

Understanding physical activity in firefighters through a social ecological lens

by

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B.S., Pittsburg State University, 2020

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AN ABSTRACT OF A DISSERTATION

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Abstract

Firefighting is a high-risk, physically demanding occupation that requires firefighters to perform tasks in life-threatening situations. Engaging in physical activity (PA) and exercise regularly can mitigate health concerns and enable firefighters to achieve fitness levels to safely perform their job duties. Although PA and exercise barriers among firefighters have been studied previously, including through a Social Ecological Model lens, little is known about how these multilevel influences shape PA participation and how interpersonal, organizational, and environmental exercise supports can be systematically assessed using a firefighter-specific audit tool. The purpose of this dissertation was to: 1) explore multilevel influences on firefighters' on- and off-duty PA; 2) adapt a multilevel workplace PA audit tool for firefighters and evaluate reliability; 3) examine frequencies of multilevel exercise supports and PA behaviors across three fire departments; and 4) examine relationships between audit tool domains and PA volume at different intensities. This dissertation is composed of three studies (Chapters 2, 3, and 4). **Methods:** In Chapter 2, a mixed-methods study, we explored multilevel influences on both on- and off-duty PA using a survey ($N = 32$) followed by focus groups ($N = 30$). Chapter 3 implemented three phases to select, adapt, and pilot test a fire department, exercise-specific audit tool. Fifty-eight firefighters from three career fire departments completed the adapted tool via online survey. Chapter 4 used the newly adapted audit tool to explore differences in fire departments' exercise supports ($N = 58$ firefighters), and participants wore accelerometers for 7 consecutive days to examine PA behaviors ($n = 44$). **Results:** Chapter 2 found intrinsic motives and self-efficacy to be moderately associated with PA. Several themes emerged indicating firefighters' PA participation is shaped by peer and family dynamics, departmental norms, operational demands, and their physical environment and resources. Chapter 3 resulted in an adapted Fire Department Multilevel Exercise Supports (FD-

MES) tool focused on exercise (i.e., structured PA) using a total of 104 items across five domains. Reliability varied across rater comparisons and showed distinct rank-based patterns (e.g., captain vs. firefighters) with captain-to-captain raters having the highest proportion of items (21.2%) considered to have moderate to perfect reliability compared to captain-to-firefighter and firefighter-to-firefighter raters (10.6% and 11.5%, respectively). Many items (38.5%-43.3%) across rater comparisons lacked sufficient variability for kappa estimation. Additional refinement is needed to operationalize terms and improve reliability of some items. Results in Chapter 4 found significant differences between the three fire departments for the Community Assets & Partnership domain and few subdomains. Participants accumulated an average of 56.10 minutes of moderate-to-vigorous PA per on-duty day, with few differences in PA intensities observed between departments. No significant associations were observed between on-duty PA and FD-MES domain or subdomains scores. **Conclusions:** Qualitative findings suggest multilevel influences shape both PA opportunities and motivation for firefighters. Firefighters may have differing perceptions of their sources and resources for exercise support by rank, emphasizing the need for transparent policies and streamlined expectations across shifts or stations. This discrepancy by rank may reinforce the need for captains and crew leaders to translate policy into daily practices. The FD-MES addresses a critical gap in the literature, as no existing tool comprehensively assesses fire departments' strengths and areas for improvement related to exercise supports. Although the FD-MES tool needs additional revision to further enhance reliability and validity, it may still be beneficial for fire departments to assess and better understand their department's support for exercise. The combined information from these studies can help inform policy and leadership practices by identifying actionable opportunities to support firefighter exercise participation, such as considering flexible on-duty exercise policies, improving access to fitness resources,

strengthening leadership communication, and establishing avenues for improving PA and exercise promotion efforts across multiple levels within the fire service.

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Conclusions: Qualitative findings suggest multilevel influences shape both PA opportunities and motivation for firefighters. Firefighters may have differing perceptions of their sources and resources for exercise support by rank, emphasizing the need for transparent policies and streamlined expectations across shifts or stations. This discrepancy by rank may reinforce captains and crew leaders to translate policy into daily practices. The FD-MES addresses a critical gap in the literature, as no existing tool comprehensively assesses fire departments' strengths and areas for improvement related to exercise supports. Although the FD-MES tool needs additional revision to further enhance reliability and validity, it may still be beneficial for fire departments to assess and better understand their department's support for exercise. The combined information from these studies can help inform policy and leadership practices by identifying actionable opportunities to support firefighter exercise participation, such as considering flexible on-duty

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Dedication

This dissertation is dedicated to the loving memory of my mother, Rebecca Myriel Brin, whose unwavering love and belief in me made this achievement possible. Your influence remains with me always. I wish more than anything you were here to see this moment in person.

Chapter 1 - Introduction

Firefighter Overview

Firefighting is a unique occupation where firefighters face a myriad of physical (Al-Zaiti et al., 2015; Smith, 2011) and psychological (Del Ben et al., 2006; Jahnke et al., 2012) challenges in hazardous environments. The high-risk nature of the profession, combined with performing strenuous tasks while wearing heavy protective equipment, predisposes firefighters to an increased risk of injuries and line-of-duty deaths. According to the National Fire Protection Association (NFPA), a majority of the fatal injuries that occurred in 2024 were due to overexertion or strain, and among those, cardiac-related events remained the leading cause of death for firefighters in the United States (U.S.) (Campbell et al., 2025; Campbell & Petrillo, 2025). While overall U.S. firefighter fatalities have declined over the past 40 years (Fahy & Petrillo, 2022), the risk for cardiac-related events resulting in death remains high, highlighting the considerable physiological strain associated with the profession.

Maintaining sufficient levels of physical fitness is critical for firefighters to perform their duties, such as stair climbing, door breach, victim rescue, and fire suppression, safely and effectively (Ras, Smith, Kengne, et al., 2022). Maintaining sufficient aerobic capacity and muscular strength and endurance is essential for optimal job performance (Chizewski et al., 2021; Fyock-Martin et al., 2020). However, firefighters may not be physiologically prepared for the demands of the profession (Smith, 2011). Previous research has demonstrated firefighters generally possess poorer aerobic capacity relative to muscular strength and endurance, and there are concerns regarding overall fitness levels (Michaelides et al., 2008; Ras, Smith, Soteriades, et al., 2022; Smith, 2011). To compound this issue further, firefighters spend extended periods of time being sedentary (Barry et al., 2020) and experience high rates of overweight and obesity

similar to the general population (Poston et al., 2011). This mismatch between fitness levels and occupational demands may compromise firefighters' ability to effectively meet the demands of the job and increase the risk of cardiac events and overexertion injuries while on-duty (Gendron et al., 2020; Nazari et al., 2018; Ras, Smith, Kengne, et al., 2022).

Recognizing the concerns regarding firefighter fitness, readiness, and safety, considerable efforts have been made to establish programs and standards to support firefighter health and safety. The International Association of Fire Chiefs and the International Association of Fire Fighters collectively developed the Fire Service Joint Labor Management Wellness Fitness Initiative (WFI), a non-punitive comprehensive health and wellness program, over two decades ago. While the first edition was published in 1999 and predominately focused on physical fitness mandates, the fourth and most recent edition that was published in 2018 shifted to a more holistic approach (e.g., incorporating behavioral health protocols and scalable implementation efforts). Following the efforts early on, the National Fire Protection Association (NFPA) provided more formal guidance on health-related fitness programs for departments by establishing Standard 1583 in 2000, which took the core tenets of the WFI and outlined the following components to be included in fitness programs: 1) a qualified health and fitness coordinator; 2) an annual fitness assessment; 3) an exercise training program; 4) health promotion education and counseling; and 5) a process for collecting and maintaining health-related data (National Fire Protection Association, 2015b). Moreover, it states that fire departments should provide means for regular exercise and allow time to exercise each shift (National Fire Protection Association, 2015b). While these recommendations are established, these practices are completely voluntary for departments to adopt and it is estimated that only one-quarter (~28%) of fire departments offer programs that meet these guidelines (National Fire Protection Association, 2021). As funding is a prominent obstacle for

fire departments (National Fire Protection Association, 2015a), it may be difficult to implement all or a majority of the components in NFPA Standard 1583. As such, providing at least one-hour time block per shift for on-duty PA and exercise may be a more feasible option for many departments. However, the presence of departmental policies alone may not be sufficient for firefighters to adhere to regular participation (Melton et al., 2021), indicating broader contextual and behavioral factors are at play.

