THE ROLE OF FIREFIGHTER HEALTH AS PREDICTORS OF WORK LIMITATIONS IN FIRE SERVICE

By

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ABSTRACT

Background: Firefighters (FFs) are exposed to life-threatening conditions while carrying out their tasks. These strenuous conditions predispose them to a high rate of disability, morbidity and mortality. These hazardous conditions put them at risk for work limitations, but the literature is scarce in this matter.

Objective: The overarching objective of this thesis is to determine the role of FFs health as predictors of work limitations in fire service. Specifically, the first objective is to determine whether work limitations differ among FFs based on the location or number of painful sites. The secondary objective is to determine whether non-musculoskeletal comorbid health condition predict work limitations among FFs.

Participants: A convenience sample of FFs between the age of 18-60 years working in the province of Ontario, Canada.

Methods: Participants completed either an online or paper-based survey including a work limitation questionnaire(WLQ-26) and a self-reported comorbidity questionnaire. For the first objective, a one-way ANOVA and post hoc test was used to determine the differences in work limitations among FFs based on the number or location of painful sites. For the secondary objective, a univariate linear regression was used to evaluate whether non-MSK comorbid health condition predict work limitations among FFs.

Results: FFs with three or more painful sites had more physical limitations than FFs without pain, (Mean difference=1.03/10; 95% CI: 0.16-1.62; p=0.02). FFs with pain at the region of the spine experienced more physical limitations compared to FFs with no pain (Mean difference=0.89/10; 95% CI: 0.17-1.62; p=0.007). For the secondary objective, univariate analysis showed that having at least one comorbidity(p=0.04) had a small, but significant

association with greater mental work limitations ($F_{2,316}$=2.94; p=0.05; R^2=0.02). Separate univariate analysis showed that women FFs having one comorbidity had a small but significant association with physical (R^2=0.07; $F_{2,97}$=3.92, p=0.02) and mental work limitations (R^2=0.04; $F_{2,101}$=1.89, p=0.15) than women without non-MSK comorbidity.

Conclusion: Having multiple painful sites or pain at the spinal region influenced work limitations among FFs. Also, non-MSK comorbidity impacted mental limitations among FFs; especially among women FFs. Therefore, managing MSK and on-MSK comorbidities is a necessary health care goal to prevent work limitations.

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CONTRIBUTIONS/CO-AUTHORSHIP STATEMENT

Temitope Osifeso and Dr. Joy C. MacDermid were responsible for developing the research questions. Temitope was responsible for the analysis and interpretation of data as well as the drafting of the manuscripts and incorporating feedback. Dr. Joy C. MacDermid was responsible for reviewing and refining of the research questions. Dr. Joy MacDermid also assisted in data interpretation and provided editorial assistance with manuscript preparation. Dr. Luciana Macedo provided feedback, helped with the interpretation of data and helped reviewed the manuscripts. Dr. Kathryn E. Sinden provided feedbacks and helped reviewed manuscripts.

PREFACE

The basis of this research stemmed from my background as physiotherapist with over four years of experience and interest in occupational health and safety. Specifically, my focus has been on how musculoskeletal disorders affect work performance of employees in various occupations. Therefore, during my MSc in the school of rehabilitation science, I decided to join the FIREWELL team to examine the limitations experienced by FFs with work-related disorders or comorbidities while carrying out their various tasks. Firefighting is a high risk and strenuous occupation due to the unique set of stressors involved in the job including fire suppression, overhaul, rooftop rescues and the use of heavy tools in unpredictable environment. Therefore, prioritizing the health and wellbeing of FFs cannot be overstated as they are more predisposed to disorders in the line of duty than the general population.

OUTLINE OF THESIS

The overarching objective of this thesis is to determine the role of firefighters' health, as predictors of work limitations in the fire service. The thesis is organized in a manuscript format. A brief introduction of the uniqueness of firefighters in relation to their occupational health concerns is presented. Details of these health concerns is then examined in a literature review in chapter one. Chapter two is the first study, a manuscript describing the role of the location or number of painful sites as predictors of work limitation among FFs. Chapter three is study two, a manuscript on non-musculoskeletal comorbid health conditions as predictors of work limitation among firefighters(FFs). Chapter four provided summaries, integrating the findings of each of the studies as well as linking these findings to the overall objective of the thesis work.

The purpose of the literature review is to provide an overview on the key health issues related to firefighting, based on the available empirical evidence. The key issues include: firefighting as a unique work context, prevalence and burden of musculoskeletal disorders among FFs, prevalence and burden of pain among FFs', risk factors of pain, ageing, gender and, common non-MSK comorbidities among FFs and other health problems. The introduction also examined obesity, physical fitness and lifestyle habits such as substance abuse in fire service including smoking and alcohol abuse. Lastly, issues in measurement of health and work limitations among FFs was examined. In this section, empirical evidence relating to each of the key issues were stated and the gaps in the literature that supports the rationale for conducting this study was discussed.

Chapter One: Introduction

1.1 Firefighting as a unique work context

Firefighters (FFs) are public employees required to perform dangerous and strenuous tasks including fire suppression, victim rescue, and handling heavy apparatus during emergencies (1). These strenuous tasks predisposes them to a wide range of hazards including extreme heat, trauma, noise and toxic gas exposures (2). Occupational hazards during firefighting tasks negatively impact the health and well-being of FFs(2). These hazards are contributory factors to health related comorbidities including musculoskeletal disorders(3), pain(4), cardiovascular diseases(5), cancer(6) and mental health challenges(7). Cardiovascular disease(CVD) is the leading cause of morbidity and mortality among FFs (8). Moreover, the relationship between firefighting tasks and CVD due to certain physiological changes in the body have been well established in the literature(9). Recently there has been a growing concern on the rate of post-traumatic stress disorder(PTSD) among FFs, with a prevalence of 22% among American FFs, 17% among Canadian and 18% among German FFs (7). Moreover, FFs who experienced PTSD have been reported to have a high risk of occupational health disorders particularly low back pain(7).

Musculoskeletal disorders among FFs including sprains, strains and musculoskeletal pain accounts for an estimated 50% of injuries during fire and non-fire ground operations(10). Evidence suggest that FFs are at higher risk of occupational disorders than the general population (1) and the leading cause of these disorders are slips trips and falls(10). For instance in the USA alone, the National Fire Protection Association (NFPA) reported a prevalence of about 7 occupational disorders per 100 FFs in 2010 (11). Obesity(12), inadequate fitness level(13), and unhealthy lifestyle choices such as heavy alcohol consumption(14) and smoking of tobacco(15) is another major epidemic in fire service. Studies have stressed how unhealthy lifestyle choices among FFs are risk factors for various comorbidities (13-15). For instance, FFs with higher BMI are less

tolerant to heat stress and more predisposed to a CVD related event in the line of duty(16). In addition inadequate fitness among FFs increases the likelihood of musculoskeletal disorders and absenteeism at work(12). Overall, these occupational health concerns and the high risk/ demands of firefighting stresses the uniqueness of their job.

1.2 Literature review

1.2.1 Musculoskeletal disorders and its prevalence

Musculoskeletal (MSK) disorders are one of the most common form of workplace complaints in the general working population(11). MSK involves injury to muscles, tendons, bones, cartilage, ligaments and nerves of the body (17). About four and a half million Canadians in the province of Ontario sustain MSK disorders annually with about 11.4% being attributed to work related activities (3). These injuries affect various body regions including the back, neck, upper and lower extremities(18). In Canada, back injuries are the most reported(27%), followed by the upper (22%), and lower extremities (10%) (18). According to WHO, an annual rate of about 120 million work related disorders and about 200,000 fatalities occur worldwide. Also, about 157 million new cases of work-related diseases may be linked to hazardous exposures in the workplace (18).

FFs are faced with approximately three times more risk of MSK disorders than the average working population (19). This may be attributed to the strenuous physical, mental and emotional demands of the job(3). The most commonly reported type of MSK disorder among FFs are overexertion injuries including strain and sprain which constitutes more than 45% of injuries, consistently followed by bruises, lacerations (19%) and fractures (8%) (3). In trying to save lives and protect properties, FFs are at an unusually high risk of MSK disorders due to the recurrent exposure to harsh and unfavorable environmental factors (asbestos, radioactive material, gases and

chemicals) (3). Likewise, tasks associated with firefighting including bending, moving or carrying heavy objects while in their personal protective equipment (PPE) predisposes them to higher work-related disorders (3). In 2016, the NFPA reported that more than 38% of injuries occurred during fire ground operations, 13% during training activities and 21% during non-fire emergency incidents (20). Up to 38% of these firefighter injuries resulted in absenteeism(20).

The Ontario Workplace Safety and Insurance Board (WSIB) reported that FFs had the second highest rate of lost work time claims in the province of Ontario in 2015 due to work-related musculoskeletal disorders (3). This suggests that the impact of work-related MSK disorders among FFs is more distressing and costly than in other working populations (3). In terms of the cost to address and prevent firefighter MSK disorders the overall average compensation is between $2.7 to 7.8 billion dollars annually, hence MSK disorders are a significant burden in fire service (21).

1.2.2 Pain at work

Pain is a global health challenge affecting the general population, regardless of gender, occupation, social status, age, and/or ethnicity (22). It is defined by the international association for the study of pain (IASP) as ‘an unpleasant sensory and emotional experience associated with actual or potential tissue damage…’ (23). It plays a significant role in protecting our body from trauma, by serving as a warning signal to prevent further tissue damage. It is the most reported health complaint among the general population (22, 23) with an estimated 20% of individual suffering from pain worldwide(22).

Pain can either be acute, chronic or intermittent or a combination of all three. Acute pain is usually described as an initial psychological response to an adverse physical, biological or mechanical stimulus triggered by tissue injury(24). Healing of acute pain usually occurs with or

without medical intervention (23). Chronic pain on the other hand, refers to the persistence of an injury after healing, for more than six months (23). Medical management of chronic pain provides a brief relief of pain but often does not resolve the underlying cause, because of other environmental, occupational or affective factors contributing to the already damaged tissue(23).

In Canada, the cost of chronic pain has been estimated to be about six billion dollars annually (4). Likewise, chronic pain is one of the most prevalent health related problems among the general public with an estimated one in four persons reporting chronic pain regularly (4). Overall, pain might worsen personal, emotional and/or societal burdens resulting in disability, absenteeism, at-work limitations and even early retirement (22).

1.2.3 Prevalence and burden of pain in FFs

Occupational disorders negatively impact the health and well-being of FFs including causing persistent pain; particularly chronic pain in various areas of the body, such as the low back, upper and lower extremities, and neck regions(4,7). The relatively high prevalence of chronic pain among first responders including FFs may be attributed to the physical, mental and emotional demands of firefighting (4). Pain can adversely affect a person's quality of life, occupation, and disrupt social relationships if not properly managed(25). Therefore, the at-work impact of pain among FFs might be traumatic because of the team work involved in firefighting (25). Pain might also reduce or limit the capability to cope with the high demands of firefighting (25). Canadian FFs suffer more than 35% of chronic pain secondary to work related disorders: 20% of the chronic pain reported, is attributed to low back or spinal pain (4). Low back pain typically occurs due to trauma, overexertion or repetitive injuries which is a commonly performed activity among FFs(3). Therefore, the occupational commitments or responsibilities of FFs influences their physical, emotional and psychological well-being.

1.2.4 Risk factors of chronic pain in FFs

According to the World Health Organization, occupational disorders including pain are caused by a number of factors such as: physical, psychological, and environmental factors(26). At the level of an individual, these factors influence the state of health and well-being of FFs within the workplace(4). There is a mounting concern for the association between psychological factors and chronic pain among FFs(26). The psychological factors describe the role of the 'state of mind' of an individual including frustration, depression, stress etc. and its impacts on health(26). These factors describes how peoples' beliefs, perceptions and attitudes can either improve or worsen a symptom such as pain (27). A recent study showed that about 40% of first responders may be experiencing chronic pain attributed to mental disorders in the line of duty(4). Likewise other studies have also emphasized the link between intense psychological stress and chronic pain among FFs(4,7). The dynamics involved in firefighting are determinants of long-term symptoms or chronic conditions such as pain in this population(25).

Lastly, working in hazardous environments is a risk factor for occupational disorders including pain among FFs (7). This factor encompasses the workplace setting and how it 'fits' or affects the individual (26). FFs are expected to perform their job in their PPE which imposes a considerable physiological burden in the line of duty due to the weight and restrictions (7,28). Also, FFs work in dangerous environments that include extreme temperatures, toxic gases, loud noise and low visibility(28). This predisposes them to imminent danger daily (4,25). For instance, evidence revealed that each year, more than 50% of FFs experiences muscular pain, slips, trips and falls mainly attributed to hazardous working environment (11).

1.2.5 Ageing and firefighting

The high level of occupational health risk faced by FFs raises questions about aging and health and safety concerns (29). In the literature, older age has been linked to a higher likelihood of having chronic diseases especially among the general population (29). Plat et al.,(30) suggested that FFs who were older reported more chronic conditions as opposed to younger FFs(30). Moreover, ageing is commonly associated with several unfavorable health conditions including, cardiovascular diseases(16), obesity(31), chronic pain(32) and musculoskeletal disorders(33). In addition, a scoping review by Graveling et al., (34) showed that older FFs took a longer time to perform firefighting tasks than younger FFs.

Cloutier and colleague (33) also examined the correlation between aging and the incidence of MSK injuries among Quebec FFs. Surprisingly, their result showed a reduced risk of injuries among older FFs when compared to middle aged or younger FFs. They explained that this findings could be because most of the older FFs were exempted from highly demanding tasks such as fire suppression and rooftop rescues(33). In parallel, another study further explained that the reduced incidence of injuries among older FFs could be because, older FFs have mastered the process of navigating the fire scenes, thereby using their built experience to take precautions during operations (19).

Likewise, age is usually put into perspective during task distribution which helps reduce the frequency of injuries among older FFs(33). However, there are still various task-related limitations with increasing age among FFs when there is no flexibility or control on the distribution of tasks(33). In addition, older FFs are suggested to experience longer injury duration (35) and chronic pain symptoms(4) than younger FFs. Hence, they require more time to recuperate from injuries as opposed to younger FFs(35). Longer time to recuperate from injuries may be related to

the decline in most physiological functions in the body(35). Physiological vulnerabilities, such as older age may enhance chronic pain symptoms particularly when exposed to certain critical environmental conditions or emergency situations(4).

1.2.6 Gender and firefighting

Despite reports from national fire service organizations including the International Association of Fire Fighters (IAFF) and International Association of Fire Chiefs (IAFC)(36), promoting gender diversity among FFs, women FFs still occupy the minority group in fire service(36). Women FFs represent about 3.7% of FFs in fire service(19) which may be attributed to a mixture of limited recruitment and poor retainment of women FFs in the fire service (36). It could also involve the mental, emotional and physical demands of the job, workplace harassment, and a general culture that disapproves of women in firefighting (36).

Gender has generally been considered as a risk factor associated with the expression of certain biomechanical demands, injury rates and chronic pain symptoms in first responders (25). The job of firefighting imposes some biomechanical demands especially those associated with the manual handling of equipment, stair climbing and rescue operations(34). Evidence suggests that female FFs may not possess the needed muscular strength to adequately perform these biomechanical demands when compared to their male peers(34). The literature also suggest that women FFs possess a lower cardiovascular endurance and muscular strength than their men counterpart(37). A study by Misner et al.(38), showed that men FFs performed better than their female peers in all simulated firefighting tasks including stair climbing, hose drag and victim rescue.

Relatively little attention has been paid to the well-being of women FFs with evidence suggesting that more than 50% of women FFs possess ill-fitting apparatus exposing them to high

concentrations of toxic chemicals in the line of duty(36). Also, recent concerns have been on the reproductive health dangers of women FFs with evidence suggesting the negative impact of exposures to various hazards in firefighting(36). However, evidence on the reproductive health of women in firefighting is scarce(36). Further investigation is needed to better understand the health concerns of women FFs to help improve and sustain the well-being of current and future women FFs.

