to their health and safety.

3) Allowing researchers to assess and record body composition and weight pre and post fire season. Body composition reveals the relative proportions of fat and lean mass in the body. Fat mass consist of two types of fat: essential and nonessential fat. The second component of body composition, lean mass, refers to bones, tissues, organs and muscle. Essential fat is the minimal amount of fat necessary for normal physiological function.

Body composition will be taken using a three-site skinfold measures using a Lange skinfold caliper (Lange, Beta Technology Inc., Cambridge, MD) will be used to assess percentage body fat using the Siri equation (1956). Standardized protocols using Jackson and Pollock (1985) site identification will be used for both males and females. All measurements will be taken on the right side of the body in a rotational manner, and repeated until duplicate measures within 2 mm are obtained. This should take approximately 3 minutes per participant. Participant's weight will be measured each time body composition is assessed. Body composition will also be measured using DXA on volunteers willing to come to the UI campus in Moscow. Participants will be asked to change into clothing that is free of metal and/or hard plastic (buttons, zippers, snaps, etc.) and asked to remove all metal from the body (jewelry, eyeglasses, hair accessories, etc.). Body composition will be measured noninvasively via the use of the Hologic DXA Scanner (Hologic Horizon™), with one scan; anteroposterior (AP) view of the total body lying supine. Very low doses of radiation are used; however, this test is non-invasive. Testing will be completed according to the manufacturer's instructions and specifications by a certified X-ray technician. Hands and feet will be secured in place to avoid unwanted movements during the body scan. The scan will take approximately 10 minutes to complete. Prior to the scan, female participants will sign a DXA consent form to ensure that there is no chance of pregnancy. This involves low exposure to radiation less than 5 mREMs per DXA scan. Doses received from DXA examinations are small in comparison to other common radiation sources and are believed to represent no significant health risk. No risk of adverse health conditions have been established for lower exposures of 5000 mREM or less. By comparison, natural background radiation is about 300 mREM/year, an x-ray of the spine is 70 mREM, a mammogram is 45 mREM, and a round trip transcontinental plane flight is 6 mREM. A research team member will be present at all times during test procedures.

4) PTSD survey. The PTSD survey is a standardized self-report rating scale for PTSD comprising 17 items that correspond to the key symptoms of PTSD is applied generally to any traumatic event. The PCL is self-administered and respondents indicate how much they have been bothered by a symptom over the past month using a 5-point (1–5) scale, circling their responses. Responses range from **1** *Not at All* – **5** *Extremely* The PCL is self-administered. Respondents indicate how much they have been bothered by a symptom over the past month using a 5-point (1–5) scale, circling their responses. Responses range from **1** *Not at All* – **5** *Extremely.*

Post-traumatic stress disorder (PTSD) is an anxiety disorder that some people may develop after seeing or living through an event that caused or threatened serious harm or death. According to the 2005 National Comorbidity Survey-Replication study, PTSD affects about 7.7 million American adults in a given year, though the disorder can develop at any age, including childhood. Symptoms include strong and unwanted memories of the event, bad dreams, emotional numbness, intense guilt or worry, angry outbursts, feeling “on edge,” and avoiding thoughts and situations that are reminders of the trauma.

Risks and benefits:

By assessing the sleeping behavior, hydration levels, and body composition of WLFF a greater understanding of firefighter fatigue and work demands can be assessed. This will assist those who plan deployments to more accurately define the capabilities of firefighters on the fireline. By understanding this behavior fire agencies may be able to regulate (whenever possible) the management of their crews to preserve their health, safety and productivity on the fireline and providing ongoing protection for the nation against the annual threat of wildfires. The results of this work will eventually help to inform policy makers on sleep hours and considerations, work demands and their impact on body composition as well as hydration status for optimal performance, health, and safety.

Expected benefits to wider community:

Research dedicated to understanding the impact that firefighters' working environment, and sleep conditions is fundamental if fire agencies are going to implement policies to preserve the health and safety of their crew. The proposed research will provide insight from which firefighting agencies can make informed decisions about management of risk associated with firefighters' work hours, workload and working conditions.