Physical Activity Overview

Current U.S. physical activity (PA) guidelines recommend adults engage in a minimum of 150 minutes of moderate-intensity aerobic PA or 75-minutes of vigorous aerobic PA and at least two days per week of muscle strengthening activity (Department of Health and Human Services, 2018; Piercy et al., 2018). Regular PA participation has numerous health benefits including reducing risk for type 2 diabetes, cardiovascular disease, metabolic syndrome, cancer, and all-cause mortality (Fletcher et al., 2018; Warburton et al., 2006). Moreover, exercise, a subset of PA that is planned and structured, may be particularly beneficial for firefighters as it represents a purposeful form of PA designed to improve fitness outcomes (Caspersen et al., 1985). Nonetheless, PA guidelines also state that additional health benefits (e.g., preventing unhealthy weight gain, higher level of physical fitness) can be achieved with up to 300 minutes/week of moderate-intensity aerobic activity or vigorous-intensity equivalent (Haskell et al., 2007). While these recommendations are intended for the general population, achieving activity levels greater than the minimum recommendation may be particularly relevant given the physically demanding nature of firefighting.

Although a few studies have reported firefighters meeting PA guidelines (Agostinelli et al., 2023; Gendron et al., 2020), many suggest that firefighters are not (Barry et al., 2020; Brin et al.,

2023; Durand et al., 2011; Poston et al., 2011; Ras & Leach, 2022). In one cohort study, researchers surveyed 527 career firefighters where roughly 25% reported meeting PA guidelines (Durand et al., 2011). Another study using objectively measured PA found more firefighters met PA guidelines while on-duty compared to off-duty; however, only little over half of the participants were considered to be meeting guidelines (Barry et al., 2020). Given the health benefits associated with regular PA and evidence indicating firefighters are not engaging in sufficient amounts of PA, understanding the factors that influence PA participation among firefighters is imperative.

Barriers and facilitators to PA and exercise among firefighters are well-documented (Kwon et al., 2022; Lovejoy et al., 2015; Melton et al., 2019, 2021; Shah et al., 2024). Constraints related to time are common due to high call volume or station responsibilities which can challenge regular participation (Kwon et al., 2022; Lane et al., 2022; Melton et al., 2019). Occupational-related barriers including unpredictability of service calls, exercise-induced fatigue, and inadequate sleep may inherently discourage firefighters from being active while on-duty (Lovejoy et al., 2015). At the same time, ambivalence has been considered a deterrent to exercise and other healthy habits (Melton et al., 2019). Additionally, social and environmental barriers may further hinder PA participation. For example, inconsistent support from leadership (e.g., officers, command staff) can weaken perceptions that exercise is encouraged within the department (Long et al., 2014; Mabry et al., 2013; Shah et al., 2025), while limited facility availability and fitness equipment can further restrict opportunities for exercise participation (Kwon et al., 2022; Shah et al., 2024). Moreover, the firehouse culture and social dynamics have also been suggested to influence various health behaviors (e.g., nutrition, exercise) (Long et al., 2014; Mabry et al., 2013; Melton et al., 2019). Indeed, social support from fellow firefighters and their superiors can play a crucial role in encouraging PA (Lane et al., 2022; Lovejoy et al., 2015; Mabry et al., 2013). Family

responsibilities and second jobs have been identified to create additional barriers for firefighters, especially while off-duty (Gendron et al., 2020; Shah et al., 2024). Despite the recognized importance of maintaining health and fitness for job duties, firefighters encounter numerous challenges that extend beyond individual choice and encompass occupational, social, and environmental influences on engagement in regular PA. These influences occur across multiple levels and warrant a comprehensive, multilevel framework to simultaneously examine the various barriers and facilitators firefighters face to enhance initiatives targeting PA and exercise engagement.

Social Ecological Model Overview

The Social Ecological Model (SEM) is a multilevel framework that originated from Bronfenbrenner's ecological theory (Bronfenbrenner, 1989) and was later adapted for health behavior change by McLeroy et al. (1988). At its core, the SEM recognizes that behaviors are shaped by interactions between individuals and their social, organizational, environmental (or community), and policy contexts (McLeroy et al., 1988). Embracing these complex sources is the premise for the SEM to understand and influence health behaviors beyond individual choice (Eriksson et al., 2025). It has been widely applied in health promotion and public health research to analyze and intervene in various health behaviors, including cancer prevention, nutrition, and PA behavior (da Silva Louza et al., 2026; Johannes & Roman, 2025; Lusmägi & Aavik, 2021; Pourjalil et al., 2025).

The individual level is the center of the model, where it focuses on personal characteristics and practices of a person, such as knowledge, beliefs, and motivation. The interpersonal level centers around an individual's social relationships and immediate support systems. These various social groups can include family, friends, peers, and coworkers that affect individual decisions and

actions. Following this is the organizational level, also referred to as the institutional level, which includes settings where people spend a majority of their time such as workplaces or schools. The structure, culture, practices, or resources within these settings may inhibit or facilitate a specific health behavior (McLeroy et al., 1988). At the community (or environmental) level, behavior can be shaped by broader geographical or large-scale social environments. These influences can consist of community norms, built environment, or resource availability. The last and highest level is the policy level, which focuses on formal laws and regulations. This can include local, state, and national laws or regulations, as well as the organizational policies, which can shape and mandate systemic behavior change (McLeroy et al., 1988).

A key assumption of the SEM is that there are reciprocal relationships and overlapping influences across levels (McLeroy et al., 1988). Thus, individual behavior and choices can contribute to broader environment change, while social, organizational, and policy decisions can facilitate individual behavior change (Eriksson et al., 2025). The dynamic interplay of the SEM levels allows for a holistic approach to understanding a population's health behavior (McLeroy et al., 1988; Stokols, 1996). Additionally, the SEM is most effective when combined with other theories or models, as Stokols (1996) described the framework as a model to integrate components of various behavior change theories (e.g., Self-Determination Theory, Social Cognitive Theory, Theory of Planned Behavior). As a result, researchers have advocated for the use of the SEM to identify the complex, multilevel factors associated with promoting and participating in PA, especially considering intervention strategies need to be tailored to the specific health behavior and population of interest (Elder et al., 2007; Sallis et al., 2008).

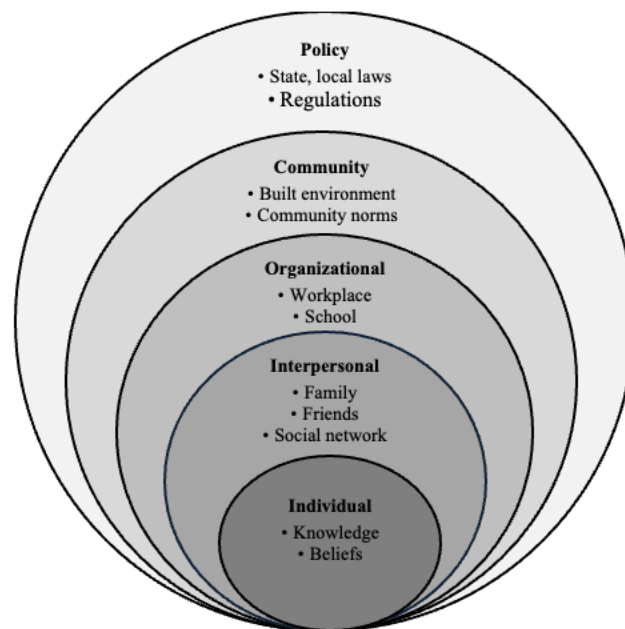
However, a criticism of the SEM is that it primarily serves as a conceptual framework rather than a theory. Technically, the SEM cannot specify the psychological or social mechanisms

that produce behavior change, and because of this, the SEM may be overly inclusive and feel overwhelming when trying to isolate factors of influence (Golden & Earp, 2012; Stokols, 1996). Despite this, the SEM has been used to explain PA participation and inform interventions in various populations, ranging from children to older adults (Lusmägi & Aavik, 2021; Zhang et al., 2015). As interventions with multilevel strategies are promising for effectively changing behavior (Sallis et al., 2008), the SEM is useful as a first step to identify the multilevel influences on PA when examining understudied or unique populations like firefighters (Golden & Earp, 2012). Since firefighters operate within a unique occupational environment shaped by distinct social, environmental, and organizational factors, using this framework enables researchers to examine how these influences interact to affect and shape PA behavior. Moreover, this comprehensive perspective can identify multilevel strategies and opportunities to support sustained participation within the fire service.