1.3 Overview of non-MSK comorbidities among firefighters

The occupational risks faced by FFs, predisposes or amplifies certain chronic health conditions (32). For instance, about 27,250 exposures to harmful conditions and 8,350 exposures to infectious diseases were reported among FFs in 2015 (10). FFs' exposure to hazardous constituents in fire smoke is also a probable risk factor for cancer(6). These hazards are due to contact with various carcinogenic compounds or combustible materials in the line of duty (2). The health impact of toxic chemical exposures, physical and mental hazards of firefighting has been studied extensively in the literature(2,6,39). Various studies have stressed the prevalence of comorbid conditions in fire service including cardiovascular diseases(16), chronic respiratory problems(2), depression(40), and smoke inhalation(10).

1.3.1 Post-traumatic stress disorder (PTSD)

PTSD is a mental health challenge that is triggered by traumatic events such as disasters, assault or accident (41). It affects various populations, and most individuals that experience this symptom recover in a few months while for others, it might take several years to resolve (41). Firefighting is a traumatic and life-threating occupation(25) that involves a series of critical traumatic events, elevating the risk of PTSD (40). Psychological distress, specifically depression, has been linked to the experience and expression of pain among first responders(25).

PTSD is usually accompanied by other disorders that negatively impact the life of an individual including increased rate of suicide, anxiety disorder and poor quality of life, if not properly addressed(40). Although FFs are trained to accommodate major traumatic incidents without feelings of emotion, suffering or pain (42). Failure to acknowledge these stressors might negatively impact the mental wellbeing of FFs and their family members. Therefore, to maintain a good level of job performance, it is necessary that FFs are able to manage and balance the physical, mental and emotional stressors of their work effectively (43).

1.3.2 Cancer

Various studies have emphasized the probable association between cancer and the risk of firefighting when compared to the general public (6,44). FFs are regularly exposed to a wide range of hazardous carcinogenic compounds in their line of duty (44). Exposure to these carcinogenic compounds from fire smoke including, benzene, formaldehyde, asbestos, lead, trichloroethylene and methylene poses a great threat to the well-being of FFs (6). A meta-analysis by LeMasters et al.,(6) revealed that fire suppression tasks increase the likelihood of multiple myeloma, non-Hodgkin lymphoma, prostate, and testicular cancer among FFs. Therefore, the development of more innovative protective clothing and reinforcement of the use of masks to reduce exposure to certain toxic compounds in the line of duty cannot be over-emphasized (6).

1.3.3 Cardiovascular diseases

Cardiovascular disease (CVD) is the leading cause of morbidity and mortality among FFs in the line of duty when compared to the general population (16). Evidence suggest that about 45% of line of duty deaths (LODD) may be linked to CVD (9). CVD events are most frequent during certain periods of the day, year and during emergency fire ground operations (9). About 67% to 77% of CVD mortality among FFs occur between noon and midnight which is in parallel to most

emergency operations (9). Performance of highly demanding physical and mental tasks including, responding to fire alarms(2), rooftop rescues and fire suppression with little time for rest during shifts are risk factors for CVD related events (16). Studies have consistently emphasized that FFs are more likely to die from CVD related events during fire ground operations than any other condition.(14,36,42,45).

1.3.4 Other health problems among FFs

Recurrent smoke or dust inhalation during fire suppression in hazardous environments can pose health related challenges including lung problems (bronchitis or lung inflammation)(2). The inhaled hot vapor can cause serious burns to the lower airway(2). Likewise, during firefighting toxic gases including hydrogen cyanide or phosgene released may cause damage to the respiratory tract or irregular lung functions(2). The physical demands associated with firefighting are increased due to their heavy personal protective equipment (PPE) and exposure to extreme temperatures leading to heat stress in the line of duty(29). The high demands associated with the job of firefighting and the heavy insulated protective clothing might also exacerbate the extreme conditions (2).

Recently there has been a rise in the prevalence and awareness of a serious health condition among FFs known as exertional rhabdomyolysis (46). Exertional rhabdomyolysis is defined as the breakdown of muscle tissue due to mechanical or metabolic trauma that leads to the release of proteins and electrolytes including calcium, potassium, organic acids, proteases, etc. into the blood stream(47). Rhabdomyolysis is characterized by muscular pain, inflammation, and weakness following over exertion, with or without extreme temperature(47). Therefore, it is important that firefighters are educated on the risk factors, signs and symptoms of exertional rhabdomyolysis,

because exertional rhabdomyolysis may become severe or lead to death of FFs if not treated or diagnosed early(46).

1.3.5 Obesity and firefighting

Obesity among FFs is a cause for concern because it negatively impacts the safety of FFs and the citizens they protect (16). Obesity is a significant risk factor for work-related disability(13,31) and obesity-related comorbidities(31). The prevalence of higher BMI is still at an unusually high rate (ranging from about 73% to 88%) in fire service (31,48). Also, FFs with class I, II and III obesities have been connected to having greater risk of cardiovascular co-morbidities and mortalities as opposed to FFs with normal weight(12). Evidence suggests that waist circumference is a better predictor of obesity among FFs than BMI despite both being highly correlated (34). A scoping review by Graveling et al., (36) showed that older FFs had higher waist circumference and BMI than younger FFs. A recent study revealed that FFs with higher BMI were reported to have missed about 2.7-5.0 more work times than those within the standard BMI range (48). This affected their productivity at work, putting them at increased risk of work-related injuries(48). In addition, higher BMI has been found to be associated with low fitness levels in FFs (13). Therefore, low fitness level, obesity and being overweight are priority health issues in fire service(31) that needs urgent attention.

1.4 Physical fitness and firefighting

Inadequate fitness levels may decrease work-related performance and increase the risk of at-work injury and/or pain among FFs (49). They are also exposed to other behavioral health challenges such as: engaging in binge eating, having low fitness, smoking and frequently being obese or overweight (48). These behavioral health challenges are major health concerns in this population because they are risk factors to chronic health conditions including cardiovascular

diseases, high blood pressure, type 2 diabetes and hypertension (50). Despite the established health risks, a gap still exists as FFs continually struggle with keeping fit regardless of recommendations in implementing fitness and wellness programs in fire service (12,43).

1.5 Life style habits and firefighting

1.5.1 Smoking among FFs

Tobacco smoking is a major preventable cause of morbidity and mortality among FFs (51). However, despite restrictions in the fire service, the use of smokeless tobacco (SLT) is still at an usually high rate (51). This may be attributed to the precautionary measures put in place in fire service and the belief that SLT reduces morbidity and mortality when compared to cigarette smoking (51). In addition, studies have shown tobacco smoking as a strong risk-factor for cardiovascular related events and cancer among FFs (9,51). Also, evidence suggest that FFs that are tobacco smokers were six times more likely to be diagnosed with anxiety disorders and about four times more likely to drive while intoxicated (15). Therefore, given the significant role of FFs and the need for their health and safety in carrying out their duties, it is vital to better understand the factors influencing the high rates of tobacco smoking to examine the necessary prevention and treatment programs in fire service organizations.

1.5.2 Alcohol consumption among FFs

Heavy alcohol intake is a major behavioral health challenge in fire service (43), with a significant amount of FFs at risk of alcohol-related problems(14). Generally, evidence suggests that heavy alcohol intake has been associated with chronic health conditions including cardiovascular diseases, chronic respiratory problems and liver problems (14). Given the important role played by FFs, heavy alcohol intake and binge drinking may negatively influence the job of firefighting (14), resulting in reduced productivity, disability and lost time at work (31). In the face

of significant penalties for intoxication in fire service(43), studies still show a high percentage of FFs who engage in binge drinking(14,31). For instance, Haddock and colleagues reported that 56% of male FFs in the US reported binge drinking while 9% reported driving while intoxicated. Therefore, if not adequately addressed, engaging in binge drinking whether on or off duty might result in chronic health conditions(14) and increased cost burden(43).

1.6 Issues in measurement of health and work limitation among FFs

Firefighting is a highly demanding occupation that requires individuals to be physically, mentally and emotionally fit with great levels of muscular strength and stamina(37). Despite recommendations and evidence emphasizing the importance of fitness and work performance(37,43,52). FFs still struggle daily with hazards that limit or restrict their job performance(28). Work limitation is defined as the gap between performance and demands of a job due to various factors(53). Standardized measures of work limitation can be utilized in the fire service to help FFs requiring health-related accommodations within the fire service(53). These measures can also be utilized for research, practice and policy purposes to improve performance of FFs. In the literature, there have been various performance based measures utilized in fire service for different purposes including training, medical evaluation and research(54). However there seems to be a dearth of subjective self-reported measures of work limitation specifically designed for FFs.

Although self-reports are subjective, they are more feasible and can assess a wider range of limitations that is beyond physical attributes e.g. mental and interpersonal limitations at work. Generic measures such as the work limitation questionnaire (WLQ-26) have been utilized in FFs and found to have some draw backs. Firstly, it has been shown to be unable to detect work limitations among FFs, which is more likely due to the very high demand tasks not adequately

represented in a generic WLQ-26 (53). Secondly, a study by McDermid et al.,(53) showed a ceiling effect of the WLQ-26 due to the lack of association between the self-report measures and the performance-based measures during simulated firefighting tasks. Therefore, the development of a firefighter specific WLQ is needed to identify limitations and manage the risks involved in firefighting.

1.7 References

1. Kim M, Kim K-S, Ryoo J-H, Yoo S-W, Isacsson A, Orbaek P, et al. Relationship between Occupational Stress and Work-related Musculoskeletal Disorders in Korean Male Firefighters. Ann Occup Environ Med [Internet]. 2013 [cited 2017 May 14];25(1):9. Available from: http://aoemj.biomedcentral.com/articles/10.1186/2052-4374-25-9

2. Guidotti TL, Clough VM. Occupational Health Concerns of Firefighting. Annu Rev Public Health [Internet]. 1992 [cited 2018 Apr 19];13(1):151–71. Available from: https://www.annualreviews.org/doi/pdf/10.1146/annurev.pu.13.050192.001055

3. Negm A, Macdermid J, Sinden K, D 'amico R, Lomotan M, Macintyre NJ. Prevalence and distribution of musculoskeletal disorders in firefighters are influenced by age and length of service. J Mil Veteran Fam Heal [Internet]. 2017 [cited 2018 Jan 9];3(2):33–41. Available from: http://jmvfh.utpjournals.press/doi/pdf/10.3138/jmvfh.2017-0002

4. Carleton, Afifi, Turner, Taillieu, El-Gabalawy S& A. Chronic pain among public safety personnel in Canada. Can J pain [Internet]. 2017 [cited 2018 Mar 23];1(1):237–46. Available from: http://www.tandfonline.com/action/journalInformation?journalCode=ucjp20

5. Slater M, Perruccio A V, Badley EM. Musculoskeletal comorbidities in cardiovascular disease, diabetes and respiratory disease: the impact on activity limitations; a representative population-based study. 2011 [cited 2018 Mar 22]; Available from: https://journals-scholarsportal-info.libaccess.lib.mcmaster.ca/pdf/14712458/v11inone/77_mcicddalarps.xml

6. LeMasters GK, Genaidy AM, Succop P, Deddens J, Sobeih T, Barriera-Viruet H, et al.

Cancer Risk Among Firefighters: A Review and Meta-analysis of 32 Studies. J Occup Environ Med [Internet]. 2006 Nov [cited 2018 Feb 13];48(11):1189–202. Available from: https://insights.ovid.com/crossref?an=00043764-200611000-00014

7. Katsavouni F, Bebetsos E, Malliou P, Beneka A. The relationship between burnout, PTSD symptoms and injuries in firefighters. Occup Med (Chic Ill) [Internet]. 2016 Jan [cited 2017 May 14];66(1):32–7. Available from: https://academic.oup.com/occmed/article-lookup/doi/10.1093/occmed/kqv144

8. Smith DL, Fehling PC, Frisch A, Haller JM, Winke M, Dailey MW. The Prevalence of Cardiovascular Disease Risk Factors and Obesity in Firefighters. J Obes [Internet]. 2012 [cited 2017 Jul 20];2012:1–9. Available from: http://www.hindawi.com/journals/jobe/2012/908267/

9. Soteriades ES, Smith DL, Tsismenakis AJ, Baur DM, Kales SN. Cardiovascular Disease in US Firefighters. Cardiol Rev [Internet]. 2011 Jul [cited 2017 May 30];19(4):202–15. Available from: http://content.wkhealth.com/linkback/openurl?sid=WKPTLP:landingpage&an=00045415-201107000-00005

10. Molis HJGHJL. U . S firefighter injuries fact sheet. NFPA Res. 2015;(November).

11. OiSaeng Hong DLC, Phelps S, Jamie Feld and SV. Occupational Injuries, Duty Status, and Factors Associated With Injuries Among Firefighters. Work Heal Saf • [Internet]. 2012 [cited 2017 Sep 28];60(12). Available from: http://journals.sagepub.com/doi/pdf/10.1177/216507991206001203

12. Poston WSC, Jitnarin N, Haddock CK, Jahnke SA, Tuley BC. Obesity and Injury-Related

Absenteeism in a Population-Based Firefighter Cohort. Obesity [Internet]. 2011 Oct 2 [cited 2017 Jun 3];19(10):2076–81. Available from: http://doi.wiley.com/10.1038/oby.2011.147

13. Jahnke SA, Hyder ML, Haddock CK, Jitnarin N, Day RS, Poston WSC. High-intensity Fitness Training Among a National Sample of Male Career Firefighters. 2015 [cited 2017 Jul 20]; Available from: http://pubmedcentralcanada.ca/pmcc/articles/PMC4372219/pdf/main.pdf

14. Haddock CK, Jahnke SA, Poston WSC, Jitnarin N, Kaipust CM, Tuley B, et al. Alcohol use among firefighters in the Central United States. Occup Med (Chic Ill) [Internet]. 2012 [cited 2018 Feb 16];62:661–4. Available from: https://journals-scholarsportal-info.libaccess.lib.mcmaster.ca/pdf/09627480/v62i0008/661_auafitcus.xml

15. Keith Haddock C, Nattinee Jitnarin Ã, Poston WS, Tuley B, Jahnke SA. Tobacco Use Among Firefighters in the Central United States. Am J Ind Med J Ind Med [Internet]. 2011 [cited 2018 Feb 15];54(54). Available from: https://journals-scholarsportal-info.libaccess.lib.mcmaster.ca/pdf/02713586/v54i0009/697_tuafitcus.xml

16. Soteriades ES, Hauser R, Kawachi I, Liarokapis D, Christiani DC, Kales SN. Obesity and Cardiovascular Disease Risk Factors in Firefighters: A Prospective Cohort Study. Obes Res [Internet]. 2005 [cited 2018 Feb 20];13(10):1756–63. Available from: https://journals.scholarsportal.info/pdf/10717323/v13i0010/1756_oacdrfifapcs.xml

17. Da Costa BR, Vieira ER. Risk Factors for Work-Related Musculoskeletal Disorders: A Systematic Review of Recent Longitudinal Studies. Am J Ind Med J Ind Med [Internet]. 2010 [cited 2018 Feb 16];53(53). Available from: https://journals-scholarsportal-

info.libaccess.lib.mcmaster.ca/pdf/02713586/v53i0003/285_rffwmdsrorls.xml

18. Kumar S. Theories of musculoskeletal injury causation. Ergonomics [Internet]. 2001 [cited 2018 Feb 13];44(1):17–47. Available from: http://injury-forensics.com/wp-content/uploads/2016/11/Theories-of-musculoskeletal-injury-causation.pdf

19. Mayer JM, Jahnke SA. Injury, Musculoskeletal Disorders, and Ergonomics. 2012 [cited 2017 Oct 26]; Available from: https://link.springer.com/content/pdf/10.1007%2F978-3-319-23069-6_10.pdf

20. Hylton J.G. Haynes and Joseph L. Molis. NFPA report - Firefighter injuries in the United States [Internet]. October 2016. [cited 2017 Sep 28]. Available from: http://www.nfpa.org/news-and-research/fire-statistics-and-reports/fire-statistics/the-fire-service/fatalities-and-injuries/firefighter-injuries-in-the-united-states

21. Walton SM, Conrad KM, Furner SE, Samo DG. Cause, Type, and Workers' Compensation Costs of Injury to Fire Fighters. Am J Ind Med J Ind Med [Internet]. 2003 [cited 2017 Oct 31];43(43). Available from: https://journals.scholarsportal.info/pdf/02713586/v43i0004/454_ctawccoitff.xml

22. Goldberg DS, McGee SJ. Pain as a global public health priority. BMC Public Health [Internet]. 2011 Oct 6 [cited 2018 Mar 22];11:770. Available from: http://www.ncbi.nlm.nih.gov/pubmed/21978149

23. Loeser D john; Melzack Ronald. Concepts of pain. Lancet [Internet]. 1999 [cited 2018 Mar 22];353:1607-09. Available from: https://journals-scholarsportal-info.libaccess.lib.mcmaster.ca/pdf/01406736/v353i9164/1607_pao.xml

24. Daniel B Carr LCG o u d a s, Postanaesthesia. What is acute pain? Lancet [Internet]. 1999 [cited 2018 Mar 22];353:2051–8. Available from: https://journals-scholarsportal-info.libaccess.lib.mcmaster.ca/pdf/01406736/v353i9169/2051_ap.xml

25. Beaton R, Murphy S, Pike ' K. Work and Nonwork Stressors, Negative Affective States, and Pain Complaints Among Firefighters and Paramedics. Int J Stress Manag [Internet]. 1996 [cited 2018 Mar 20];3(4). Available from: https://journals-scholarsportal-info.libaccess.lib.mcmaster.ca/pdf/10725245/v03i0004/223_wansnapcafap.xml

26. Hoogendoorn WE, van Poppel MN, Bongers PM, Koes BW, Bouter LM. Systematic review of psychosocial factors at work and private life as risk factors for back pain. Spine (Phila Pa 1976). 2000;25(16):2114–25.