Privacy and confidentiality:

Your privacy and confidentiality will be preserved through a number of measures. Participant's interest and participation in the research will not be anonymous, and it will probably not even be completely confidential given the activity monitors will be noticeable. Firstly, your interest and participation in, or withdrawal from will be largely anonymous. As you will be wearing an activity monitor others will know your identity. We ask, however, that all participants do not disclose the identity of any other participant without that individual's explicit consent. Secondly, your results and identity will be stored separately, such that the researchers will only refer to your data by your unique identifier code. Your data will be stored securely for a period of six years after the final publication of results, as per University guidelines. Thirdly, should you choose to withdraw from the research, after receipt of your revocation of consent form (attached), your data and personal records will be destroyed immediately should you specifically demand it. If not specified the data will be retained without analysis for a period of five years to ensure data integrity. Fourthly, your fire agency will have no record of your decision to participate in, or withdraw from the proposed research.

Dissemination of the research results:

The results from the proposed research will be presented in either a) oral presentation to fire agencies or scientific audiences, and/or b) written, peer-reviewed scientific journal articles. To protect participant's identities, in each case, only mean results will be reported and, as such, no individual results, identities, or locations will be revealed.

Ethical considerations:

Should you wish to no longer participate in the study during any stage, your decision will in no way negatively affect your relationship with researchers at the University of Idaho. Furthermore, your agency will have no knowledge of your individual results.

Should you decide to withdraw from the research project during data collection, your personal information and any research data collected to that point will be removed from any data that is analyzed and reported. This data will be retained for the specified period of time unless you specify that the data is to be destroyed immediately. If data aggregation and analysis has commenced you can no longer withdraw from the study. Your decision to withdraw from the study will in no way affect your position within your organization as either a staff member, incumbent, volunteer or contractor as all the information collected will be non-identifiable.

Research monitoring:

All research will be monitored by principal investigators Dr. Randy Brooks, and graduate students Ms. Callie Collins, and Ms. Samantha Worden.

Sources of research funding: N/A.

Should you have any questions, please contact:

Dr. Randy Brooks	Dr. Ann Brown	Callie Collins	Samantha Worden
University of Idaho	University of Idaho	University of Idaho	University of Idaho
875 Perimeter Dr.	875 Perimeter Dr.	875 Perimeter Dr.	875 Perimeter Dr.
MS 1132	MS 2410	MS 1132	MS 1132
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rbrooks@uidaho.edu	afbrown@uidaho.edu	coll6852@vandals.uidaho.edu	word9534@vandals.uidaho.edu

Complaints:

If you have any complaints about any aspect of the project, the way it is being conducted or any questions about your rights as a research participant, then you may contact:

Office of Research Assurances, University of Idaho, 875 Perimeter Dr. MS 3010, Moscow, ID 83844-3010, Telephone: 208-885-6162; IRB@uidaho.edu . This study has been reviewed and approved but the University of Idaho Institutional Review Board. IRB Number 17-131

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PLAIN LANGUAGE STATEMENT AND CONSENT FORM

TO: Participants

Consent Form

Date: 15 May 2018

Full Project Title: *Identifying Physiological and Nutritional Related Factors Affecting Wild Land Firefighters Health and Safety*

Principal Researchers: Dr. Randy Brooks, Dr. Ann Brown

Associate Researchers: Ms. Callie Collins, Ms. Samantha Worden

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I have read and I understand the attached Plain Language Statement.

I freely agree to participate in this project according to the conditions in the Plain Language Statement.

I have been given a copy of the Plain Language Statement and Consent Form to keep.

The researcher has agreed not to reveal my identity and personal details, including where information about this project is published, or presented in any public form.

Participant’s Name (printed) ……………………………………………………….

Signature ………………………………………Date …………………………

Should you wish to return your consent form (and have lost your reply-paid envelope), please send the forms to:

Randy Brooks
University of Idaho
College of Natural Resources
875 Perimeter Dr. MS 1132
Moscow, ID 83844-1132
208-885-6356

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PLAIN LANGUAGE STATEMENT AND CONSENT FORM

TO: Participants

Revocation of Consent Form

(To be used for participants who wish to withdraw from the project)

Date: 15 May 2018

Full Project Title: *Identifying Physiological and Nutritional Related Factors Affecting Wild Land Firefighters Health and Safety*

Principal Researchers: Dr. Randy Brooks, Dr. Ann Brown

Associate Researchers: Ms. Callie Collins, Ms. Samantha Worden

---

I hereby wish to WITHDRAW my consent to participate in the above research project and understand that such withdrawal WILL NOT jeopardize my relationship with University of Idaho or my fire agency.