Developing effective interventions requires an understanding of the individual characteristics of a population, such as firefighters, and the interactive social, environmental, and organizational level factors. Audit tools provide a systematic method for assessing these factors within a specific setting to identify opportunities for improvement and intervention. Previous research has used audit tools to assess various health behaviors in workplaces (Lang et al., 2020; Loitz et al., 2021), schools (Ajja et al., 2015), and within parks and communities (Besenyi et al., 2016; Ivy et al., 2006). Since occupational settings are effective settings for health promotion efforts, applying a comprehensive framework and using a tool to identify PA supports within workplace settings can strengthen health promotion programming (Loitz et al., 2021). Existing workplace audit tool traditionally target PA broadly and are generally designed for office-based settings (Loitz et al., 2021). As a result, these tools are not tailored to the unique occupational

environment of fire departments nor are designed to assess the multilevel influences that enable structured, planned exercise necessary to meet firefighters' fitness expectations. Therefore, the SEM is a valuable framework for understanding firefighters' PA behavior more broadly as it addresses multiple levels of influence by emphasizing the interaction of these factors across contexts and audit tools are a useful method to systematically identify contextual determinants towards exercise to inform future intervention strategies for the fire service as a whole.

Figure 1.1. Social Ecological Model framework (adapted from McLeroy et al., 1988)



Purpose of Dissertation

Despite growing interest in firefighters' PA and exercise behavior to address concerns regarding health (e.g., cardiovascular disease, obesity) and fitness levels, relatively little research has examined factors influencing PA from a multilevel perspective (Staley et al. 2011), particularly one that simultaneously considers individual, interpersonal, organizational, community, and policy influences. Additionally, few studies have incorporated audit-based approaches within the fire service setting, and most rely on self-reported PA rather than objective assessments (Agostinelli

et al., 2023, Barry et al. 2020). Further, there is a lack of fire department-specific tools designed to comprehensively evaluate multilevel supports for firefighters' exercise within the fire service. Targeting exercise rather PA broadly is necessary due to the nature of the job and to align with fire organization recommendations (e.g., National Fire Protection Association, Fire Service Joint Wellness Fitness Initiative) which emphasize exercise and fitness to maintain occupational readiness. These gaps in the literature limit fire departments' ability to identify key areas for improvement and develop targeted strategies that support firefighter health and fitness. To address these gaps, this dissertation consists of three interconnected studies (i.e., chapters). Chapter 2 explores multilevel influences on firefighters' on- and off-duty PA using mixed methods. Building on these findings, Chapter 3 adapted and pilot tested a fire department-specific audit tool to assess multilevel supports for exercise. Finally, Chapter 4 applied the adapted audit tool and examined three fire departments' exercise supports and the relationship with objectively measured PA behaviors.

Chapter 2 - Multilevel Influences on Physical Activity Among Firefighters: A Mixed Methods Cross-sectional Study using the Social Ecological Model

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Abstract

Firefighters perform a wide range of occupational tasks that require a high level of physical fitness yet also exhibit high rates of physical inactivity and obesity. Physical activity (PA) behaviors among firefighters may be shaped by various influences, including their personal and work environments. **Methods:** This mixed methods study explored influences on firefighters' on- and off-duty PA behaviors across levels of the Social Ecological Model (SEM). Career firefighters (N=32) from a mid-size, midwestern city completed a survey assessing on- and off-duty physical activity, self-efficacy, PA beliefs, exercise motives (EMI-2), social support, perceived work environment supports (WEIS), and community- and policy-level factors supporting PA. Thirty participants (n=30) participated in one of seven semi-structured focus groups to discuss multilevel influences of PA. **Results:** Correlations revealed significant associations between EMI-2 subscales stress management, revitalization, and enjoyment with on-duty moderate PA. Enjoyment and self-efficacy were significantly associated with off-duty vigorous PA, whereas the social WEIS subscale and friend social support were negatively associated with moderate PA while off-duty. Inductive thematic analysis of qualitative data revealed that peer and family dynamics, leadership support, departmental culture, and local or departmental resources and policies were key positive influences on firefighters' PA behavior. **Conclusions:** High levels of PA were reported regardless of duty status, and qualitative themes highlight the complexity of PA influences that firefighters face, shaping both PA opportunities and motivation. On-duty PA opportunities may be more feasible, and accessible given off-shift demands, whereas PA while off-duty seems to be centered around family and within the local community. Fire departments may enhance PA and long-term adherence through supportive leadership, flexible scheduling, equitable resources, and clear policy expectations that reinforce a culture of firefighter health and wellness.

Introduction

Firefighters face unique occupational demands, requiring them to maintain a high level of aerobic and muscular fitness to perform life-saving tasks and ensure their own safety (Ras et al., 2022). However, previous research suggests firefighters exhibit high rates of physical inactivity and overweight or obesity (Barry et al., 2019; Poston et al., 2011), thus negatively impacting job performance and increasing risk for injury and cardiac events while on-duty (Ras et al., 2022). Given that roughly 65% of a career firefighter's work shift is spent performing non-emergency duties (Kales et al., 2007) and engaging in prolonged sedentary periods (Barry et al., 2020), achieving adequate levels of physical activity (PA) is essential (Achmat et al., 2025). Current PA guidelines recommend adults should achieve at least 150 minutes of moderate or 75 minutes of vigorous PA per week, or a mix of both, to prevent various diseases and conditions, although participation in greater amounts may provide additional benefits including higher levels of physical fitness (Durand et al., 2011; Piercy et al., 2018). Prior research suggests firefighters are not meeting PA recommendations (Barry et al., 2019; Baur et al., 2012; Brin et al., 2023; Durand et al., 2011; Ras & Leach, 2022), thus, exploring firefighters' facilitators and barriers to PA may provide necessary insights into their ability to meet or exceed these recommendations.

The Social Ecological Model (SEM) is a common framework used to explain complex interactions between various factors and health behaviors across five levels: individual (i.e., knowledge, attitudes), interpersonal (i.e., family, friends), organizational (i.e., schools, workplaces), community (i.e., community design and safety, facility accessibility), and policy (i.e., local, state, national policies) (McLeroy et al., 1988; Sallis et al., 2008). The SEM has been used to explain PA participation and inform interventions in various populations, from children to older adults (Lusmägi & Aavik, 2021; Zhang et al., 2015). Based on the well-documented applications

of the SEM, this framework provides a valuable lens for understanding firefighters' PA behavior given their unique occupational demands. As the model emphasizes the interaction of influences across different levels, understanding the important factors at each level is essential to identify strategies that address social and physical environments in conjunction with individual-level factors.

Individual factors, such as motivation and self-efficacy, are personal characteristics and beliefs shown to influence PA behavior (Golden & Earp, 2012). PA motives encompass both intrinsic motives (e.g., enjoyment, alignment with goals/outcomes) and extrinsic motives (e.g., appearance, external pressure). Among firefighters, previous research has found those who valued the benefits of PA, found it enjoyable, or personally challenging were more physically active (Long et al., 2014; Vancampfort et al., 2023), as well as motivated to improve their overall health (Long et al., 2014). Additionally, self-efficacy (i.e., an individual's belief to successfully engage in a behavior) is consistently shown to be a strong predictor of PA engagement and adherence (Chen et al., 2017; Grimaud et al., 2025). Thus, higher levels of self-efficacy may enhance PA directly. Conversely, ambivalence and lack of time have been reported as deterrents to exercise among firefighters (Melton et al., 2019), potentially creating conflict in priorities that hinder participation in regular PA. While motives and self-efficacy are important variables, PA participation may also be enhanced by social factors.