27. Malcolm H. Pope. Risk Indicators in Low Back Pain. 2009; Available from: http://informahealthcare.com/doi/abs/10.3109/07853898909149226

28. Smith DL. Firefighter fitness: Improving performance and preventing injuries and fatalities. Curr Sports Med Rep. 2011;10(3):167–72.

29. Kenny GP, Larose J, Wright-Beatty HE, Boulay P, Sigal RJ, Flouris AD. Older firefighters are susceptible to age-related impairments in heat dissipation. Med Sci Sports Exerc. 2015;47(6):1281–90.

30. Marie-Christine J Plat MHF-D and JKS. Impact of Chronic Diseases on Work Ability in Ageing Firefighters. J Occup Heal [Internet]. 2012 [cited 2018 Apr 14];54. Available from: https://www.jstage.jst.go.jp/article/joh/54/2/54_11-0105-OA/_pdf

31. Poston WSC, Haddock CK, Jahnke SA, Jitnarin N, Tuley BC, Kales SN. The Prevalence

of Overweight, Obesity, and Substandard Fitness in a Population-Based Firefighter Cohort. J Occup Environ Med [Internet]. 2011;53(3):266–73. Available from: http://content.wkhealth.com/linkback/openurl?sid=WKPTLP:landingpage&an=00043764-201103000-00008

32. Sharp TJ, Harvey AG. Chronic pain and posttraumatic stress disorder: Mutual maintenance? Clin Psychol Rev. 2001;21(6):857–77.

33. Cloutier E, Champoux D. Injury risk profile and aging among Quebec firefighters. Int J Ind Ergon [Internet]. 2000 [cited 2018 Feb 16];25:513–23. Available from: https://journals-scholarsportal-info.libaccess.lib.mcmaster.ca/pdf/01698141/v25i0005/513_irpaaaqf.xml

34. Graveling R. Scoping study : Review of aging and the demands of firefighting Head of Human Sciences Honorary Senior Lecturer , School of Medicine and. 2011;(August).

35. Liao H, Arvey RD, Butler RJ, Nutting SM. Correlates of work injury frequency and duration among firefighters. J Occup Health Psychol [Internet]. 2001 [cited 2018 Jan 9];6(3):229–42. Available from: http://doi.apa.org/getdoi.cfm?doi=10.1037/1076-8998.6.3.229

36. Jahnke SA, Poston WSC, Haddock CK, Jitnarin N, Hyder ML, Horvath C. The health of women in the US fire service. BMC Womens Health [Internet]. 2012 Oct 31 [cited 2018 Feb 13];12:39. Available from: http://www.ncbi.nlm.nih.gov/pubmed/23114186

37. Findley BW, Brown LE, Whitehurst M. Anaerobic power performance of incumbent female firefighters. J Strength Cond Res. 2002;16(3):474–6.

38. Misner JE, Plowman SA BR. Performance Differences between Males and Females on Simulated Firefighting Tasks..pdf. 1987.

39. Jahnke SA, Carlos Poston WS, Keith Haddock C, Jitnarin N. Injury among a population based sample of career firefighters in the central USA. Inj Prev [Internet]. 2013 [cited 2017 Sep 28];19:393–8. Available from: http://injuryprevention.bmj.com/content/injuryprev/19/6/393.full.pdf

40. Arble E, Arnetz BB. A Model of First-responder Coping: An Approach/Avoidance Bifurcation. wiley online Libr [Internet]. 2016 [cited 2018 Jan 9]; Available from: https://journals-scholarsportal-info.libaccess.lib.mcmaster.ca/pdf/15323005/v33i0003/223_amofcaab.xml

41. Ehlers A, Clark DM. A cognitive model of posttraumatic stress disorder. Behav Res Ther [Internet]. 2000 [cited 2018 Jan 9];38:319–45. Available from: https://journals-scholarsportal-info.libaccess.lib.mcmaster.ca/pdf/00057967/v38i0004/319_acmopsd.xml

42. Kitt LR. Breaking the silence : insights into the impact of being a firefighter on men's mental health. 2009;(July). Available from: http://search.ebscohost.com/login.aspx?direct=true&db=edsoai&AN=edsoai.680291094&site=eds-live%5Cnhttp://hdl.handle.net/2429/15226

43. The Fire Service Joint Labor Management Wellness-Fitness Initiative. 2008 [cited 2017 May 29]; Available from: http://www.iaff.org/hs/LODD_Manual/Resources/IAFF-IAFC WFI 3rd Edition.pdf

44. Pukkala E, Martinsen JI, Weiderpass E, Kjaerheim K. Cancer incidence among firefighters: 45 years of follow-up in five Nordic countries. Occup Env med [Internet].

2014 [cited 2018 Feb 20];71:398–404. Available from: http://oem.bmj.com.libaccess.lib.mcmaster.ca/content/oemed/71/6/398.full.pdf

45. Soteriades ES, Smith DL, Tsismenakis AJ, Baur DM, Kales SN. Cardiovascular disease in US firefighters: A systematic review. Cardiol Rev. 2011;19(4):202–15.

46. West M, Domitrovich J, Symonds J. Rhabdomyolysis in Wildland Fire A review of reported cases. 2008 [cited 2018 Jun 8]; Available from: http://wildfiretoday.com/documents/Rhabdo_5_9_16.pdf

47. O'Connor FG, Brennan FH, Campbell W, Heled Y, Deuster P. Return to physical activity after exertional rhabdomyolysis. Curr Sports Med Rep. 2008;7(6):328–31.

48. Poston WSC, Haddock CK, Jahnke SA, Jitnarin N, Day RS. An examination of the benefits of health promotion programs for the national fire service. BMC Public Health [Internet]. 2013 Sep 5 [cited 2017 May 27];13:805. Available from: http://www.ncbi.nlm.nih.gov/pubmed/24007391

49. Abel MG, Sell K, Dennison K. Design and Implementation of Fitness Programs for Firefighters. Strength Cond J. 2011;33(4).

50. Wilkinson ML, Brown AL, Seward W, Poston C, Haddock CK, Jahnke SA, et al. Physician Weight Recommendations for Overweight and Obese Firefighters, United States, 2011–2012. Prev Chronic Dis [Internet]. 2014 [cited 2017 Nov 28];11. Available from: http://dx.doi.org/10.5888/pcd11.140091

51. Jitnarin N, Poston WS, Haddock CK, Jahnke SA, Day RS. Tobacco use pattern among a national firefighter cohort. Nicotine Tob Res. 2015;66–73.

52. Kuehl H, Mabry L, Elliot DL, Kuehl KS, Favorite KC. Factors in adoption of a fire department wellness program: champ-and-chief model. J Occup Environ Med [Internet]. 2013 Apr [cited 2017 Jun 14];55(4):424–9. Available from: http://www.ncbi.nlm.nih.gov/pubmed/23302702

53. J M, K T, K S, R D. Work functioning among firefighters: a comparison between self-report and functional task performance. J Occup Rehabil [Internet]. 2017;0(0):0. Available from: http://dx.doi.org/10.1007/s10926-018-9778-6

54. Rhea R. Matthew AAB& GR. J Ob P Erformance. Strength Cond. 2004;18(2):348–52.

Chapter Two:

Work limitations in firefighters based on the number or location of painful sites.

2.0 Abstract

Background: The unique demands of firefighting results in a high prevalence of repetitive occupational injuries including sprains and strains resulting in acute, recurrent and chronic pain complications. The impact of at work limitations among FFs secondary to pain has been less studied and few studies include a substantial number of women FFs.

Objective: a) To determine whether work limitations differ among FFs based on the number or location of painful sites. b) To determine whether age, sex, BMI and years in fire service influence work limitation among FFs

Design: Cross-sectional study

Participants: Consenting men (n=216) and women (n=106) FFs between the ages of 18-60 years were recruited via convenience sampling.

Methods: FFs completed a work limitations questionnaire (WLQ-26) and a checklist to indicate painful regions of the body using either a paper format or online survey. A one-way ANOVA and post-hoc correction were utilized to determine if work limitations differ among FFs based on the number or location of painful sites while controlling for age, sex, BMI and years in fire service.

Results: The effect of the number of painful sites on physical work limitations showed a significant difference ($F_{3,312}$=3.72, p=0.01). Sidak post-hoc results demonstrated that FFs with three or more body pain sites had more physical limitations than those with no body pain, (Mean difference=1.0/10; 95% CI: 0.1-1.9; p=0.02). The effect of the location of body pain showed a significant difference ($F_{3,312}$=3.74, p=0.01) on physical work limitations. Post-hoc results confirmed that FFs with spinal pain (Mean difference=0.8/10; 95% CI: 0.1-1.6; p=0.01) experienced more physical limitations compared to FFs without pain.

Conclusion: Having multiple painful sites or the location of body pain influences work limitations in FFs. Therefore, more attention should be paid to FFs with these conditions to prevent detrimental effect to the work force.

Keywords: Firefighters; Musculoskeletal pain; Work limitations; Disability

2.1 Introduction

Firefighting is widely recognized as an inherently dangerous occupation (1). It has one of the highest prevalence of occupational injury and fatality rates when compared to other working populations (1). Firefighters (FFs) have high rates of work related pain (2) and they are three times more predisposed to injuries than workers in the private sector(3). This is not surprising because FFs are expected to perform at high levels of physical, emotional and mental capacity to meet the demands of emergency situations (3,4). This may require adopting awkward or restricted postures, lifting heavy loads or sustained work over long periods of time with little or no time for rest on shifts (1). These factors predispose FFs to repetitive trauma or overexertion injuries including sprains and strains that often result in work limitations (1,5). For the purpose of this study, at work limitations will be defined as the degree to which health challenges influence specific aspects of job performance(6).

A recent study in the province of British Columbia, Canada revealed that strains and sprains constitute more than 35% of reported at work injuries incurred by FFs during emergency operations (4). In Canada, there is evidence that one in eight working Canadians reported work limitations mainly due to back pain(7). Although FFs often report work limitations, there is little or no evidence that the number or location of painful sites impact work limitations. In addition, women in the fire service occupy a small percentage of FFs in North America, hence relatively little is known about their work limitations(8) or occupational health concerns(9). In terms of cost, there is a significant economic cost associated with occupational injuries among FFs (2). In the United States, the cost of pain secondary to occupational injuries sustained by FFs annually is about $900 million with an average cost of about 5000 USD per person (2). Approximately a third of claims made by FFs are related to work-related pain and more than 80% of these are associated

with sprains and strains(2,10). Overall, work-related pain from sprains, strains, cuts, laceration and so on occur predominantly among FFs either during emergency fire ground operations, physical exercise or training drills(2,3,11,12).

Despite numerous evidence of prevalence(1), lost time at work(13) and cost of work-related pain in FFs(2), there has been less attention to the impact of at work limitations among FFs. The overall goal of this study is to determine the work limitations among FFs based on the location of body pain or multiple painful sites in the body. Specifically, the purpose of this study is: a) To determine whether work limitations differ among FFs based on the number or location of body pain. b) To determine whether age, sex, BMI and years in the fire service influence work limitation among FFs. We hypothesize that there will be differences in work limitations depending on the number or location of body pain. Those with multiple sites of injuries will experience more work limitations than FFs with no site of body pain. In addition, those who experienced spinal and extremity pain will experience more work limitations than those with no body location affected.

2.2 Methods

2.2.1 Study design/participants

This was a cross sectional study that utilized convenience sampling. Participants included men and women FFs between the ages of 18-60 years. They were recruited primarily from the city of Hamilton, Ontario for the Firefighter Injury Reduction Enterprise: Wellness Enabled Life & Livelihood (FIREWELL) study between 2013-2014. Due to the under-representation of women FFs in the city of Hamilton Ontario, more women FFs were recruited from other cities in Ontario, Canada for appropriate representation. Ethical approval was received from the McMaster Research Ethics board (#:14-540). Written and signed voluntary informed consent was obtained from all participants before the commencement of the study.

2.2.2 Inclusion criteria

Consenting men and women FFs between the ages of 18-60 years in fire service.

2.2.3 Data collection

FFs completed several self-report measures, including a work limitations questionnaire and a questionnaire for sociodemographic factors, anthropometry (age, sex, height, and weight) and years in firefighting service. Participants had a choice to complete either a web-based questionnaire administered via a lime survey tool or a paper-based questionnaire administered by research staff. Responses for the presence of pain were answered as either a 'yes' or 'no' and the location of body was indicated based on a checklist of 'location of body' provided in the questionnaire. These locations of body included: head, neck, shoulder, arm/elbow/hand, back, stomach/abdomen, upper thigh, knee, lower leg, foot and others.

2.2.4 The Work Limitations Questionnaire

The work limitations questionnaire(WLQ-26) is derived from the WLQ-25 that was initially developed and tested in persons with chronic conditions(14). The WLQ-26 consists of 26 items which are divided into 4 subscales: time, mental-interpersonal, output and physical work limitations(14). The physical limitations sub-scale asks questions concerning the participants ability to carry out tasks that involve muscle strength, endurance and co-ordination. The mental-interpersonal limitations sub-scale questions the participants' ability to carry out cognitive tasks and social interactions at work. Finally, the output limitations asks questions that cover productivity on the job while time limitations addresses difficulty handling timeliness and scheduling demands at work (6).

The WLQ-26 has been utilized in various working populations with MSK injuries or other chronic conditions(14). It takes less than10 minutes to complete and each subscale is scored on a

Likert scale ranging from 0-4 (0=difficulty none of the time; 1= difficulty a bit of the time; 2=difficulty a some of the time; 3=difficulty most of the time; 4= difficulty all of the time)(6). A total score ranges between 0 (no limitations) and 100 (most limitations)(6). The WLQ-26 has been found to have good construct validity and content validity(15). It is sensitive to change with a standardized responsive mean of 0.65 and a minimally clinical important difference (MCID) of 13/100 points for summed score(15).