Participant's Name (printed) …………………………………………………….

Signature …………………………………………Date…………………………

Please email or mail this form to:

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University of Idaho
College of Natural Resources
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Moscow, ID 83844-1132
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APPENDIX C: SURVEY

What is your job title?

____

1. Rate (common/uncommon) how much the following factors contribute to accidents during fire operations: *Please Circle (1= not at all common, 5=very common)*

1= Not at all common 2= Uncommon 3= neither common or uncommon 4= Common 5= Very common

FACTORS	1	2	3	4	5
Inadequate sleep due to long shifts or travel time	1	2	3	4	5
Pressure from others to protect structures or other resources at all costs (perceived or actual)	1	2	3	4	5
Inadequate sleep due to other factors (sickness, noise, etc)	1	2	3	4	5
Reduced awareness due to smoke	1	2	3	4	5
Distraction due to issues in family or personal life (e.g., marital/financial stress)	1	2	3	4	5
Reduced awareness due to weather conditions (e.g., rain, snow, heat)	1	2	3	4	5
Physical fatigue/tiredness due to manual labor	1	2	3	4	5
Inadequate fitness level	1	2	3	4	5

Inadequate job skill level or experience	1	2	3	4	5
Inadequate safety training or safety meetings	1	2	3	4	5
Reduced alertness due to alcohol or other substance use	1	2	3	4	5
Distraction due to hunger	1	2	3	4	5
Tunnel Vision	1	2	3	4	5
Distraction due to disagreement with co-workers or supervisor	1	2	3	4	5
High stress after 10-12 days on fire	1	2	3	4	5
Peer pressure from others to perform	1	2	3	4	5
Mental fatigue- long fire season	1	2	3	4	5
Distraction due to thirst	1	2	3	4	**5**

2. How often do you wear all PPE (goggles, hardhat, ear protection, gloves etc.) on fire assignment?

   Always○ Often○ Rarely○ Never○

3. How often do you monitor the amount of food eaten while on fire assignment?

   Always ○ Often○ Rarely○ Never○

4. How often do you drink alcohol at while on fire assignment?

   Multiple times a day○ Daily○ Weekly○ Never○

5. How common or uncommon are the following accident situations during fire operations? *Circle the appropriate number (1 = not at all common, 5 = very common).*

1= Not at all common 2= Uncommon 3= neither common or uncommon 4= Common 5= Very common

ACCIDENT SITUATION	1	2	3	4	5
Injury while working on/around heavy equipment or vehicles	1	2	3	4	5
Slips, trips, or falls	1	2	3	4	5
Communication failures, miscommunication or none at all	1	2	3	4	5
Being hit/pinned by branch, snag or live tree domino effect	1	2	3	4	5
Injury related to chainsaw or other hand tools/equipment	1	2	3	4	5
Accident related to “horse play” or “goofing off”	1	2	3	4	5

6. Are there common accident situations on fire operations that we did not ask you about in questions 1- 5? If so, please list them here:

7. When on a fire assignment, how much water (or Powerade/ Gatorade etc.) do you typically drink a day? (1 Nalgene bottle holds 32oz) __________ oz
8. How many hours of sleep do you get in a 24hr period during fire season ______ hours
9. While on an active fire assignment specifically how many hours of sleep do you get a night _____ hours

10. Approximately how many seasons have you worked in firefighting?

___________seasons?

11. What is your age? ______________ years old

12. What is highest degree or level of education you have completed?

o Some high school (no degree) or less
o High school diploma or GED
o Some college (no degree)
o Technical or Associate's degree
o Bachelor's degree
o Graduate or professional degree (e.g., MS, MA, PhD, MD, JD)

13. What is the zip code of where you grew up? ___________________________

14. Thank you for your time! Do you have any additional comments about any of the above topics or the survey itself?