Interpersonal variables including social support have been shown to positively influence PA (G. L. Smith et al., 2017) and enhance adherence to regular PA (Courneya & McAuley, 2016). Similarly, family support can facilitate PA through mechanisms such as direct assistance and joint family engagement (Gustafson & Rhodes, 2006; G. S. E. Smith et al., 2023). In occupational settings, coworker support is a strong correlate of PA participation (Sarkar et al., 2016). Within

the fire service specifically, camaraderie and competition between peers enhance motives to be physically active (Lovejoy et al., 2015; Mabry et al., 2013) and peer modelling can promote others to engage in PA (Cheskin et al., 2014). Conversely, lack of peer and family support has been shown to be barriers to PA engagement (Spiteri et al., 2019). Dobson et al. (2013) highlighted peer pressure towards new recruits' eating habits (e.g., large portion sizes) within the firehouse, and while not specific to PA behavior, it suggests interpersonal dynamics may also promote unhealthy behaviors in this population.

At the organizational level, fire departments play a critical role in shaping several health behaviors like PA. Firehouse culture, including teamwork, competition, and camaraderie can provide an environment essential to shift social norms and promote behavior change (Mabry et al., 2013), whereas it may also perpetuate the individual-level barriers previously described (Gold et al., 2022). Organizational structures including onsite fitness equipment availability (Agostinelli et al., 2023), allotted exercise time (Agostinelli et al., 2023; Melton et al., 2021), and supportive leadership (Shah et al., 2025) can further facilitate PA. Nevertheless, occupational barriers including inadequate sleep (Lovejoy et al., 2015), unpredictability of service calls (Lovejoy et al., 2015), and constraints related to time and facility availability (Kwon et al., 2022; Melton et al., 2023) continue to challenge regular participation. Beyond the workplace, the community environment plays an important role for firefighters' off-duty PA participation. Community-level factors including facility accessibility and neighborhood safety, have been identified as important facilitators of PA participation (Andrade et al., 2021). As such, having opportunities both on- and off-duty is crucial for firefighters to engage and participate in PA. While research has primarily examined barriers and facilitators surrounding firefighters' occupational setting, comparatively

little is known about the community and other multilevel influences that facilitate or hinder PA participation during off-duty hours.

Moreover, programs and policies play a central role in the U.S. fire service to promote health and wellness initiatives. Two primary organizations to promote firefighter safety and well-being include the International Association of Fire Chiefs and the International Association of Fire Fighters, which historically represent the management and labor perspectives, respectively. Collectively, these organizations developed the Fire Service Joint Labor Management Wellness Fitness Initiative (WFI), a comprehensive health and wellness program to promote healthy behaviors including fitness and medical evaluations, offering on-duty exercise time, allocating spaces to exercise, and providing rehabilitation and behavioral health services. Based on programs like the WFI, the National Fire Protection Association (NFPA) established voluntary standards to guide how departments should develop and implement fitness programs (National Fire Protection Association, 2015). Despite these recommendations, most U.S. fire departments (72%) still lack sufficient programs to maintain basic firefighter fitness and health (National Fire Protection Association, 2021), leaving firefighters to manage their PA and exercise independently. To support firefighters' fitness, departments may adopt nonpunitive fitness policies, such as providing a one-hour time block per shift for on-duty PA. However, even when such policies are in place, adherence may be of concern. Melton et al. (2021) found that only 12.5% of firefighters adhered to their department's fitness policies, even though greater compliance to the fitness policy was associated with better physical fitness (Melton et al., 2021), emphasizing the benefits of regular adherence. Although health and fitness policies are important to set department-wide expectations, there is a need to understand the multilevel factors that influence firefighters' PA behavior.

Understanding firefighters' PA behavior requires a lens that captures the complexity of their personal and work environments. Although previous research has identified barriers and facilitators to firefighter PA, limited research has examined how these multilevel factors are experienced within and outside of the occupational context. Applying the SEM through mixed methods offers a comprehensive approach to identify key determinants of PA. Consequently, the findings from this study may provide important insights for designing effective interventions, health and fitness programs, and informing policy developments that address the unique needs of firefighters. Therefore, the aim of this mixed methods study was to examine firefighters' on- and off-duty PA behavior and explore the various influences on their PA across levels of the SEM.

Methods

Overview of Study Design

This cross-sectional, mixed methods study used a survey and focus groups to assess firefighters' current PA behaviors and explore key influences at various levels of the Social Ecological Model (SEM). Convenience sampling was used to recruit participants from a mid-sized, midwestern career fire department. Participants provided informed consent separately for the survey and focus group during the spring of 2024. All procedures were approved by the university's institutional review board (protocol #11899).

Participants & Procedures

Participants were recruited using convenience sampling via email containing an overview of the study and a link to the full survey, which was distributed through fire department listservs to approximately 72 personnel. Additionally, flyers with QR codes to the same survey were posted in each fire station to enhance recruitment efforts, with the hope to recruit personnel from a variety of ranks within the department (e.g., battalion chief, captain, driver, firefighter). Upon accessing

the survey, participants were directed to screening questions to determine that they met all inclusion criteria: 1) an incumbent firefighter (i.e., firefighters who complete academy and work full-time at the department) and 2) physically able to engage in fire emergency tasks (e.g., search and rescue, fighting fires, climbing ladders). Personnel in traditional administrative roles (e.g., Assistant Chief, Fire Chief) were excluded from the study. Eligible participants provided informed consent, then proceeded to the full survey. As a recruitment incentive, all participants who completed the survey were entered into a drawing for one of five \$30 gift cards.

At the end of the survey, respondents were asked whether they were willing to participate in an upcoming in-person focus group session. Those who agreed provided their contact information (i.e., email addresses) and were redirected to a scheduling platform to sign up for a focus group session, which were held in-person at one of the department's fire stations. To enhance recruitment efforts for the focus groups, flyers were distributed to each fire station with a QR code linking to the same screening questions. Eligible individuals were then redirected to the scheduling platform. Focus groups continued until data saturation was achieved after seven sessions when no new information emerged.

Participants were informed via email and at the beginning of each session that the lead researcher was a female doctoral student with prior experience working with firefighters to promote PA and improve fitness outcomes, and an interest in learning about their on- and off-duty PA motives, facilitators, and barriers. Three focus groups sessions had a student researcher assist with focus group set up and logistical support. Focus group sessions lasted between 45 minutes and one hour. All sessions started with collecting participant informed consent and demographics (i.e., age, height, weight, race, sex, rank, and years in fire service) via Qualtrics, followed by a discussion of current PA behaviors, motives, facilitators, and barriers using a semi-structured

interview guide (see Appendix Figure A.1). All focus group sessions were led by the first author, audio recorded, and transcribed verbatim. Only those who were participating in the focus group were present in the room. Participants were paid \$20 for their focus group participation.

Survey Measures

Survey measures were selected to target at least one level of the SEM and have been widely used across diverse adult populations. To the author's knowledge, these instruments have not undergone formal validation testing in firefighters but have demonstrated acceptable reliability and validity in various adult populations.

Physical Activity. Current PA behaviors were assessed using the International Physical Activity Questionnaire Short Form (IPAQ-SF), a widely used self-report measure that captures walking, moderate-intensity, and vigorous-intensity PA performed over the past 7 days (Craig et al., 2003). The IPAQ-SF has demonstrated acceptable reliability across diverse adult populations (Craig et al., 2003; Lee et al., 2011). To capture both on- and off-duty PA, participants completed the IPAQ-SF twice: once to reflect on the last 7 days on-duty and once on the last 7 days off-duty. PA was classified into total moderate-intensity PA minutes, total vigorous-intensity PA minutes, total walking minutes, and total weekly MET-minutes for on- and off-duty PA, respectively. A maximum of 4 hours per day was recorded for each PA intensity.