2.2.5 Statistical methods

All statistical analysis was conducted using the STATA/14.2C software. The scores of individual items of the work limitations score were summed, averaged, and standardized to a range of 0– 100, with a higher score indicating more limitations. Visual impression using a histogram of the total score of the work limitations data and each of the subscale showed that the data were skewed to the left. Requisite assumptions were also tested using the Shapiro-Wilk test of normality (alpha≤0.05), confirming the data were skewed with an unequal variance for the number or location of painful sites. Therefore, a stabilizing transformation (square root of the work limitations score) was utilized to normalize the data to meet the requisite assumptions. Histograms and the Shapiro-Wilk test demonstrated that transformed scores (0-10) were normally distributed. Descriptive summary statistics were calculated as median and interquartile range for the untransformed variables of interest including time, physical, output and mental-interpersonal work limitations scores. Means and standard deviations, were utilized for demographic characteristics while frequencies and percentages were derived for the location or number of painful sites.

A chi-squared analysis was used to test the proportion between demographic factors (sex, age, BMI and years in fire service) and the location or number of body pain of FFs. Furthermore, age was categorized as being >45 and ≤45 years and years of fire service as 0 to 10years, >10 to

20 years and >20years. A one-way ANOVA was employed to analyze the transformed work limitations scores, this was a two-sided test with significance level of ≤0.05. Painful locations were classified as: having no location of pain, upper extremity (shoulder, arm, elbow and hand), lower extremity (upper thigh, knee, foot and lower leg) and spine (back, head and neck). The number of painful sites were also divided into: having no pain, one location of pain, two locations of pain and three or more locations of pain. Each transformed sub-scale of physical, time, output and mental work limitations was treated as a dependent variable while the number of painful sites and location of pain, were the independent variables. When overall effects were identified, a post-hoc test was conducted to further determine where the differences existed generally for FFs, and for both men and women FFs.

2.3 Results

2.3.1 Sample demographics

The data analyzed consisted of 325 (men=216, women =109) FFs in total. **Table 2.1** shows the participant characteristics. Men FFs had a mean(SD) age of 43 (±9) years while women FFs had a mean age of 35 (±8) years. Chi-square analysis showed that BMI categories among men and women FFs was significant ($\chi 2_{(3)} = 55.8$; $p<0.05$) as men FFs had higher BMI than women FFs. The years in the fire service among men and women FFs was also significant ($\chi 2_{(2)} = 63.9$; $p<0.05$). There was an equal distribution of men and women FFs between 0 to 10 years in the fire service. However, a larger proportion of men FFs are represented in fire service between >10 to 20 years (76.4% vs 23.5%; $p<0.05$) and > 20 years (94.3% vs 5.7%; $p<0.05$) than women FFs.

2.3.2 Number and location of body pain

The frequencies and percentages of the number or location painful sites by sex are displayed in **Figures 2.1-2.4**.

2.3.3 Work limitations scores

The median work limitation scores ranges from 3.1/100 to 15.6/100 for the number of painful sites and 0/100 to 17.7/100 for the location of body pain. The untransformed median work limitations scores for each WLQ-26 subscale are displayed in **Table 2.2**. There was no significant effect between the transformed average work limitations scores of FFs and other covariates including sex, BMI and years in the fire service. However, the difference between the transformed average work limitations score and age categories had a significant effect in FFs ($F_{1,314}$=7.11, p=0.008). FFs >45 years of age experienced more physical work limitations than FFs ≤45years (mean difference: 0.74/10; 95% CI .19-1.29; p=0.008).

2.3.4 Effect of location of body pain on work limitations

The mean differences and confidence interval are displayed in **Table 2.3**. The location of body pain showed significant differences for physical work limitations ($F_{3,312}$=3.72, p=0.01). FFs with spinal pain (Mean difference=0.8/10; 95% CI: 0.1-1.6; p=0.01) experienced more physical limitations compared to FFs with no location of pain. In addition, there was a significant effect of physical limitation ($F_{3,207}$=3.01, p=0.03) between men FFs who reported spinal pain(p=0.02) and men FFs without pain. However, there was no significant effect of physical limitation based on the location of pain among women FFs. For mental work limitations, FFs experienced a significant difference in the location of body pain ($F_{3,\ 319}$ =5.67; p=0.001), as FFs with upper extremity (p=0.03: mean difference=1.4/10; 95% CI:0.1-2.7) and spinal pain (p=0.003; mean difference=

0.9/10; 95% CI: 0.2-1.6) experienced more mental limitations than FFs with no pain. There was a significant effect of mental limitation ($F_{3,210}$=3.26, p=0.02) between men FFs who reported spinal pain(p=0.02) and those without pain. In addition, there was a significant effect of mental limitation ($F_{3,101}$=4.51, p=0.01) between women FFs with upper extremity pain(p=0.05) and women FFs without pain.

Output limitations scores among FFs who reported a location of pain was significant ($F_{3, 310}$ =3.37; p=0.01), as FFs with spinal pain (p=0.02; mean difference=0.9/10; 95% CI: 0.1-1.6) experienced more output limitations than FFs without pain. By sex, there was a significant difference of output limitation ($F_{3, 310}$ =3.37; p=0.01), as women FFs with lower extremity pain (p=0.02) experienced more output limitations than women FFs without pain. There was no significant effect of output limitations based on the location of pain among men FFs. Lastly, for time limitations there was no difference between FFs with or without body pain. Also, there was no significant difference of time limitation among men and women FFs based on the location of painful sites.

2.3.5 Effect of number of painful sites on work limitations

Mental limitations scores showed a significant difference ($F=_{3,314}$ =6.38; p=0.0003), for the number of painful sites reported among FFs. Having two painful locations (p=0.004; mean difference:1.1/10; 95% CI: 0.3-2.0) or three or more painful locations in the body (p=0.002; mean difference: 1.2/10; 95% CI: 0.3-2.0) were significant compared to having no painful sites. Men FFs with two (p=0.03) or three or more(p=0.05) painful locations reported significant effect for mental limitation than men FFs without pain. There was no significant effect of mental work limitation based on the number of painful sites for women FFs. The physical limitations scores

showed a significant difference ($F_{3, 312}$ =3.72; p=0.01) in number of painful sites. FFs with three or more painful sites (p=0.02; mean difference: 1.0/10; 95% CI: 0.1-1.9) had more work limitations than FFs with no body pain.

By sex, there was no significant difference of mental work limitations between men and women FFs. However, there was a significant difference of mental work limitations ($F_{3,212}$=3.19, p=0.02) among men FFs. Men with two painful sites (Mean difference:1.1 /10; p=0.05) experienced more mental work limitations than men FFs without pain. For women FFs, there was a significant effect of the number of painful sites for mental work limitations scores ($F_{3, 103}$=3.61; p=0.02). Women with three or more painful sites (Mean difference: 1.5/10; p=0.02) experienced more mental work limitations than women FFs without pain. There was no effect of the number of painful sites on time limitations ($F_{3, 299}$ =2.27; p=0.08).

2.4 Discussion

Our findings showed a small and inconsistent effect for the location or number of painful sites among FFs. In the literature, work limitations based on the number or location of painful sites have been mostly attributed to musculoskeletal disorders or injuries in varying working populations (2,3,7). For instance, Carleton et al., revealed that about half of the first responders in Canada reported that their chronic pain was associated with an injury at work(16). Furthermore, men FFs were older and bigger (42.6years vs 27.8kg/m^2) compared to women FFs (34.6 years vs 24.7kg/m^2). Also, for the years in fire service, men FFs reported longer tenure (16 years) compared to women FFs (7years). This is expected as firefighting is a male dominated occupation with a very small percentage of women FFs(9). Older FFs, experienced more physical work limitations compared to younger FFs. This result agrees with another study by Sinden et al.,(17) who found

that performance of firefighting tasks such as the hose drag was adversely influenced by increased age in fire service (17).

2.4.1 Location of body pain

Our study showed that the most reported location of body pain among FFs was the spine (41%) followed by the extremities (15%) i.e. upper extremity (7%) and lower extremity (9%). The prevalence of painful site in our study is in agreement with Carleton et al., (16) study which showed that the most reported location of body pain was the spine (18.4%) followed by the upper extremity (15.7%). The difference in percentages may be due to the duration of prevalence of the location of body pain. The prevalence of the location of body pain reported in our study was four weeks which is a shorter duration compared to Carleton study that lasted 3 months (16). Findings from our study also showed that FFs with spinal pain experienced more physical, output and mental limitations compared to FFs with no painful site. Moreover, men FFs with spinal pain experienced more physical and mental limitations than men FFs with no pain. This agrees with a study by Bos et al.,(18) which showed that Dutch FFs with back complaints experienced greater work limitations or disability in meeting their job demands(18). Our study also showed that FFs with upper extremity pain experienced more mental limitations than FFs with no pain. Likewise, women FFs with upper extremity pain reported more mental limitations, and those with lower extremity pain reported more output limitation than women FFs with no pain. This is consistent with other studies in literature(5,7,16).

2.4.2 Number of painful sites

Our study showed that FFs reported multiple painful sites with an estimated 19% having two painful sites and 21% with three or more painful sites. Our findings are in contrast to a study by Jahnke et al.,(2) who reported a lower prevalence of multiple injuries among FFs in the central

USA. About 3% reported two injuries while 1.7% reported three or more injures. The difference may be due to the study samples of both studies as our study included both men and women FFs while the study by Jahnke et al., (2) excluded the women participants from her study. Findings from our study also showed that FFs with multiple painful sites experienced more physical and mental limitations compared to those with no body pain which agrees with other studies in literature (5,18).

For example, a literature review by Gallagher et al.,(5) showed that employees who frequently adopt restricted or unusual postures during job performance are at an increased likelihood of MSK disorder that results in physical limitations(5). Likewise, evidence emphasizes the prevalence and association between mental health limitations and the impact of multiple painful sites of the body in various working population(18,20). By sex, our findings showed that men FFs with multiple painful sites experience more physical and mental limitation than men FFs with no pain. Women with three or more painful sites had more mental work limitations than women without pain. Also, women FFs with lower extremity pain experienced more output limitations than women without pain. Lastly, the time required to carry out specific task by FFs and the output or productivity of FFs had no significant effect based on the number of painful sites. Therefore, FFs are able to carry out their tasks within a stipulated time and are productive regardless of the number of painful sites in the body.

2.5 Strengths

Our study is a significant representation of FFs in Hamilton, Ontario with a good representation of both sexes. The literature suggests that most FFs studies usually exclude the

women FFs because they occupy a small percentage of the entire FFs population (9) but this study includes a representative sample of women FFs participants.

2.6 Limitations

The study was a cross sectional study, hence does not provide a definitive information about cause and effect relationship between the location of body or the number of pain sites in the body and work limitations among FFs. We were unable to say what specific diagnoses or type of health problem was causing the painful location reported by FFs. We also found generally low levels of work limitations but given the high demand tasks that FFs perform the WLQ-26 may not adequately represent the highly demanding tasks of FFs. This is not surprising as FFs are more likely to exhibit the healthy worker effect due to a lower morbidity and mortality rate at work compared to the general population. Therefore a self-report performance limitations scale designed for FFs may be needed to identify limitations at work (14)

2.7 Recommendations

This work indicates the connection between painful locations and both physical and mental demands at work. Although firefighting is thought of as a physically demanding job which can cause pain and has a high risk of traumatic events that can cause posttraumatic stress disorder, the overlap between physical and mental health may be underappreciated. Future studies should explore this interrelationship, with trauma being a common pathway for both musculoskeletal and mental health problems.

2.8 Conclusion

Given the prevalence and influence of location or number of painful sites on work limitations, more attention should be paid by clinicians to FFs having multiple pain sites or pain at the spine for early intervention and treatment to prevent detrimental effects on the work force.

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Table 2.1: Sample demographics

Demographics Characteristics	All	Men	Women
N (%) Sample size	325	216 (66%)	109 (34%)
Mean(SD)			
Age (yrs.)	39.9±9.4	42.6±8.7	34.7±8.5
Height (m)	1.8±0.3	1.8±0.3	1.7±0.1
Weight (kg)	83.2±14.2	89.9±11.3	70.5±9.5
BMI (kg/m^2)	26.8±4.3	27.8±4.1	24.7±4.0
Years of service (yrs.)	12.9±8.6	15.9±8.1	7.4±7.5

BMI=Body mass index

Table 2.2: Untransformed Median and IQR work limitations scores for number or body location of painful sites

Limitations scores for Location/ Number of painful sites	One painful sites Median (IQR)	Two painful sites Median (IQR)	Three or more painful sites Median (IQR)	Upper extremity Median (IQR)	Lower extremity Median (IQR)	Spine Median (IQR)
Physical limitations	3.1 (0, 12.5)	3.1 (0, 15.6)	6.3 (0,15.6)	3.1 (0, 15.6)	0 (0, 15.6)	6.3 (0, 12.5)
Output limitations	12.5 (6.2, 25)	12.5 (6.2, 25)	12.5 (6.2, 18.7)	12.5 (6.2, 25)	12.5 (3.1, 21.8)	12.5 (6.2, 18.7)
Time limitations	8.3 (0, 16.6)	8.3 (4.1, 16.6)	8.3 (4.1, 16.6)	12.5 (6.2, 25)	6.2 (0, 16.6)	8.3 (4.1, 16.6)
Mental limitations	15.6 (3.1, 21.8)	15.6 (6.2, 25)	15.6 (6.2, 25)	17.1 (9.3, 31.2)	12.5 (3.1, 21.8)	15.6 (6.2, 25)

Range of work limitations scores for each subscale = 0-100. Higher scores denote greater work limitations

Table 2.3: Effect of area of body pain and number of painful sites on work limitation in FFs.

Limitation scores for location/ number of painful sites	One area of pain Mean difference (95% CI)	Two body area of pain Mean difference (95% CI)	Three or more areas of pain Mean difference (95% CI)	Upper extremity Mean difference (95% CI)	Lower extremity Mean difference (95% CI)	Spine Mean difference (95% CI)
Physical limitations	0.6 (-0.3-1.6)	0.7 (-0.2-1.7)	1.0* (0.1-1.9)	0.8 (-0.6-2.2)	0.4 (-0.8-1.7)	0.8* (0.1-1.6)
Mental limitations	0.5 (-0.4-1.5)	1.1* (0.3-2.0)	1.2* (0.3-2.0)	1.4* (0.9-2.7)	0.9 (-0.3-2.0)	0.9* (0.2-1.6)
Time limitations	0.6 (-0.4-1.5)	0.7 (-0.2-1.6)	0.7 (-0.2-1.5)	1.3 (-0.1-2.6)	0.5 (-0.7-1.7)	0.6 (-0.1-1.3)
Output limitation	0.9 (-0.03-1.9)	0.8 (-0.1-1.8)	0.8 (-0.1-1.7)	1.0 (-0.4-2.5)	0.9 (-0.4-2.1)	0.8* (0.1-1.6)

Reference group: Having no region or number of painful sites; * significant at $p \leq 0.05$