Self-Efficacy. An adapted version of the Barriers Self-Efficacy Scale (McAuley, 1992) was used to measure participants' current self-efficacy to exercise in the face of common barriers while off-duty ($\alpha=0.90$). Following the prompt "How confident are you right now that you could exercise on your days off of work for at least 20 minutes, three times per week if ...", participants responded on a scale from 0 (not at all confident) to 100 (completely confident) for eight items

(e.g., weather, boredom, pain, exercising alone, too busy). Items were averaged for a total score ranging from 0-100.

Social Support. Perceived social support for PA and exercise was measured using the Social Support for Exercise Scale (Sallis et al., 1987). Participants responded to ten items reflecting different types of support (e.g., providing encouragement, giving reminders, planning PA outings, adjusting schedules to be active together, asking for ideas to be more active). Family and friends were scored independently for each item on a 6-point Likert scale from 1 (Never) to 5 (Very Often) with 6 (Does not apply) recoded as “Never”. Items were summed within each subscale, and scores were calculated separately for support from family ($\alpha=0.96$) and support from friends ($\alpha=0.93$).

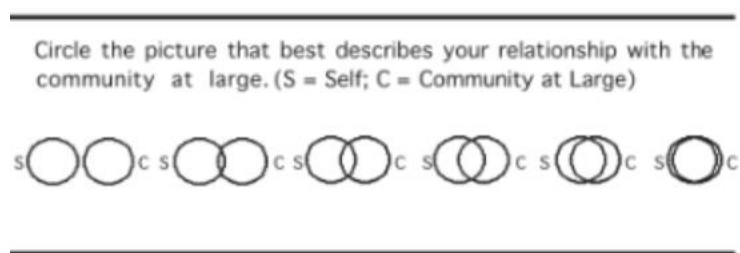
Motivation. A modified version of the previously valid and reliable Exercise Motivation Inventory (EMI-2) (Markland & Ingledew, 1997) was used to measure participants’ motivation for exercise using 32 items across 9 subscales: stress management ($\alpha=0.91$), revitalization ($\alpha=0.78$), enjoyment ($\alpha=0.93$), challenge ($\alpha=0.83$), social recognition ($\alpha=0.85$), health pressure ($\alpha=0.70$), ill health avoidance ($\alpha=0.82$), positive health ($\alpha=0.54$), and strength and endurance ($\alpha=0.87$). Subscales from the original tool including weight management, appearance, nimbleness, affiliation, and competition were excluded to reduce participant burden. Items were scored on a 6-point Likert scale from 0 (Not at all true) to 5 (Very true). For each motivational subscale of the EMI-2, mean scores were calculated by averaging responses from relevant items.

Beliefs. A modified version of the Multidimensional Outcome Expectations for Exercise Scale (MOEES) (Wójcicki et al., 2009) was used to measure participants’ beliefs towards the benefits of regular PA. An item was added to reflect firefighters’ occupational abilities (i.e., “PA will improve my ability to perform occupational tasks”). Items were scored into three subscales: physical outcome expectations ($\alpha=0.76$), social outcome expectations ($\alpha=0.79$), and self-

evaluative outcome expectations ($\alpha=0.87$). The additional item was scored under the “physical outcome expectation” subscale. Each subscale was scored by summing the numerical ratings for each response. Higher scores are indicative of higher levels of outcome expectations for exercise.

Community. Participants’ perceived community connectedness was measured using the Inclusion of Community in Self (ICS) scale (Mashek et al., 2007), a single-item pictorial consisting of six pairs of overlapping circles, with the overlap gradually increasing between each pair (see Figure 2.1.). Participants were asked to select the image that best represents their perceived relationship with their overall neighborhood and local community. Additionally, participants completed the same scale to reflect their perceived relationship with their department. In each image, 'S' denoted “self”, and 'C' represented their neighborhood/community or department with varying degrees of overlap to indicate different levels of perceived connectedness. Greater overlap between circles indicates a stronger sense of connectedness. Scores range from 1 (no overlap) to 6 (complete overlap).

Figure 2.1. Inclusion of Community in Self (ICS) scale



Workplace Environment Impact Scale (WEIS). Adapted from Zhang et al. (2021), a 10-item measure was used to assess participants’ perceptions of workplace social and environmental determinants of PA. Items included colleague influence (2 items), superior influence (3 items), physical environment (e.g., exercise facilities) (1 item), allotted time (1 item), work burden (1 item), department culture (1 item), and policy (1 item). Items were rated on a 5-point Likert scale from 1 (Strongly Disagree) to 5 (Strongly Agree). Responses were grouped into two subscales: the

social environment ($\alpha=0.76$) and the work environment ($\alpha=0.60$), with mean scores calculated for each.

Policy. Participants responded to a series of custom questions targeting the department's policy environment surrounding health and wellness. Two dichotomous questions (i.e., yes/no) included "Are you required to maintain a standard level of physical fitness for duty?" and "Do you believe the department's health and wellness policies/resources (e.g., annual health and fitness assessments, allotted exercise time, and access to gym space/equipment) help you be more physically active?" Participants identified which departmental policies they perceived to encourage PA by selecting all applicable options (e.g., exercise equipment/space, allotted time, medical evaluations, performance assessment) from a provided list, and a write in response was available by selecting 'other.' A single question asked participants to rate their satisfaction towards their department's efforts to promote health, wellness, and PA on a Likert scale from 1 (extremely dissatisfied) to 5 (extremely satisfied). Lastly, participants were asked an open-ended question: "What other policies or resources would you like to have in your department that you currently don't?"

Analysis

Shapiro-Wilk's tests and histograms were used to assess the normalcy of the data. Descriptive statistics are reported using mean $\pm$ standard deviation (SD), with policy-related questions reported as frequencies. The quantitative components of this study were exploratory and hypothesis-generating; therefore, no a-priori power analysis was conducted. Accordingly, analyses focused on examining preliminary patterns of association between all study variables and on- and off-duty PA, respectively. Correlations were conducted using all available non-missing pairs of observations. All quantitative components of the study adhered to the Strengthening the Reporting

of Observational Studies in Epidemiology (STROBE) guidelines for cross-sectional studies (Vandenbroucke et al., 2007).

The qualitative portion of the study followed the Consolidated Criteria for Reporting Qualitative research (COREQ) checklist (Tong et al., 2007). Focus group transcripts were imported into Dedoose (version 9.0.17, SocioCultural Research Consultants, LLC), an application which allows for coding and analysis of qualitative data. Inductive thematic analysis (Braun & Clarke, 2006) was used to explore participants' perceptions of multilevel influences on their on- and off-duty PA. Levels of the SEM were used as an organizational framework and within each level broad themes were initially identified based on the focus group questions, encompassing motives, facilitators, and barriers to PA and the perceived impact of coworkers, friends, family, occupation, community, and departmental policies. The lead author served as the primary coder and conducted open coding to generate a preliminary list of codes. Sub-themes were then developed and refined through an iterative process until no new themes emerged, during which some sub-themes were combined or eliminated. A second coder independently coded 28% of the transcripts to assess coding agreement. Agreement between coders for this subsample was 77%, and all discrepancies were resolved through discussion. The lead coder re-read all excerpts by theme and selected representative quotes highlighted in the subthemes.

Results

Participant Characteristics

A total of 32 participants completed the survey (age: 37.45 ± 9.65 years). All participants identified as male and a majority (96.9%) identified as white, with one participant identifying as African American; similar demographics to the fire service as a whole. On average, participants were considered overweight in terms of BMI. Many respondents held the rank of Driver Engineer

(43.8%) and had more than 10 years of service (53.3%). Thirty participants (age: 37.00 ± 9.09 years) attended one of seven focus groups (5-6 firefighters per session), including 17 who also completed the survey and 13 who only participated in a focus group. Focus group demographics were similar to the survey participants. Survey and focus group participant characteristics are summarized in Table 2.1.