LIST OF FIGURES

Figure 2.1: Number of painful sites

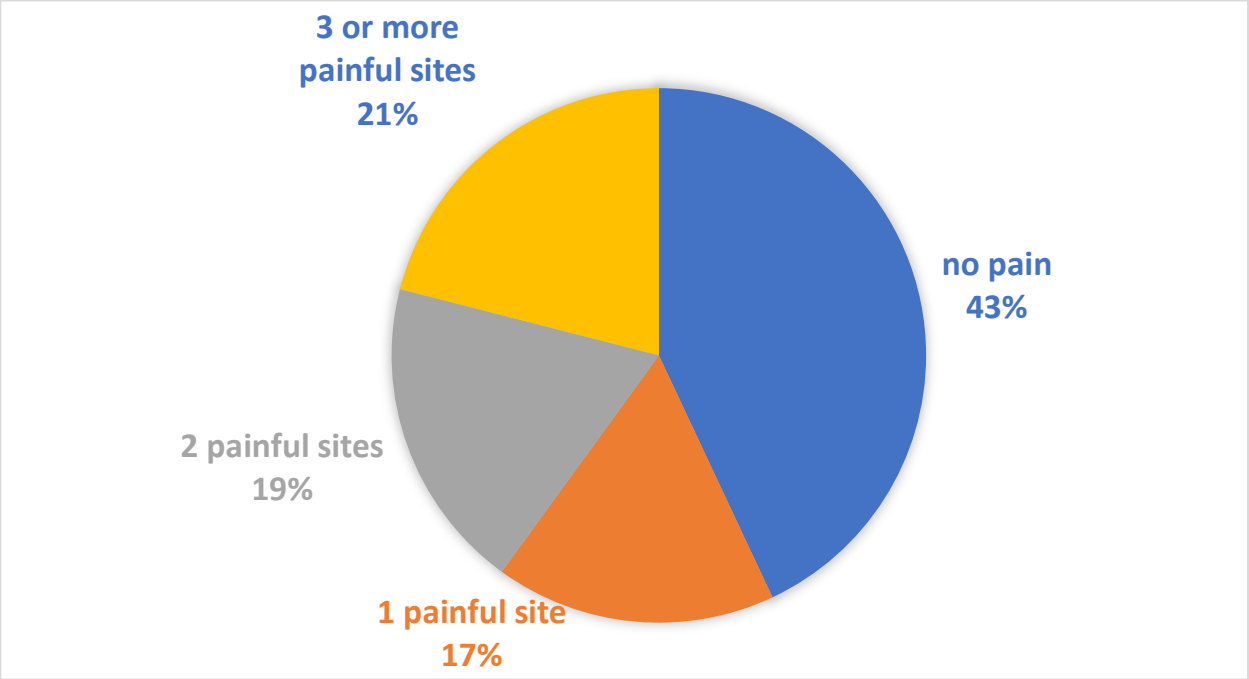


Figure 2.2: Number of painful sites by sex

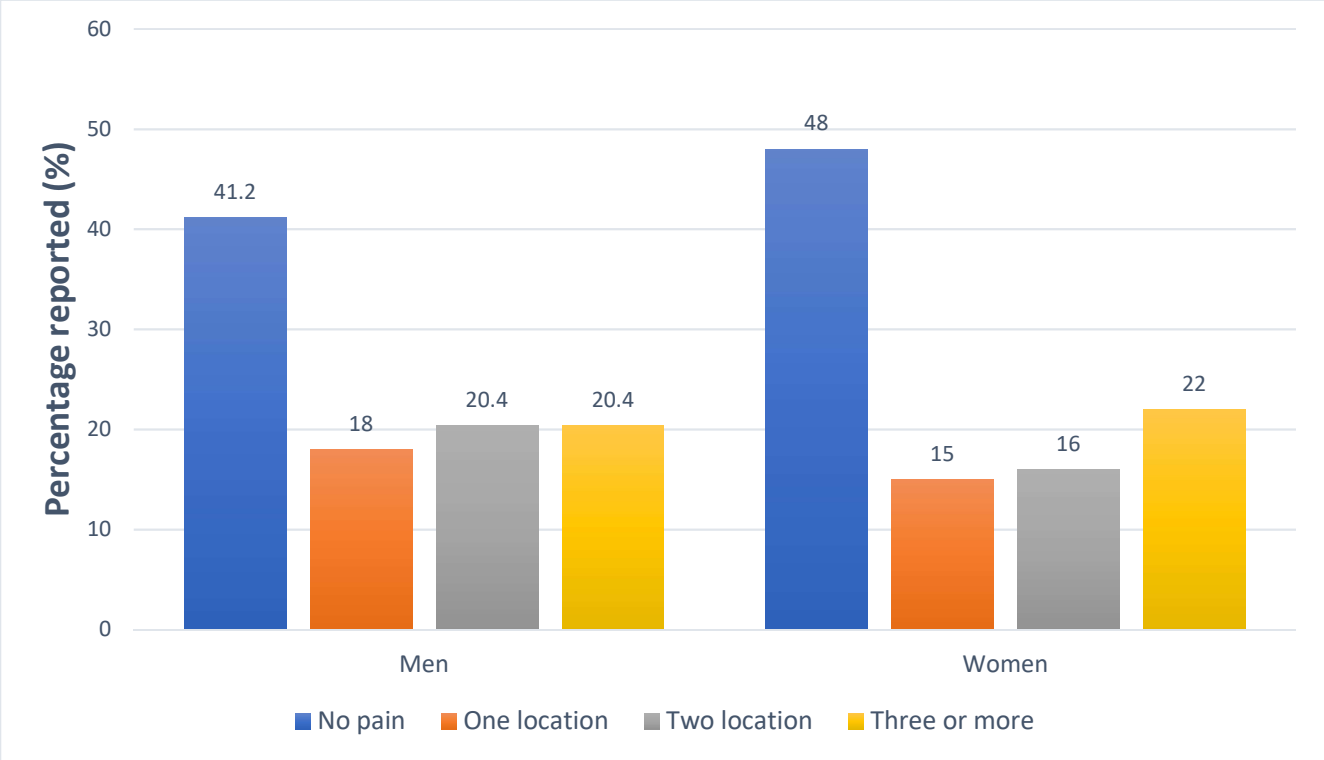


Figure 2.3: Location of painful sites

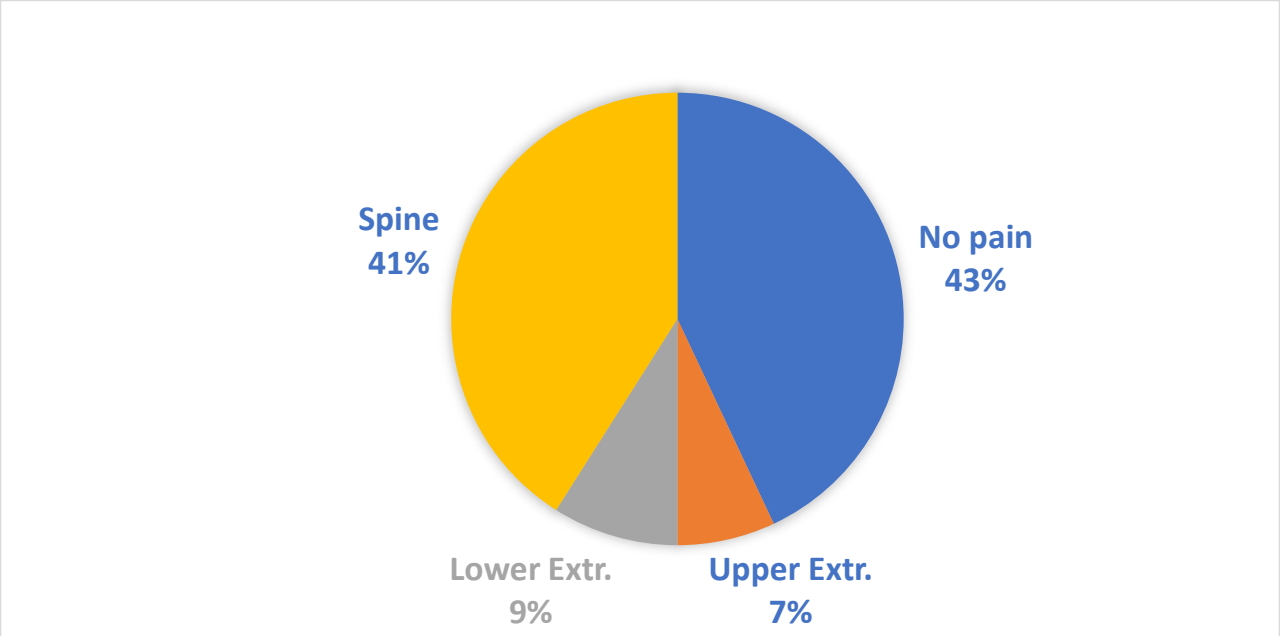
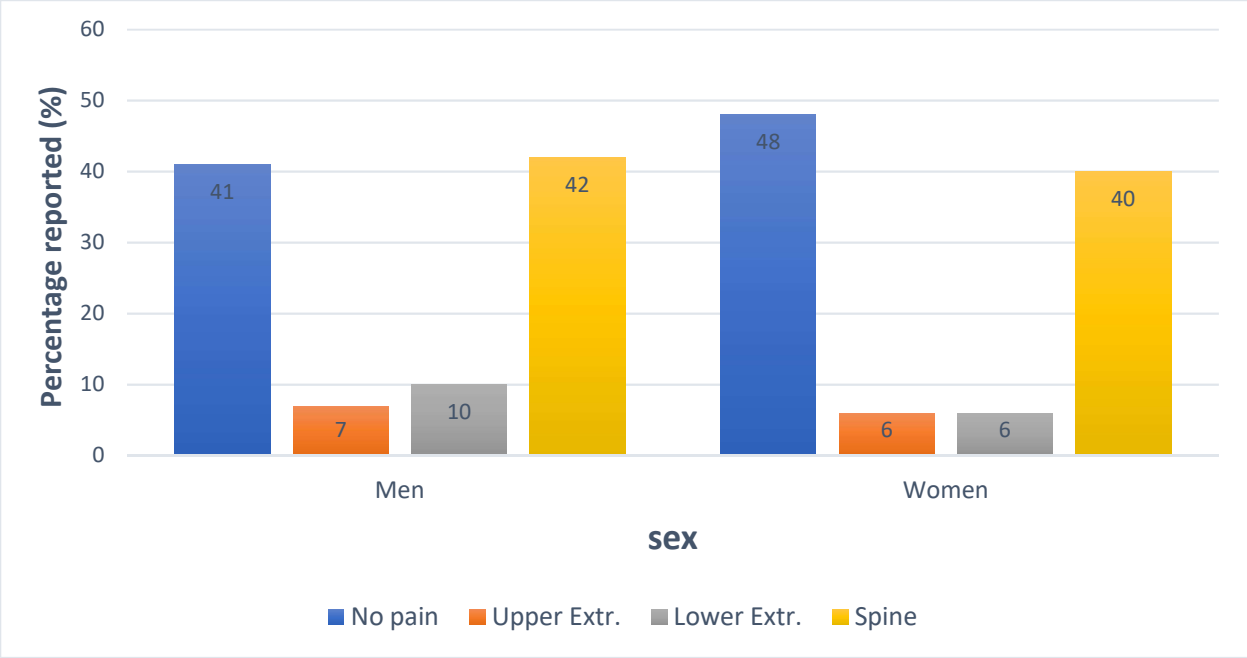


Figure 2.4: Location of painful sites of sex



2.9 References

1. Negm A, Macdermid J, Sinden K, D 'amico R, Lomotan M, Macintyre NJ. Prevalence and distribution of musculoskeletal disorders in firefighters are influenced by age and length of service. J Mil Veteran Fam Heal [Internet]. 2017 [cited 2018 Jan 9];3(2):33–41. Available from: http://jmvfh.utpjournals.press/doi/pdf/10.3138/jmvfh.2017-0002

2. Jahnke SA, Carlos Poston WS, Keith Haddock C, Jitnarin N. Injury among a population based sample of career firefighters in the central USA. Inj Prev [Internet]. 2013 [cited 2017 Sep 28];19:393–8. Available from: http://injuryprevention.bmj.com/content/injuryprev/19/6/393.full.pdf

3. Mayer JM, Jahnke SA. Injury, Musculoskeletal Disorders, and Ergonomics. 2012 [cited 2017 Oct 26]; Available from: https://link.springer.com/content/pdf/10.1007%2F978-3-319-23069-6_10.pdf

4. Tyakoff A, Garis L, Thomas L. Firefighter Injuries in British Columbia: An Examination of Frequency, Severity, Locational and Temporal aspects. 2015 [cited 2017 Oct 26]; Available from: https://www.surrey.ca/files/FirefighterInjuryStudyFinal.pdf

5. Gallagher S. Physical limitations and musculoskeletal complaints associated with work in unusual or restricted postures: A literature review. J Safety Res [Internet]. 2005 [cited 2017 Oct 26];36:51–61. Available from: https://journals.scholarsportal.info/pdf/00224375/v36i0001/51_plamcaorpalr.xml

6. Lerner D, Reed JI, Massarotti E, Wester LM, Burke TA. The Work Limitations Questionnaire's validity and reliability among patients with osteoarthritis. J Clin Epidemiol [Internet]. 2002 [cited 2017 Nov 13];55:197–208. Available from:

https://journals-scholarsportal-info.libaccess.lib.mcmaster.ca/pdf/08954356/v55i0002/197_twlqvarapwo.xml

7. Cole DC, Ibrahim SA, Shannon HS, Scott F. Work Correlates of Back Problems and Activity Restriction Due to Musculoskeletal. Eyles Source Occup Environ Med [Internet]. 2001 [cited 2017 Oct 26];58(11):728–34. Available from: http://www.jstor.org/stable/27731586

8. Findley BW, Brown LE, Whitehurst M. Anaerobic power performance of incumbent female firefighters. J Strength Cond Res. 2002;16(3):474–6.

9. Jahnke SA, Poston WSC, Haddock CK, Jitnarin N, Hyder ML, Horvath C. The health of women in the US fire service. BMC Womens Health [Internet]. 2012 Oct 31 [cited 2018 Feb 13];12:39. Available from: http://www.ncbi.nlm.nih.gov/pubmed/23114186

10. Walton SM, Conrad KM, Furner SE, Samo DG. Cause, type, and workers' compensation costs of injury to fire fighters. Am J Ind Med. 2003;43(4):454–8.

11. Poplin GS, Harris RB, Pollack KM, Peate WF, Burgess JL. Beyond the fireground: injuries in the fire service. J Inj Prev [Internet]. 2012 [cited 2017 Sep 28];18:228–33. Available from: http://injuryprevention.bmj.com.libaccess.lib.mcmaster.ca/content/injuryprev/18/4/228.full.pdf

12. Poston WSC, Jitnarin N, Haddock CK, Jahnke SA, Tuley BC. Obesity and Injury-Related Absenteeism in a Population-Based Firefighter Cohort. Obesity [Internet]. 2011 Oct 2 [cited 2017 Jun 3];19(10):2076–81. Available from: http://doi.wiley.com/10.1038/oby.2011.147

13. Newton D, Sofian N. Fire service occupational health and fitness program evaluation to evaluate and verify the benefits and cost effectiveness of the occupational health and fitness programs presented to Seattle firefighters (union #27) seattle fire chiefs (UNION #2898). 2007 [cited 2017 Jun 10]; Available from: http://www.iaff.org/HS/wfiresource/Seattle/CostJustification/FinalReport82207Seattle.pdf

14. J M, K T, K S, R D. Work functioning among firefighters: a comparison between self-report and functional task performance. J Occup Rehabil [Internet]. 2017;0(0):0. Available from: http://dx.doi.org/10.1007/s10926-018-9778-6

15. The Work Limitations Questionnaire (WLQ-25). J Physiother [Internet]. 2013 [cited 2018 May 7];59. Available from: https://pdfs.semanticscholar.org/f21d/2b469a3eed77494bf9178b4605a134af4db4.pdf

16. Carleton, Afifi, Turner, Taillieu, El-Gabalawy S& A. Chronic pain among public safety personnel in Canada. Can J pain [Internet]. 2017 [cited 2018 Mar 23];1(1):237–46. Available from: http://www.tandfonline.com/action/journalInformation?journalCode=ucjp20

17. Kathryn Sinden BE, Kathryn Sinden by E. Identifying Determinants of firefighter work and health task performance: Implications for injury management. [cited 2017 May 27]; Available from: https://macsphere.mcmaster.ca/bitstream/11375/15948/1/Sinden KE_PhD Thesis_Occupational Health and Firefighting.pdf

18. Bü U, Ae L, Franche R-L, Hogg-Johnson S, Côté P, Hyunmi A, et al. Health status, work limitations, and return-to-work trajectories in injured workers with musculoskeletal disorders. Qual Life Res [Internet]. 2007 [cited 2017 Oct 26];16:1167–78. Available from:

https://link.springer.com/content/pdf/10.1007%2Fs11136-007-9229-x.pdf

19. OiSaeng Hong DLC, Phelps S, Jamie Feld and SV. Occupational Injuries, Duty Status, and Factors Associated With Injuries Among Firefighters. Work Heal Saf • [Internet]. 2012 [cited 2017 Sep 28];60(12). Available from: http://journals.sagepub.com/doi/pdf/10.1177/216507991206001203

20. Dersh J, Gatchel RJ, Polatin P, Mayer T. Prevalence of psychiatric disorders in patients with chronic work-related musculoskeletal pain disability. J Occup Env Med [Internet]. 2002;44(5):459–68. Available from: http://www.ncbi.nlm.nih.gov/pubmed/12024691%5Cnhttp://graphics.tx.ovid.com/ovftpdfs/FPDDNCLBEHHDJP00/fs024/ovft/live/gv013/00043764/00043764-200205000-00014.pdf

APPENDIX

Appendix A: Participant demographic form

Date: ___/___/_____ ID Code: _____
dd mm yyyy

Participant Demographics Form

Gender: M F

Age: _____ Date of Birth: ___/___/___
(dd/mm/yyyy)

Height: _____ft/inch or cm

Weight: _____ kg or lbs

Number of years as a firefighter: _____

Rank/Job Title (please check all that apply):
__ Recruit
__ Volunteer Firefighter
__ Professional / Career Firefighter
__ Supervisor role (e.g., Captain, Acting Captain, etc.)
__ Worker role (e.g., 1st Rank Firefighter, etc.)
__ Other, please specify: _____

Fire Service Location (please specify CITY): _____

Please indicate whether you have experienced pain in any body region within the **last week**
__ Yes __ No

If YES, please indicate any / all areas where you have felt pain within the **last week**:
__ Head
__ Neck
__ Shoulder
__ Arm/Elbow/Hand
__ Back
__ Stomach/Abdomen
__ Upper Thigh
__ Knee
__ Lower Leg
__ Foot
__ Other, please specify: _____

Please indicate the region where you experienced the **most pain**: _____
_____

Rate your pain (0 = No pain, 10 = worst possible pain) within the **last week** for this region:
___/10

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Appendix B: The Work Limitations Questionnaire (WLQ-26)

Date: ___/___/_____ ID Code: _____
dd / mm / yyyy

WL-26

These questions ask you to rate the amount of time during the ***past four weeks*** that you had difficulty handling certain parts of your job. Please read and answer every question.