Table 2.1. Participant characteristics

Variable	<i>Survey (N=32)</i>		<i>Focus Groups (N=30)</i>	
	M $\pm$ SD	N (%)	M $\pm$ SD	N (%)
BMI (kg/m²)	27.96 $\pm$ 3.54		27.75 $\pm$ 3.16	
Underweight (<18.5 kg/m ²)		0 (0%)		0 (0%)
Normal Weight (18.5–24.9 kg/m ²)		7 (21.9%)		6 (20.7%)
Overweight (25–29.9 kg/m ²)		17 (53.1%)		17 (58%)
Obese ($\geq$ 30 kg/m ²)		7 (21.9%)		6 (20.7%)
Years of service				
Less than 1 year		2 (6.3%)		2 (6.7%)
1 - 5 years		3 (9.4%)		4 (13.3%)
6 - 10 years		7 (21.9%)		8 (26.7%)
11 - 15 years		5 (15.6%)		3 (10.0%)
16 - 20 years		8 (25%)		6 (20.0%)
More than 20 years		7 (21.9%)		7 (23.3%)
Rank				
Probationary Firefighter		2 (6.3%)		2 (6.7%)
Firefighter		3 (9.4%)		4 (13.3%)
Driver Engineer		14 (43.8%)		15 (50%)
Captain		12 (37.5%)		7 (23.3%)
Battalion Chief		1 (3.1%)		2 (6.7%)

Quantitative Results

Descriptive statistics of survey variables are highlighted in Table 2.2. Participants reported high levels of PA, both on- and off-duty. The median weekly on-duty vigorous PA was 180 minutes (IQR 120 – 360) and weekly on-duty moderate PA was 360 minutes (IQR 180 – 720), whereas median weekly off-duty vigorous and moderate PA were 285 minutes (IQR 185 – 480) and 510 minutes (IQR 247 – 720), respectively (Figure 2.2). A majority of variables were non-normal; therefore, Spearman’s rank correlations were applied. For on-duty PA, EMI-2 subscales stress management ($r=0.41$, $p=0.02$), revitalization ($r=0.36$, $p=0.047$), and enjoyment ($r=.37$, $p=0.042$) had weak to moderate associations with moderate PA. No other variables were associated with the other on-duty PA categories including vigorous PA, walking, or total METs. For off-duty PA, enjoyment ($r=0.36$, $p=0.047$) and self-efficacy ($r=.44$, $p=0.017$) had weak and moderate associations with vigorous PA, respectively, whereas friend social support ($r=-0.38$, $p=0.045$) and the social subscale within WEIS ($r=-0.40$, $p=0.03$) showed weak and moderate negative associations with moderate PA, respectively. All other variables had no association with off-duty PA categories (see Appendix Table A.1 for a complete correlation table).

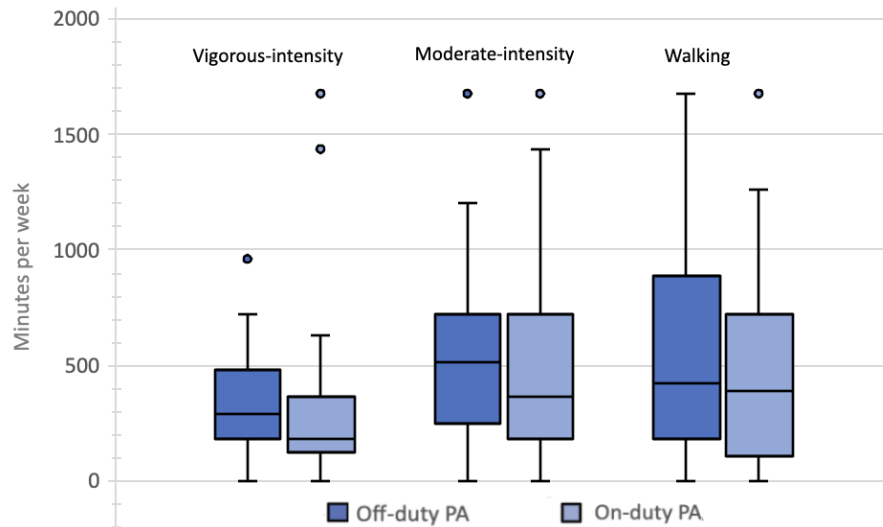
Table 2.2. Descriptive statistics for survey variables (N = 32).

Variable (Range)	M ± SD
Physical Activity (PA)	
<i>On-Duty</i>	
Total MET-mins per week	5913.94 ± 4555.05
<i>Off-Duty</i>	
Total MET-mins per week	6571.31 ± 3823.25
Self-Efficacy (0-100)	67.93 ± 18.54
Social Support (10-50)	
Friends Social Support	27.46 ± 10.52
Family Social Support	24.48 ± 12.93

EMI-2 (0-5)	
Stress management	3.78 ± 1.08
Enjoyment	3.99 ± 1.05
Revitalization	3.98 ± 0.99
Social Recognition	2.10 ± 1.29
Challenge	3.15 ± 1.18
Health Pressures	2.37 ± 1.34
Ill Health Avoidance	4.15 ± 0.76
Positive Health	4.63 ± 0.49
Strength/Endurance	4.47 ± 0.60
MOEES	
Social (4-20)	14.97 ± 2.95
Physical (6-30)	28.09 ± 2.28
Self-Evaluative (5-25)	23.09 ± 2.59
ICS (1-6)	
Fire Department Community	4.21 ± 1.01
Neighborhood/Local Community	3.00 ± 1.41
WEIS (1-5)	
Social Environment	3.34 ± 0.70
Work Environment	4.03 ± 0.51
<i>Work Burden Item Only</i>	3.03 ± 1.05

Notes: Exercise Motivation Inventory (EMI-2); Multidimensional Outcome Expectations for Exercise Scale (MOEES); Inclusion of Community in Self (ICS); Work Environment Impact Scale (WEIS).

Figure 2.2. Self-reported on- and off-duty physical activity (PA) minutes.



Policy-related survey responses were missing three responses (n=29) and are shown in Table 2.3. On average, participants were neutrally satisfied with their department's promotion of PA ($3.76 \pm .95$). All participants indicated 'yes' to their department requiring personnel to maintain physical fitness, with 68.8% reporting their department's policies enabled them to be more physically active. A majority of participants viewed allotted exercise time (87.5%) and access to exercise space/equipment (84.4%) as encouraging PA, followed by their physical performance assessment (68.8%), and then medical evaluation (56.3%). A few participants provided an additional write-in response for the 'other' option, noting that the occupation itself and the crew they were stationed with also encouraged their PA. Open-ended responses regarding policy suggestions most commonly focused on expanding access to gyms, particularly through discounted or department-funded memberships, to include swimming pools and fitness classes. Several respondents also mentioned seeking professional support for workout programming and nutritional guidance. Others highlighted the desire for improved equipment and facilities, flexible workout times during shifts, and the inclusion of incentives (e.g., competitions, recognition), while a few participants noted they were satisfied with the current policies.

Table 2.3. Participants endorsing policy-related items (n = 29).

Survey Item	M ± SD	n (%)
Satisfaction with department 's PA promotion	3.76 ± 0.95	
Required to maintain a standard level of physical fitness for duty		29 (100%)
Department health and wellness policies help you be more physically active		22 (68.8%)
Policy component believed to encourage PA		
<i>Exercise space/equipment</i>		27 (84.4%)
<i>Allotted exercise time</i>		28 (87.5%)
<i>Annual physical performance assessment</i>		22 (68.8%)
<i>Annual medical evaluations</i>		18 (56.3%)
<i>Other</i>		3 (10.3%)

Qualitative Results

Thirty participants (age: 37.00 ± 9.09 years) attended one of seven focus groups (5-6 firefighters per session). Qualitative findings help contextualize the ambiguous quantitative results and are presented by level of influence (i.e., individual, interpersonal, community, organizational, and policy) with main themes and subthemes highlighted below. The initial section describes the types of PA firefighters engaged in, and the subsequent sections address the factors that influence their activity in both on- and off-duty contexts. Field notes were recorded to capture nonverbal cues or group dynamics (e.g., laughs, head nods in agreement), while also noting if any participants left the session due to alarm interruptions and whether they returned afterwards. In at least three sessions, notes were taken by a student researcher, while in others they were recorded by the lead researcher when moderating alone, which may have led to inconsistent details across sessions. The final themes and subthemes are displayed in Table 2.4, and representative quotes for all subthemes are included in Appendix Table A.2.