- Mark the "Does Not Apply to My Job" box only if the question describes something that is not part of your job.
- If you have more than one job, report on your main job only.

In the past 4 weeks, how much of the time did your physical health or emotional problems make it difficult for you to do the following?

DIFFICULT	Difficult All of the Time (100%)	Difficult Most of the Time	Difficult Half of the Time (50%)	Difficult Some of the Time	Difficult None of the Time (0%)	Does Not Apply to My Job
a. Get to work on time	☐1	☐2	☐3	☐4	☐5	☐6
b. Stick to a routine or schedule without having to rearrange your work tasks	☐1	☐2	☐3	☐4	☐5	☐6
c. Work without taking frequent rests or breaks to avoid discomfort	☐1	☐2	☐3	☐4	☐5	☐6
d. Work the required number of hours	☐1	☐2	☐3	☐4	☐5	☐6
e. Handle very demanding or stressful work situations	☐1	☐2	☐3	☐4	☐5	☐6
f. Do your work without becoming tense or frustrated	☐1	☐2	☐3	☐4	☐5	☐6
g. Do your work carefully	☐1	☐2	☐3	☐4	☐5	☐6

Date: ___/___/_____
dd / mm / yyyy

ID Code: _____

DIFFICULT	Difficult All of the Time (100%)	Difficult Most of the Time	Difficult Half of the Time (50%)	Difficult Some of the Time	Difficult None of the Time (0%)	Does Not Apply to My Job
h. Satisfy those people who judge your work	☐1	☐2	☐3	☐4	☐5	☐6
i. Feel a sense of accomplishment	☐1	☐2	☐3	☐4	☐5	☐6
j. Finish work on time	☐1	☐2	☐3	☐4	☐5	☐6
k. Handle the workload	☐1	☐2	☐3	☐4	☐5	☐6
l. Lift, carry or move objects at work weighing 10 pounds or less	☐1	☐2	☐3	☐4	☐5	☐6
m. Lift, carry or move objects at work weighing 10 pounds or more	☐1	☐2	☐3	☐4	☐5	☐6
n. Walk more than one block or climb up or down one flight of stairs while working	☐1	☐2	☐3	☐4	☐5	☐6
o. Sit, stand, or stay in one position for longer than 15 minutes while working	☐1	☐2	☐3	☐4	☐5	☐6
p. Bend, twist, or reach while working	☐1	☐2	☐3	☐4	☐5	☐6
q. Use hand operated tools or equipment (for example: hose, saw, ax)	☐1	☐2	☐3	☐4	☐5	☐6

Date: ___/___/_____
dd / mm / yyyy

ID Code: _____

DIFFICULT	Difficult All of the Time (100%)	Difficult Most of the Time	Difficult Half of the Time (50%)	Difficult Some of the Time	Difficult None of the Time (0%)	Does Not Apply to My Job
r. Use your upper body to operate tools or equipment (upper body means arms, head, neck, shoulders or upper back)	☐1	☐2	☐3	☐4	☐5	☐6
s. Use your lower body to operate tools or equipment (lower body means legs, knees, feet or lower back)	☐1	☐2	☐3	☐4	☐5	☐6
t. Keep your mind on your work	☐1	☐2	☐3	☐4	☐5	☐6
u. Keep track of more than one task or project at the same time	☐1	☐2	☐3	☐4	☐5	☐6
v. Concentrate on your work	☐1	☐2	☐3	☐4	☐5	☐6
w. Remember things having to do with your work	☐1	☐2	☐3	☐4	☐5	☐6
x. Talk with people in person, in meetings, or on the phone	☐1	☐2	☐3	☐4	☐5	☐6
y. Control irritability or anger toward people when working	☐1	☐2	☐3	☐4	☐5	☐6
z. Help other people get work done	☐1	☐2	☐3	☐4	☐5	☐6

Chapter Three:

Non-musculoskeletal(MSK) comorbid health condition as predictors of work limitations among firefighters.

3.0 Abstract

Background: Firefighters (FFs) typically start their career with good health but may experience hazardous exposures that increase the risk of health conditions. Evidence of the impact of comorbidities on work limitations among FFs remains scarce, especially among women FFs.

Objective: a) To determine whether the number of non-musculoskeletal comorbid health conditions predicts work limitations in FFs. b) To determine whether demographics and years in fire service influence work limitations in FFs with non-MSK comorbidity.

Design: Cross sectional study

Participants: A total of 325 Men (n=216) and women (n=106) FFs between the ages of 18-60 years were recruited via convenience sampling.

Methods: FFs completed a web-based survey consisting of The Work Limitation Questionnaire (WLQ-26) and a Katz self-reported comorbidity questionnaire. Linear regression was used to model the impact of the number of non-MSK comorbid condition and other covariates including age, sex, BMI, and years in firefighting on WLQ-26 sub-scale scores.

Results: The WLQ scores were low across all subscales; physical (0/100), mental (14/100), output (12.5/100), and time (8.3/100) work limitations. Univariate regression demonstrated that having at least one comorbidity (p=0.03) is a small but significant predictor of mental work limitations only (R^2=0.02; $F_{2,316}$=2.94, p=0.05). For separate univariate analysis, women FFs having one comorbidity showed a small but significant association with physical (R^2=0.07; $F_{2,97}$=3.92, p=0.02) and mental work limitations (R^2=0.04; $F_{2,101}$=1.89, p=0.15) compared to women without non-MSK comorbidity.

Conclusion: Firefighters had generally low work limitation scores. There was a small but significant effect of non-MSK comorbidity on mental work limitations alone. In addition, older

age showed a small but significant association with work limitations (physical, mental, output and time) in fire service.

Keywords: Firefighters; work limitations; Non-musculoskeletal comorbidity; women

3.1 Introduction

Firefighters (FFs) are exposed to life-threatening hazardous conditions repeatedly during their careers (1). This predisposes them to various chronic health conditions in the line of duty including cardiovascular diseases(CVD) (2), chronic respiratory disease(3), cancer(4) and post-traumatic stress disorders(PTSD)(5). The presence of these comorbidities may affect their job performance through reduced productivity, absenteeism, reduced quality of life and even early retirement (3). For instance, FFs are exposed to poisonous chemicals and gases like hydrogen cyanide that causes cancer (6) or damage the respiratory tract (4). Also, CVD is the leading cause of on-duty fatalities and morbidity in fire service(2). The high prevalence of CVD in this population has adverse public safety consequences as well as significant cost effects on government agencies(2).

In fire service, the impact of having a comorbidity may be higher due to the physical and psychological demands of the job(7). Studies have shown that FFs are three times more at risk of death from CVD related events than the general population (2,8) suggesting a need for further research on the impact of these non-MSK related conditions in fire service. It is widely known that MSK injury and health problems are prevalent amongst FFs(3). A number of studies have addressed the prevalence(9–11), and we have previously reported their impact on work limitations among FFs(12). However, the etiology and impact of non-musculoskeletal(MSK) health conditions might be quite different than MSK conditions. These occupational health conditions are major health concerns in fire service due to increased risk to colleagues whose well-being is dependent on the performance of other team members(8,13).

Furthermore, there is very little to no research on the occupational health of women FFs despite recurrent exposures to various firefighting hazards as men FFs(14). Evidence suggests that

increased age is related to the prevalence of non-MSK comorbidities (6) and reduced work ability in FFs. However little to no attention has been paid to the high demands of firefighting and aging amongst female FFs, possibly because of the relatively small fraction of women in the fire service (7). There has also been a growing concern on the prevalence of mental health challenges including post-traumatic stress disorder among FFs and the impact on work ability in fire service (5,13). For instance, the economic cost of depression in Canada ranged from $14.4 billion to $33 billion for health expenses and at-work disability costs(15). Studies investigating the relationship between non-MSK comorbidity and work limitations in FFs are sparse. Therefore, the purpose of this study was to determine the following: a) whether the number of self-reported non-MSK comorbid health condition predict work limitations among FFs. b) if demographics and years of service influences work limitations among FFs with non-MSK comorbid conditions.

3.2 Methods

3.2.1 Study design/participants

This was a cross sectional study that employed convenience sampling. The study included FFs between the ages of 18-60 years. Men were recruited primarily from the city of Hamilton, Ontario for the Firefighter Injury Reduction Enterprise: Wellness Enabled Life & Livelihood (FIREWELL) study between 2013-2014. To ensure adequate representation, more women FFs were recruited from other cities in Ontario. Ethical approval was received from the McMaster Research Ethics board (#:14-540). Consent forms were signed by the participants before the commencement of the study.

3.2.2 Data collection

FFs completed a web-based WLQ-26, Katz self-administered comorbidity questionnaire and a questionnaire for demographic factors including: age, sex, height, and weight and years in fire service.

3.2.3 Health problem

The Katz self-administered comorbidity questionnaire was used to assess the presence of a comorbid health condition among FFs. Responses for the presence, treatment and limitations by the comorbid condition were answered as either 'yes' or 'no'. This was used to categorize non-MSK health conditions (heart disease, high blood pressure, diabetes, cancer, depression, lung disease, ulcer or stomach disease, kidney disease, anemia or other blood problems, and other medical disease) as: 0=having no health problems, 1=having one health problem and 2=having two or more health problems.

3.2.4 The Work Limitations Questionnaire (WLQ-26)

There are 26 items in the work limitations questionnaire(WLQ-26) which are divided into 4 subscales: time, mental-interpersonal, output and physical work limitations (16). The physical limitations inquire about participants capability to carry out tasks involving strength, endurance and co-ordination. The mental-interpersonal limitations inquiries about participants' capability to carry out mental tasks and social relations at work. While the output limitations inquiries about productivity at work, the time limitations questioned about time management doing work-related tasks(17).

The WLQ-26 has been employed in different working population and it takes less than10 minutes to complete the WLQ-26 (16). Each subscale ranges from 0-4 (0=difficulty none of the time; 1= difficulty a bit of the time; 2=difficulty a some of the time; 3=difficulty most of the time;

4= difficulty all of the time) (17). A total score range between 0 (no limitations) and 100 (most limitations) (17). The scale has good internal consistency, test-retest reliability and construct validity(17). A minimally clinical important difference (MCID) of 13 points for raw score and 5 points for index score has been identified (17).

3.2.5 Statistical analysis

STATA/1C14.2 was used for all statistical analysis. Scores of individual items of the WLQ-26 were summed, averaged, and standardized to a score of 0–100, with a higher score signifying more wok limitations. A histogram enabled a visual impression of each sub-scale. Shapiro-wilk test of normality (alpha≤0.05) confirmed that the data were skewed so medians, interquartile range of work limitations scores were reported. Means and standard deviation were then derived for firefighters' demographics, including their age, sex, BMI and years in fire service. Frequencies and percentages were derived for the number and type of non-MSK comorbidities.

Univariate linear regression models were constructed with work limitations (time, output, mental and physical sub-scales) as a dependent variable and non-musculoskeletal comorbid health conditions (0, 1, 2 or more comorbidities) as a predictor. Multivariate models using backward elimination were constructed using each sub-scale as dependent variable while the demographics (age, sex, BMI), years in fire service and non-MSK comorbid condition were predictors. Also, separate univariate and multivariate models were run for men and women FFs as per sex and gender equity research (SAGER) guidelines(18).

3.3 Results

3.3.1 Sample demographics

The sample analyzed consisted of 325 FFs of which 216 were men and 109 were women. The mean(SD) age of FFs in the study was 39.9(±9) years and they had been in fire service for an average of 12.9(±8.6) years **See Table 3.1.** The median and interquartile range work limitation scores (/100) of each sub-scale are displayed in **Table3.2**.

3.3.2 Non-MSK comorbidity by demographic characteristics

An estimated 31% of FFs (n=102) reported non-MSK comorbidity with 23% (n=76) reporting at least one non-MSK comorbidity and 8% (n=26) reported having two or more comorbidities **See Figure 3.1 and 3.2.** The most reported type of non-MSK comorbidity among FFs was having depression 9.2%(n=30) and high blood pressure 8.6% (n=28). **See Table 3.3.**

3.3.3 Work limitations by the number of non-MSK comorbidity

Analysis of the univariate models demonstrated that having at least one comorbidity (p=0.03) was a significant predictor of mental work limitations alone (R^2=0.02; $F_{2,316}$=2.94, p=0.05). **See Table 3.4.** Univariate models for men and women showed that only women FFs having one comorbidity predicted physical and mental work limitations compared to women without non-MSK comorbidity. There was no significant predictor of work limitations among men FFs. **See table 3.4.** Age had a significant univariate association with each sub-scale (physical, mental, time and output) **See Table 3.5.** We were able to identify a multivariate model for the mental work limitations (R^2=0.05; $F_{4,313}$=4.36, p=0.002) that included one non-MSK comorbidity, age and years in fire service. We were also able to identify a multivariate model for output work

limitation (R^2=0.03; $F_{2,306}$=5.28, p=0.005) with age and years of service in the model. **See Table 3.5.** There were no significant predictors in the multivariate model for men and women FFs.

3.4 Discussion

Our study showed a generally low median work limitations scores among FFs despite having at least one non-MSK comorbidity. In addition, there was a small but significant impact of non-MSK comorbidity on work limitations among FFs. Similarly, a study by MacDermid et al.,(16) reported low work limitations, among FFs with at least one comorbid health condition. Our study showed that older age was a significant predictor of work limitations among FFs which is in contrast with a study by Lusa et al., (19). Her study examined how firefighting tasks affected FFs across different age groups in Finland. She concluded that carrying out certain firefighting tasks including smoke diving, roof work and handling heavy equipment remains the same throughout a firefighter's career irrespective of age. The difference in results of both studies might be due to the different questionnaire that was used in assessing FFs. Our study utilized the WLQ-26 while the study by Lusa and colleagues (19) employed a questionnaire that specified various firefighting tasks.