Table 2.4. Final themes from qualitative analysis.

Category	Themes	Subthemes
Physical Activity (PA) Practices	<i>On-Duty PA</i>	- Duty status - Crew and PA preference
	<i>Off-Duty PA</i>	- Seasonal, household, or recreational activities - Physically demanding second jobs
Individual Level Influences	<i>Motives</i>	- Job security & readiness - Health & well-being - Family & peer responsibility - Affective motives & internalized pressures
	<i>PA Barriers</i>	- Competing demands - Weather
Interpersonal Level Influences	<i>Coworker Norms & Support</i>	- Crew-dependent & leadership Norms - Peer support, encouragement, or modelling - Peer pressure
	<i>Family Support</i>	- Early influences/foundations - Family participation or shared activity - Logistical & emotional support
Organizational Level Influences	<i>Administration Support</i>	- Flexible implementation of exercise policy - Commitment to enhance firefighter health & wellness
	<i>Fire Department Cultural Norms</i>	- Buy-in/culture change - Academy development as a catalyst - Station dependent norms
	<i>Occupation-specific Barriers</i>	- Work demand - Lack of sleep or fatigue
	<i>Physical Resources & Environment</i>	- Gym space characteristics - Equipment quality & availability - Desired improvements
Community Level Influences	<i>Community Facilities</i>	- Access to local gyms - Use of municipal/city-owned spaces
	<i>Built Environment</i>	- Access to parks & trails - Valuable & walkable outdoor spaces

Policy Level Influences	<i>Existing Policies</i>	- Policies as motivators for PA - Constraints for how policies are implemented
	<i>Programs</i>	- Benefits - Drawbacks
	<i>Desired Policies</i>	- Financial incentives & support - Purposeful fitness standards & evaluations

Physical Activity Practices

Type of Activity. The type of exercise participants indicated they engaged in while on-duty predominantly included strength training (e.g., body weight exercise, free weights) (41.5%) and aerobic exercise (e.g., running, walking, cycling) (18.8%). Seldomly, participants expressed participation in more high-intensity and functional-type workouts (e.g., CrossFit) (13.2%). Comparatively, off-duty PA predominately focused on more leisure and recreational activities such as hiking, fishing, and playing sports with their kids, as well as tasks related to secondary employment (e.g., lawn care, construction work).

On-Duty PA. Participants described their on-duty PA being influenced by both *duty status* and *crew and PA preference*. Participants described how the duration, type, and intensity of their PA often depended on whether they were on- or off-duty (i.e., duty status). While on-duty, they reported being mindful of workout intensity to maintain readiness for emergency calls, prioritizing time efficient activities to avoid interruptions, and taking advantage of the safety supports (e.g., spotters) and physical resources (e.g., exercise equipment) that may be unavailable off-duty. As one participant noted,

“I do enough to stay active in this job and not hurt myself so that's kind of my goal: be able to do the job. It's kind of what I think about when I do work out. I'm not trying to win any

competitions or anything like that or get myself hurt in the weight room and then be off work, so I take it easy here [at the fire station] ...” (Session 4, Driver)

Participants’ workout structures, chosen activities, and decisions to exercise alone or with others were influenced by the crew they were on shift with and their personal PA preferences. For instance, one participant mentioned:

“You might get a different crew out here [at the station] and everybody might be all into weightlifting, that everybody kind of works out together, or it might be a crew of all CrossFitters. [It] just kind of depends [on] the day, I mean, who else is here [with you].” (Session 7, Driver)

Off-Duty Physical Activity. Many participants expressed that their off-duty PA was centered around *seasonal, household, or recreational activities* and *physically demanding second jobs*. Various activities such as hunting and fishing, doing household chores, or playing sports outside with their kids were described. Many of these activities also reflected barriers, highlighted in subsequent paragraphs, as participants felt that lack of time and family responsibilities took precedence. One participant mentioned, *“For off-duty days, I stay busy – physically. I have a toddler, whether it's taking them on a walk or just doing things around the house, whatever it might be, I get my steps in as well.” (Session 1, Firefighter)*. Additionally, participants felt they were more physically active while off-duty due to their second jobs involving lawn care or construction work. The subtheme physically demanding second jobs embodies how participants felt their PA off-duty depended on the type of work they did or the season (e.g., summer vs. winter):

“During my busy time of year, I'm way more physically active on my days off. I'm more tired at the end of the day on my days off just doing my work [lawn care] than when I am here [at the fire station]. That's not to say I don't work out on my days off, but I [usually]

walk...I'll go out for hours just walking. I'll wear myself out doing that more than I will here because I guess I try not to get too tired here.” (Session 4, Captain)

Individual Level Influences

Motives to PA. When participants were asked what generally motivates them to be physically active, ***job security & readiness*** was viewed as important given the demands and expectations of the fire service, with one participant discussing how being physically fit is essential to job performance: *“You can't choose fire department A or fire department B. You got us, that's what you get and so, it's important that we provide a professional high level of service and a big part of that is being fit.”* (Session 1, Captain). Another participant added how being physically fit is important for job security:

“We've had guys who would smoke [do well at] the physical performance assessment (PPA) and were physically fit. Then I've seen guys that kind of later in their age, right close to retirement anyway, kind of deteriorate and I've seen them quit during the PPA and then they retired two weeks later. I want to make sure I maintain that [fitness level], not to where it sneaks up on me. I can definitely feel that now, all that stuff is sneaking up on me. So, job security is it, that's why we do it [exercise].” (Session 4, Captain)

Health & well-being emerged as a prominent subtheme reflecting participants' personal reasons for engaging in PA; participants identified various indicators of health as motives for being physically active including quality of life, mental well-being as well as establishing healthy lifestyle habits. For some, physical activity served as a critical outlet for managing stress and supporting mental health. One participant shared,

“One of my primary reasons is my mental health – it helps it. When I don't exercise, I feel terrible, and I get stressed out and it just is a release for me to go to the gym, and it does that more than anything else for me.” (Session 1, Driver)

Participants also described motivations tied to **family & peer responsibility**, especially when it came to keeping up with their children or being a role model for them and maintaining a level of fitness their coworkers could depend on. One participant mentioned,

“I mean I do it for my kids. We have two boys and a girl. It's hard enough to keep up with them if I let myself go at times and try to run around with them, it's harder. Then, they wonder why you can't run around with them”. (Session 2, Driver)

Lastly, rather than being driven by pure enjoyment, participants described engaging in PA due to **affective motives & internalized pressures**. Competition with peers, often across shifts or stations, provided motivation and camaraderie:

“You get variety [on shift]. You move stations, move shifts, [and] work with different guys. You got CrossFitters, bodybuilders, powerlifters, whatever it is, so that's kind of always fun – especially like the camaraderie of it sometimes. It ups the intensity.” (Session 3, Captain)

At the same time, participants highlighted self-imposed accountability or expectations and avoiding negative feelings (e.g., guilt, stress) to maintain their PA and exercise routines: *“I feel almost demoralized when I don't [workout] or when I have to skip the gym to do something. That's just like ‘well three days I haven't gone and I haven't done anything’, so all of a sudden, I just feel down.”* (Session 1, Probationary Firefighter), while a second participant emphasized relying on discipline when initially feeling unmotivated:

“I’ve definitely been there – feeling unmotivated – but going through the motions helps get [me] there. Like when I was in high school, I ran cross-country and there was kind of the mentality of it’s better to go run an easy three miles [rather] than do nothing. I’ve had plenty of days where I don’t want to be in the weight room... So, I go do something and most of the time I get on the bike and ride for 30 minutes, get 10 miles, [and] call it good.”