Furthermore, there was a moderate prevalence of non-MSK comorbidity (31%) among FFs with an almost uniform prevalence in women FFs (32%) and men FFs (31%). In contrast to our study, Plat et al.(7), examined the impact of comorbidity among Dutch FFs. The result showed that about a quarter (23%) of FFs reported the presence of at least a comorbidity, however the comorbidity did not impact the work ability of the FFs. The difference in the result of both studies might be related to the different geographic locations under study. Women FFs are often excluded from studies but our study had a significant sample of women FFs. Hence, our findings showed

that women FFs having at least one non-MSK comorbid health condition experience greater physical limitations. Older age showed a small but significant association with greater output and mental work limitations in this study. This agrees with a study by Slater et al.(20), who reported that comorbid health condition increases the risk of physical limitations specifically in persons with existing comorbidities(20).

In contrast to Sinden et al.,(21), our study showed that lesser years in fire service influences mental and output limitations among FFs with non-MSK conditions. The difference in results may be attributed to the population under study and measure of work performance in both studies. Our study focused on FFs with non-MSK comorbid conditions and used a generic self-reported WLQ-26 while her study examined healthy FFs and specific firefighting tasks such as hose drag to determine work performance. Our study also indicated that despite the moderate prevalence of non-MSK comorbid conditions among FFs, a large percentage (80%) of FFs reported being treated for the condition. This is expected as firefighting is a strenuous occupation that requires physically fit and healthy population(22). Lastly, men were on average older and bigger (42.6years vs 27.8kg/m^2) than women FFs (34.6 years vs 24.7kg/m^2). Men FFs also reported longer tenure (16 years) in fire service than the women FFs (7years). This is not surprising as firefighting is a male dominated occupation with a very low percentage of women FFs(14). Similar to other studies in the literature, the differences in BMI between men and women FFs may be linked to women FFs being smaller and having lesser muscle mass and more body fat on average than men FFs (14,23).

3.5 Strengths

This study is a substantial representation of FFs in Hamilton, Ontario with adequate representation of men and women FFs. Evidence suggest that most FFs studies usually exclude

the female FFs because they occupy a low fraction of the whole FFs population (14) but this study had an adequate number of female FFs participants.

3.6 Limitations

Our study was a cross sectional study, and therefore does not provide absolute information about a causal relationship between the number of non-MSK comorbid health condition and work limitations among FFs. We were unable to determine the specific diagnoses made for the non-MSK comorbid health condition reported by FFs. There was a generally low score of work limitations among FFs with non-MSK comorbid conditions, given the arduous task that FFs perform the WLQ-26 may not be a sufficiently representative instrument. This is expected as firefighters are more likely to possess the healthy worker effect due to a lower morbidity and mortality rate at work compared to the general work force. Therefore a self-report performance limitations scale should be considered for FFs to identify limitations at work(16).

3.7 Recommendation

Our study highlights the non-MSK comorbid health concerns of men and women in firefighting thus supporting the need for inclusion of women FFs in future studies. Future studies are needed to provide greater insight into how comorbidity might affect work performance in firefighters. The study should include firefighter specific work limitations questionnaire and might consider using mixed methods along with more detailed quantification of the nature and severity of the medical conditions affecting firefighter health and work performance.

3.8 Conclusion

Our findings suggested a generally healthy population of FFs with moderate comorbid health challenges. Having one non-MSK comorbidity had a small but significant association with mental work limitations. Also, older age indicated a small but significant association with each sub-scale. Women FFs with one non-MSK comorbid health conditions experienced more physical limitations than women without non-MSK condition. There was no significant association between men FFs with and those without non-MSK comorbidity.

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Table 3.1: Sample demographics

Demographics Characteristics	All	Male	Female
Frequency (%)	325	216 (66%)	109 (34%)
Mean(SD)			
Age (yrs.)	39.9±9.4	42.6±8.7	34.7±8.5
Height (m)	1.8±0.3	1.82±0.3	1.69±0.1
Weight (kg)	83.2±14.2	89.9±11.3	70.5±9.5
BMI (kg/m^2)	26.8±4.3	27.8±4.1	24.7±4.0
Years of service (yrs.)	12.9±8.6	15.9±8.1	7.4±7.5

BMI=Body mass index

Table 3.2: Median and interquartile range (IQR) work limitation scores

Median and IQR of Work limitations	No comorbidity	One comorbidity	Two or more comorbidity
Physical limitation scores	0 (0, 9.3)	1.6 (0, 12.5)	0 (0, 12.5)
Mental limitation scores	12.5 (3, 21.8)	15.5 (6.2, 28.1)	12.5 (0, 18.7)
Time limitation scores	4.2 (0, 16.6)	8.3 (0, 16.6)	4.2 (0, 12.5)
Output limitation scores	6.3 (0, 18.7)	12.5 (6.2, 25)	6.3 (0, 18.7)

IQR- Interquartile range

Table 3.3: Prevalence of the type of Non-MSK comorbidity among FFs

Frequency (%)	All	Male	Female
Presence of comorbidity	102(31.4%)	67 (31%)	35 (32%)
Heart disease	6(1.8%)	5 (2.3%)	1 (0.9%)
High blood pressure	28 (8.6%)	21 (9.7%)	7 (6.5%)
Lung Disease	4 (1.2%)	3 (1.4%)	1 (0.9%)
Diabetes	2 (0.6%)	2(0.9%)	0
Ulcer/stomach pain	6(1.8%)	5 (2.3%)	1 (0.9%)
Kidney disease	0	0	0
Anaemia	11(3.3%)	6 (2.8%)	5 (4.6%)
Cancer	5 (1.5%)	4 (1.8%)	1 (0.9%)
Depression	30 (9.2%)	17 (7.7%)	13 (11.7%)
Others	41 (12.5%)	27 (12.4%)	14(12.8%)

Table 3.4: Univariate regression results for the work limitation sub-scales among firefighters

Overall	Physical (R^2=0.01)		Mental (R^2= 0.06)		Output (R^2= 0.04)		Time (R^2= 0.02)	
	β (S.E)	ρ	β (S.E)	ρ	β (S.E)	ρ	β (S.E)	ρ
One comorbidity	2.39(1.76)	.17	4.48(2.06)	.03*	2.84(2.04)	.16	1.51(1.85)	.41
Two or more CM	-1.53(2.77)	.58	-2.26(3.21)	.48	-2.64(3.18)	.40	1.13(2.95)	.70
Cons	7.27(.89)	<.05	14.76(1.05)	<.05	12.64(1.03)	<.05	10.09(.93)	<.05
Male	Physical (R^2=0.004)		Mental (R^2= 0.02)		Output (R^2= 0.01)		Time (R^2= 0.001)	
One comorbidity	.66(2.32)	.77	3.57(2.58)	.16	2.33(2.56)	.36	.13(2.24)	0.95
Two or more CM	-3.48(4.03)	.38	-5.20(4.35)	.23	-4.88(4.30)	.25	-1.77(3.67)	0.62
Cons	8.16(1.19)	<.05	15.41(1.32)	<.05	12.80 (1.32)	<.05	10.66(1.13)	<.05
Female	Physical (R^2=0.07)		Mental (R^2= 0.04)		Output (R^2= 0.01)		Time (R^2= 0.04)	
One comorbidity	6.27(2.40)	.01*	6.71(3.45)	0.05*	4.05(3.36)	.23	4.64(3.31)	.16
Two or more CM	1.72(3.18)	.58	2.23(4.66)	0.63	0.80(4.56)	.86	6.77(4.94)	.17
Constant	-2.01(7.21)	<.05	13.39 (1.72)	<.05	12.31(1.62)	<.05	8.84(1.63)	<.05

BMI=body mass index; CM=comorbidities; *= p is significant if ≤ .05

Table 3.5: Multivariate regression results for the work limitation sub-scales among firefighters

	Physical (R^2=0.05)		Mental (R^2= 0.05)		Output (R^2= 0.04)		Time (R^2= 0.02)	
Overall	β (S.E)	ρ	β (S.E)	ρ	β (S.E)	ρ	β (S.E)	ρ
One comorbidity	-	-	4.25(2.06)	.04*	-	-	-	-
Two or more CM	-	-	.75(3.20)	.81	-	-	-	-
Age	.31(.07)	<.05*	0.28(.09)	.004*	0.27(.09)	.004*	0.17(.08)	.04*
Years in service	-	-	-.25(.10)	.02*	-.22(.10)	.03*	-	-
Cons	-4.38(3.21)	.12	14.76(1.05)	<.05	5.05(3.77)	0.18	3.49(3.50)	.31
Male	Physical (R^2=0.06)		Mental (R^2= 0.01)		Output (R^2= 0.01)		Time (R^2= 0.00)	
Age	.39(.11)	.001*	.20(.12)	.09	.19(.12)	.12	-	-
Cons	-8.50(4.89)	.08	6.99(5.47)	.20	4.86(5.44)	.37	-	-
Female	Physical (R^2=0.08)		Mental (R^2= 0.06)		Output (R^2= 0.07)		Time (R^2= 0.00)	
One comorbidity	5.52(2.49)	.02*	-	-	-	-	-	-
Two or more CM	1.74(3.17)	.58	-	-	-	-	-	-
Age	.11(.12)	.35	.40(.16)	.02*	.43(.16)	.01*	-	-
Constant	-1.43(4.39)	.74	.95(5.94)	.87	-1.63(5.83)	.78	-	-

BMI=body mass index; CM=comorbidities; *= p is significant if ≤ .05

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Figure 3.1: Number of comorbidities

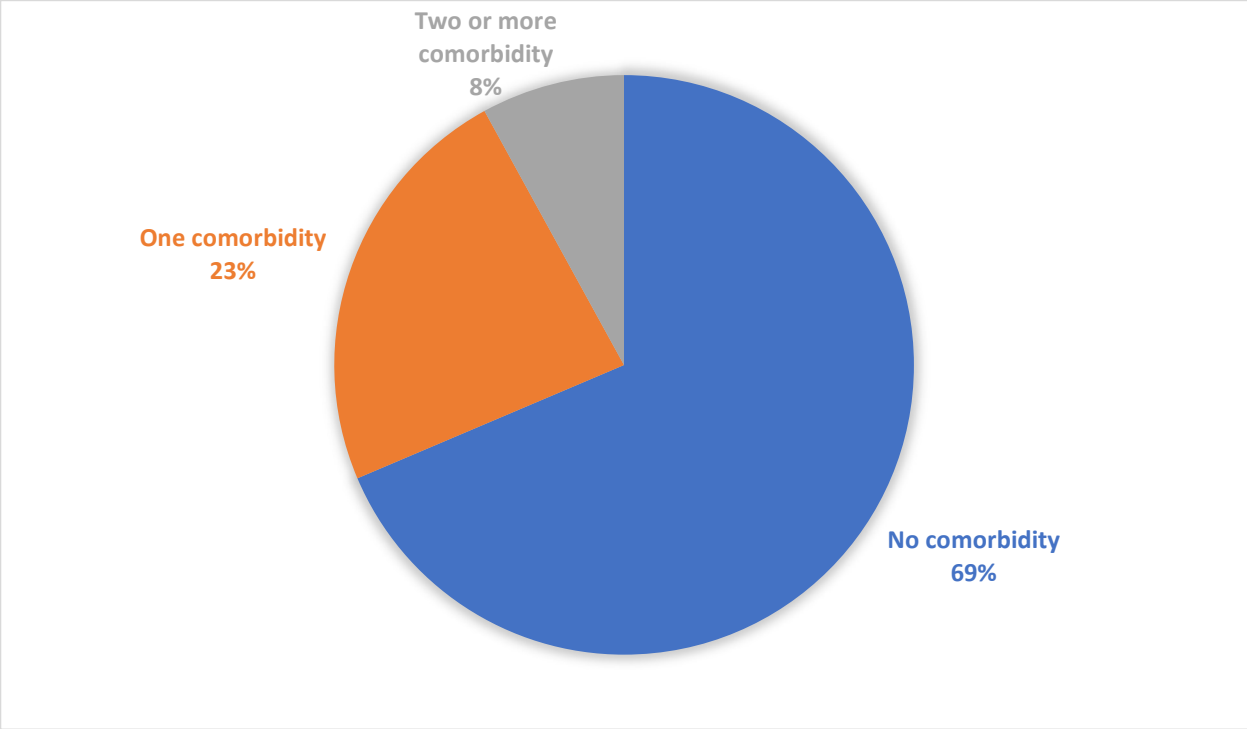
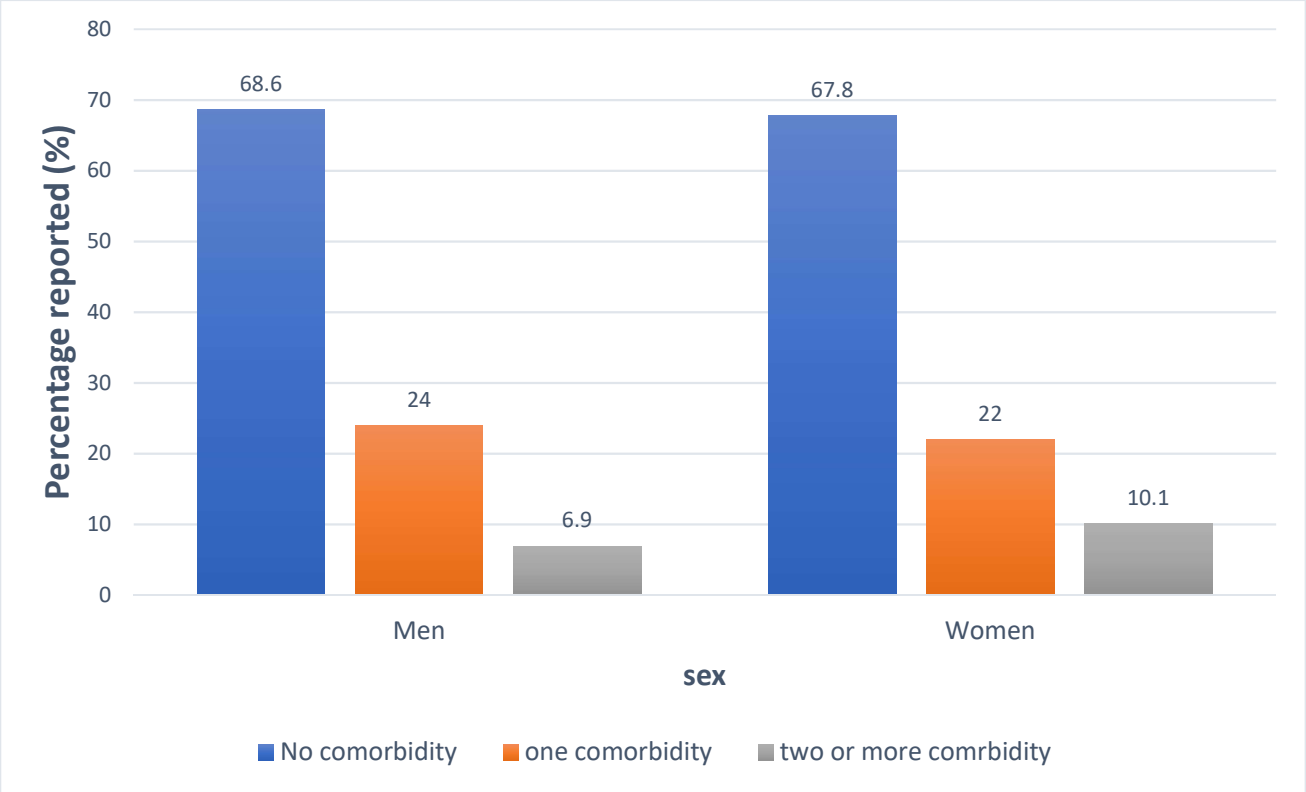


Figure 3.2: Number of comorbidities by sex



3.9 References

1. Guidotti TL, Clough VM. Occupational Health Concerns of Firefighting. Annu Rev Public Health [Internet]. 1992 [cited 2018 Apr 19];13(1):151–71. Available from: https://www.annualreviews.org/doi/pdf/10.1146/annurev.pu.13.050192.001055

2. Soteriades ES, Smith DL, Tsismenakis AJ, Baur DM, Kales SN. Cardiovascular disease in US firefighters: A systematic review. Cardiol Rev. 2011;19(4):202–15.

3. Guidotti TL, Clough VM. Occupational Health Concerns of Firefighting. Annu Rev Public Health [Internet]. 1992 May [cited 2018 Jan 9];13(1):151–71. Available from: http://www.annualreviews.org/doi/10.1146/annurev.pu.13.050192.001055

4. LeMasters GK, Genaidy AM, Succop P, Deddens J, Sobeih T, Barriera-Viruet H, et al. Cancer Risk Among Firefighters: A Review and Meta-analysis of 32 Studies. J Occup Environ Med [Internet]. 2006 Nov [cited 2018 Feb 13];48(11):1189–202. Available from: https://insights.ovid.com/crossref?an=00043764-200611000-00014

5. Katsavouni F, Bebetsos E, Malliou P, Beneka A. The relationship between burnout, PTSD symptoms and injuries in firefighters. Occup Med (Chic Ill) [Internet]. 2016 Jan [cited 2017 May 14];66(1):32–7. Available from: https://academic.oup.com/occmed/article-lookup/doi/10.1093/occmed/kqv144

6. Daniels RD, Bertke S, Dahm MM, Yiin JH, Kubale TL, Hales TR, et al. Exposure–response relationships for select cancer and non-cancer health outcomes in a cohort of US firefighters from. Occup Env med [Internet]. 2015 [cited 2018 Feb 20];72:699–706. Available from: http://dx.doi.org/10.1136/

7. Marie-Christine J Plat MHF-D and JKS. Impact of Chronic Diseases on Work Ability in

Ageing Firefighters. J Occup Heal [Internet]. 2012 [cited 2018 Apr 14];54. Available from: https://www.jstage.jst.go.jp/article/joh/54/2/54_11-0105-OA/_pdf

8. Graveling R. Scoping study : Review of aging and the demands of firefighting Head of Human Sciences Honorary Senior Lecturer , School of Medicine and. 2011;(August).

9. Negm A, Macdermid J, Sinden K, D 'amico R, Lomotan M, Macintyre NJ. Prevalence and distribution of musculoskeletal disorders in firefighters are influenced by age and length of service. J Mil Veteran Fam Heal [Internet]. 2017 [cited 2018 Jan 9];3(2):33–41. Available from: http://jmvfh.utpjournals.press/doi/pdf/10.3138/jmvfh.2017-0002

10. Jahnke SA, Carlos Poston WS, Keith Haddock C, Jitnarin N. Injury among a population based sample of career firefighters in the central USA. Inj Prev [Internet]. 2013 [cited 2017 Sep 28];19:393–8. Available from: http://injuryprevention.bmj.com/content/injuryprev/19/6/393.full.pdf

11. Lunde L-K, Koch M, Knardahl S, Waersted M, Mathiassen SE, Forsman M, et al. Musculoskeletal health and work ability in physically demanding occupations: study protocol for a prospective field study on construction and health care workers. BMC Public Health [Internet]. 2014 [cited 2017 Oct 26];14. Available from: http://www.biomedcentral.com/1471-2458/14/1075

12. Temitope A. Osifeso, Joy C MacDermid, Kathryn E. Sinden LGM. Differences in work limitations in firefighters based on the number or location of body pain. Unpubl Manuscr. 2018;1–4.

13. The Fire Service Joint Labor Management Wellness-Fitness Initiative. 2008 [cited 2017 May 29]; Available from: http://www.iaff.org/hs/LODD_Manual/Resources/IAFF-IAFC

WFI 3rd Edition.pdf

14. Jahnke SA, Poston WSC, Haddock CK, Jitnarin N, Hyder ML, Horvath C. The health of women in the US fire service. BMC Womens Health [Internet]. 2012 Oct 31 [cited 2018 Feb 13];12:39. Available from: http://www.ncbi.nlm.nih.gov/pubmed/23114186

15. Dinç AT. Work impairment and limitations associated with depression. Clinical Bulletin. 2007.

16. J M, K T, K S, R D. Work functioning among firefighters: a comparison between self-report and functional task performance. J Occup Rehabil [Internet]. 2017;0(0):0. Available from: http://dx.doi.org/10.1007/s10926-018-9778-6

17. Lerner D, Reed JI, Massarotti E, Wester LM, Burke TA. The Work Limitations Questionnaire's validity and reliability among patients with osteoarthritis. J Clin Epidemiol [Internet]. 2002 [cited 2017 Nov 13];55:197–208. Available from: https://journals-scholarsportal-info.libaccess.lib.mcmaster.ca/pdf/08954356/v55i0002/197_twlqvarapwo.xml

18. Heidari S, Babor TF, De Castro P, Tort S, Curno M. Sex and Gender Equity in Research: rationale for the SAGER guidelines and recommended use. [cited 2018 May 17]; Available from: https://researchintegrityjournal.biomedcentral.com/track/pdf/10.1186/s41073-016-0007-6

19. Lusa S, Louhevaara V, Kinnunen K. Are the job demands on physical work capacity equal for young and aging firefighters? [Internet]. Vol. 36, Journal of Occupational and Environmental Medicine. 1994. p. 70. Available from: http://journals.lww.com/joem/abstract/1994/01000/are_the_job_demands_on_physical_w

ork_capacity.17.aspx

20. Slater M, Perruccio A V, Badley EM. Musculoskeletal comorbidities in cardiovascular disease, diabetes and respiratory disease: the impact on activity limitations; a representative population-based study. 2011 [cited 2018 Mar 22]; Available from: https://journals-scholarsportal-info.libaccess.lib.mcmaster.ca/pdf/14712458/v11inone/77_mcicddalarps.xml

21. Kathryn Sinden BE, Kathryn Sinden by E. Identifying Determinants of firefighter work and health task performance: Implications for injury management. [cited 2017 May 27]; Available from: https://macsphere.mcmaster.ca/bitstream/11375/15948/1/Sinden KE_PhD Thesis_Occupational Health and Firefighting.pdf

22. Jahnke SA, Hyder ML, Haddock CK, Jitnarin N, Day RS, Poston WSC. High-intensity Fitness Training Among a National Sample of Male Career Firefighters. 2015 [cited 2017 Jul 20]; Available from: http://pubmedcentralcanada.ca/pmcc/articles/PMC4372219/pdf/main.pdf

23. Fitness and Work Capacity 2009 Edition. 2009 [cited 2017 May 30]; Available from: https://www.nwcg.gov/sites/default/files/products/pms304-2.pdf

APPENDIX

Appendix C: The Katz self-administered Comorbidity Questionnaire

The Self-Administered Comorbidity Questionnaire

Instructions:
The following is a list of common health problems. Please indicate if you currently have that problem listed in the first column. If you do not have that problem skip to the next problem.
If you do have the problem, please indicate in the second column if you receive medications or some other types of treatment for the problem.
In the third column indicate if the problem limits any of your activities.
Finally, indicate all medical conditions that are not listed, as "other medical problems", and list them at the end of the page.

Problem	Do you have the problem?		Do you receive treatment for it?		Does it limit your activities?	
	Yes	No	Yes	No	Yes	No
Heart disease						
High blood pressure						
Lung disease						
Diabetes						
Ulcer or stomach disease						
Kidney disease						
Anemia or other blood disease						
Cancer						
Depression						
Osteoarthritis, degenerative arthritis						
Back Pain						
Rheumatoid arthritis						
Other medical problems						
Please list other medical problems:						

Scoring No = 0 Yes = 1

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Chapter Four: Discussion and Future Directions

4.0 Summary

The purpose of this thesis was to provide evidence on the role of firefighter health as a predictor of work limitations in fire service. Findings from this study are intended to help inform and decrease individual and occupational health-related burden of firefighters (FFs) at work. Musculoskeletal (MSK) disorders or non-MSK comorbidities influence the work ability of FFs through the loss of productivity, absenteeism, sick leaves, workers compensation, and even early retirement(1). These conditions are due to several factors unique to FFs during firefighting tasks including repetitive trauma, sustained or awkward postures and recurrent exposures to toxic chemicals or gases (2). The impact of occupational health hazards on work limitations is an important aspect in fire service that cannot be over-emphasized.

Therefore, a thorough literature review examined the health experience of FFs and existing gaps in literature relating to sex, ageing, MSK disorders, non-MSK comorbidities, unhealthy lifestyle challenges and issues in measurement of work limitations. Based on this extensive review, several occupational factors in fire service influences work limitations. Firstly, older men and women FFs experience more work limitations than younger peers due to the high demands and risks involved in firefighting (3). Also, there is a paucity on the occupational health concerns of women FFs. Therefore, there is a crucial need for more research involving women FFs to better address their health concerns. Another issue or gap in the literature is the use of generic work limitations measures that are not specific to FFs. A recent study found a ceiling effect in utilizing such measures (4), hence the need of FFs specific measures of work limitations.

Our first study examined the differences in work limitations among FFs based on the number or location of painful sites using a checklist of location of body pain. The WLQ-26 questionnaire was used to evaluate 325 FFs primarily in Hamilton, and other cities in Ontario.

Findings from the study showed that FFs with multiple painful sites or pain at the spinal region experience more work limitations than FFs with no pain. There are very few studies involving women FFs but our study had an adequate representation of women in fire service. The work limitation scores of men and women FFs were generally low, and the number or location of painful sites had a small but significant effect on work limitations. Men and women FFs with multiple painful sites experience more mental work limitations than their counterparts without pain. In addition, older age had an impact on physical work limitations in this population. Therefore, ageing is a significant factor that influences work limitations in fire service. This should be put into perspective when delegating firefighting tasks to avoid unfavorable effects within the teams or public. Also, designated training programs that address the ageing population in fire service should be encouraged.

The second study focused on non-MSK comorbid health condition as predictors of work limitations among FFs. Having completed the self-reported comorbidity questionnaire, there was a moderate prevalence (31%) of non-MSK comorbid conditions. Men and women FFs also reported a uniform prevalence. The most reported non-MSK comorbid condition among FFs was high blood pressure and depression. In the literature high blood pressure is a risk factor for CVD which is the foremost cause of morbidity and mortality in fire service (5). Despite the moderate prevalence of comorbidities, a large percentage (80%) of FFs reported actively managing the condition. This study also found that men and women FFs with non-MSK comorbidities reported low work limitation scores which further establishes the active management of the conditions reported. In general, having at least one comorbidity had a small but significant effect on mental work limitations. Lastly, women FFs with one comorbidity predicted physical and mental limitations compared to peers without non-MSK comorbidity. There was no significant predictor

of work limitations between men FFs with or without non-MSK comorbidity. This agrees with most evidence in the literature that suggests that women FFs have low levels of physical strength, anaerobic power and cardiovascular endurance needed to carry out firefighting tasks compared to men FFs (3,5). However, these MSK properties can be improved among FFs with training to effectively perform these tasks (5).

4.1 Clinical and research implications

The literature review on the role of FFs health as predictors of work limitations found consistent evidence that the job of firefighting is an arduous occupation that impacts their health and well-being (1,3). The number of years in fire service and demographic factors including age and sex have a significant impact on work limitations experienced in firefighting. Also, it contributes to the understanding of the impact of work limitation among FFs; especially women FFs. In addition, it informs the prevalence of specific categories of work limitations and the limitation risk associated with chronic conditions. Therefore, it might be practical for clinicians, fire organizations and other stakeholders to ensure that adequate healthcare goals are emphasized and adhered by FFs to alleviate individual, societal and organizational burdens.

The first study emphasizes the detrimental effect of having pain at multiple sites and how pain at the spinal region influences work limitations. Various evidence has established the high prevalence and burden of musculoskeletal disorders(1) among FFs including the individual(3), organizational and economic cost (7). However, little to no evidence has effectively demonstrated the broader range of work limitations, including challenges related to the interpersonal or mental demands of the job. Therefore, our study contributes to the literature by stressing the impact of musculoskeletal disorders on work limitations among FFs. It also included a substantial sample of

women FFs in a male dominated occupation to emphasize the need for inclusion and a better understanding in managing their various health concerns.

The second cross-sectional study contributes substantively to the impact of certain chronic conditions on work limitations among FFs. Similar to other studies(8), our study emphasized the prevalence of high blood pressure which is a significant risk factor for CVD among FFs. Depression was also prevalent in this population; hence, it is crucial for FFs with underlying non-MSK conditions to undergo consistent medical evaluations or screening to avoid endangering the lives of other team members and the public. This should be the key goal of every fire organization and physicians providing care to FFs. Overall, this study showed a small but significant association between mental work limitations and having at least one non-MSK comorbidity in FFs. Also, women FFs with one non-MSK comorbidity experienced physical limitations more than women FFs without non-MSK comorbidity. Therefore, tailoring or modifying firefighting tasks to reduce the physical load among women FFs with an underlying comorbid condition might be a possible beneficial effect.

4.2 Strengths

The strength of this thesis is the adequate representation of FFs in Hamilton, Ontario. Likewise, this thesis has an adequate representation of female FFs which has been found to be very scarce in the literature. Therefore, the impact of FFs health condition on work limitations in this study may be easily generalizable to both sexes.

4.3 Limitations

In this dissertation, two studies were conducted to examine the research question on the role of FFs health as predictor of work limitations in fire service, focusing on the location or number of painful sites and non-MSK comorbid health condition among FFs. Although there were

some interesting findings on work limitations among FFs, however the fact that this study was cross-sectional makes it difficult to draw causal inferences between the health experiences of FFs and their work limitations. Furthermore, a direct measurement of percentage body fat or the use of waist circumference would have been a better determinant of being overweight or obese in fire service than BMI that was utilized in our study due to its documented limitations(8). Although, BMI may overestimate body fat measures in FFs, it is the most recognized measure and provides a basis of comparison across literature.

4.4 Future directions

There are few studies in the literature that examine the impact of health experiences of FFs in the workplace, hence the need for more high-quality studies examining work limitations among FFs. Also, this study would like to encourage more studies that include women FFs to increase awareness of occupational health concerns in this population. Given that FFs are an ageing workforce especially in industrial countries like Canada, more studies on older FFs are highly warranted. Mental health in fire service is another area of health that greatly impacts their work limitations, it should therefore be investigated appropriately in parallel with physical health conditions. Lastly, researchers are encouraged to develop validated work limitations measure specific to FFs to adequately measure work limitations in this population.

4.5 References

1. Negm A, Macdermid J, Sinden K, D 'amico R, Lomotan M, Macintyre NJ. Prevalence and distribution of musculoskeletal disorders in firefighters are influenced by age and length of service. J Mil Veteran Fam Heal [Internet]. 2017 [cited 2018 Jan 9];3(2):33–41. Available from: http://jmvfh.utpjournals.press/doi/pdf/10.3138/jmvfh.2017-0002
2. Kumar S. Theories of musculoskeletal injury causation. Ergonomics [Internet]. 2001 [cited 2018 Feb 13];44(1):17–47. Available from: http://injury-forensics.com/wp-content/uploads/2016/11/Theories-of-musculoskeletal-injury-causation.pdf
3. Graveling R. Scoping study : Review of aging and the demands of firefighting Head of Human Sciences Honorary Senior Lecturer , School of Medicine and. 2011;(August).
4. J M, K T, K S, R D. Work functioning among firefighters: a comparison between self-report and functional task performance. J Occup Rehabil [Internet]. 2017;0(0):0. Available from: http://dx.doi.org/10.1007/s10926-018-9778-6
5. Soteriades ES, Smith DL, Tsismenakis AJ, Baur DM, Kales SN. Cardiovascular disease in US firefighters: A systematic review. Cardiol Rev. 2011;19(4):202–15.
6. Findley BW, Brown LE, Whitehurst M. Anaerobic power performance of incumbent female firefighters. J Strength Cond Res. 2002;16(3):474–6.
7. Walton SM, Conrad KM, Furner SE, Samo DG. Cause, type, and workers' compensation costs of injury to fire fighters. Am J Ind Med. 2003;43(4):454–8.
8. Marie-Christine J Plat MHF-D and JKS. Impact of Chronic Diseases on Work Ability in Ageing Firefighters. J Occup Heal [Internet]. 2012 [cited 2018 Apr 14];54. Available from: https://www.jstage.jst.go.jp/article/joh/54/2/54_11-0105-OA/_pdf