(Session 1, Driver)

General Barriers to PA. When discussing individual barriers to PA, participants commonly mentioned *competing demands* related to their family responsibilities, and kids often take precedent to exercising or being physically active. For instance, one participant mentioned:

“Our family schedule is killer, like I mean they’re all in basketball, got school, in a thousand different things so if you’re running them around, it’s kind of hard to make it to the gym...time is a massive barrier on your off days.” (Session 2, Driver)

Similarly, competing leisure activities or having a second job makes exercising or wanting to be physically active challenging. While the nature of off-duty jobs varied, it influenced the extent to which participants participated in or detracted from physical activity:

“Number one [barrier] is family. Number two would be off day jobs, but you [can] get some physical [activity].... some people’s off day jobs are more physical than others. Like building a fence for instance is physical, cleaning chimneys is probably the hardest thing you can do on your off day.” (Session 4, Driver)

Some participants also mentioned that *weather*, especially depending on the season, can play a role in whether they are physically active or not:

“I would say the only thing to keep me inside is when it keeps me from mowing the grass or doing something I need to do is just the weather. Whether it’s too hot or too cold, going outside is therapeutic.” (Session 1, Driver)

Interpersonal Level Influences

Coworker Norms and Support. Across participants, ***crew-dependent & leadership norms*** were described as central to sustain PA and fostered a positive outlook. Many participants emphasized PA expectations differed between stations, crews, and leadership styles. Captains were frequently identified as a key influence in either prioritizing or de-emphasizing PA within daily operations. One participant noted the variability across crews:

“I think you’ll find a lot of variances as you talk to other firefighters [of] different ages, different stations; just every crew is different. [Other firefighter] is not part of our crew. His crew does [PA] differently, every crew’s different, right, wrong, or whatever.” (Session 1, Captain)

Coworkers often support each other through ***peer support, encouragement, or modeling***. Tailoring expectations to how someone was feeling physically or mentally that day seemed to help enhance motivation:

“They’ll adjust the workout...if it’s been a terrible day or even if we’re just not feeling it... ‘how about we just dial this back, we’ll cut this out, we’ll adjust this’, and I feel like that helps me more than anything.” (Session 1, Driver)

Peer modelling (i.e., seeing others being active) served as a strong cue, making it easier to join in rather than initiate the activity alone. One participant described it as a “herd mentality”, creating an environment where PA is encouraged and expected. Some crews also organized

informal recreational activities (e.g., basketball, pickleball, kickball) with members from other stations. These were described as voluntary, socially driven opportunities to stay active:

“That's kind of hit or miss too, like when we get together [to] play games and stuff it's really just *the types of people on those crews and their willingness to come out... so you just had these guys [who] really wanted to go do it*”. (Session 3, Captain)

Distinct from supportive behaviors, participants acknowledged that **peer pressure** and expectations could also urge others to participate as a form of social accountability. While no one is formally required to exercise on-shift, social norms made opting out visible, with others mentioning this peer pressure and form of accountability reinforced their motivation for PA. One participant described this dynamic clearly:

“*No one makes somebody work out, it's essentially the officer's responsibility [to] but unless it's a chronic issue, a person can be tired and not work out that day. [But] it doesn't mean they're not going to get busted down about it. The whole crew will let [them] know that they're a piece of crap and didn't work out.*” (Session 4, Driver)

Family Support. Participants mentioned support from their family impacted their PA engagement, particularly while off-duty. The subtheme **early influences/foundations**, particularly through sports, and having health-based conversations with their family or spouse developed a foundation of values towards PA and other healthy habits. One participant stated,

“*Growing up, I mean, I just got pushed into sports....So I've kind of had it in me since I was a kid I guess so that's made it really easy just to keep going, it wasn't something I had to learn as an adult. I feel worse when I don't work out...it's harder for me to miss a day than it is to go to the gym. They [parents] were both athletes too, so it's always been part of life really...it's not negotiable really.*” (Session 3, Captain)

While some participants established PA habits early on, others shared that **family participation or shared activity** with their spouse or children increased their motivation:

“As a dad, it's really nice to see my kids enjoying the workout. They like to go to the gym with me, they stretch with me, work out at home, wrestle and do sports at home so having that same drive and passion with them is nice. It keeps me going.” (Session 3, Driver)

Additionally, participants mentioned family dynamics provided both **logistical and emotional support**, such as providing encouragement, dedicating time, and passively modelling PA.

“Now, I go with them [my kids] to Genesis when they're back in town, they do their lifting, and I do my swimming or go on the elliptical. For instance, [they'll say] ‘Hey Dad come with us’, so there's that support [from the] family. It may not that we're all doing the same activity but we're still going to do stuff.” (Session 3, Battalion Chief)

Organizational Level Influences

Administrative Support. When asked about how the administration supports their current PA behavior, participants mentioned a **flexible implementation of exercise policy** and **commitment to firefighter health and wellness**. Providing personnel with a set one-hour and thirty-minute time block for exercise each shift, along with on-site access to fitness equipment and space, enabled personnel to participate in either PA or exercise while on-duty. Participants noted that although exercise time was given, work responsibilities (e.g., training, maintenance) sometimes interfered. One participant highlighted the benefit of administration allowing flexibility:

“I think that they [Battalion Chiefs and Administration] give the captains a lot of leeway, and I feel they leave it in the captain's hand... they'll change up the workout time for us.

There's nothing set in stone that we can't move it, which I feel the department has done a very good job with, allowing us the opportunity to stay fit.” (Session 1, Driver)

However, while some participants considered exercise time flexible, others perceived subtle discouragement from administration: *“If we're doing training in the afternoon, we might have the morning to kill and then we could work out in the morning, but I mean it's kind of taboo a little bit. They [administration] don't like it.” (Session 2, Driver)*

Participants also discussed how other department components, including the Health and Safety Committee and annual health assessments, are viewed as a ***commitment to enhance firefighter health and wellness*** and considered intentional steps by administration to enhance buy-in, prioritize firefighters’ well-being, prevent injuries, and limit any financial burdens (e.g., overtime, recovery):

“We have the health and safety committee... and they meet about well-being essentially as part of the overall health of the department and go over safety, accident reports, stuff like that. So, I think there's some level of getting information to the guys, what we like and don't like, [exercise] machines that we want [to invest in] and stuff like that.” (Session 4, Driver)

“When I first came on, we didn't have a workout time...it was a big sign of faith... They also saw the need for wanting to reduce injuries and all that kind of stuff, so on that level having remembered what it was like to not have a workout time, it still rings in my head that they are behind us to stay in shape and want us to do the best job we can for the citizens and for each other.” (Session 7, Captain)

Fire Department Cultural Norms. Participants mentioned various factors shaping the organizational culture towards PA. Improving personnel *buy-in* & [organizational] *culture change* surrounding PA seemed to be influenced largely by broader generational shifts. As one participant shared:

“We didn’t get the contract working out time until like let’s just say ~20 years ago... The guys that I came on with that were older...they certainly didn’t grow up in that culture... They didn’t need to, or at least in their mind, they didn’t need to work out because they thought it was stupid.” (Session 4, Captain)

The second subtheme, *academy development as a catalyst*, emphasized expectations established at the Fire Academy (i.e., firefighter recruit training program) helped with personnel buy-in, with one participant stating:

“It’s been a transition...when I came on, during our Academy you never worked out. Now, there’s required workouts during our Academy for new hires...so that culture has changed over the last probably seven years or so... [It] has changed the culture in the firehouse.” (Session 3, Battalion Chief)

“...the department [has] really done [well] developing the Academy...when I started, we didn’t do any work; we ran like a mile and stuff but that was it. Now, these guys are doing CrossFit workouts. I mean they’re getting them prepared, setting expectations immediately the first day on the job.” (Session 2, Driver)

Station-dependent norms were identified as localized expressions of the department’s broader cultural norms, varying based on how peer dynamics, leadership expectations, and operational routines around PA were interpreted at individual stations:

“The motivation [to work and be physically active] is really low out there [at specific station]. You can either take it one way or another...work out a bunch out there or not at all because you’re ready to go home as soon as you show up. You can also get into bad habits.” (Session 4, Driver)

Participants also discussed leaning on peer support when station dependent norms played a role, and while on-duty exercise and PA are supported by the administration or via policy, participants get reminded of obligations to keep the activity and intensity within limits to still perform the job:

“You can be tight [close knit] no matter where you’re at, but obviously there are personalities involved and I’m the type of person that where I’m at affects my personality too, like at station [X]... [other firefighter] would come get me, some guy would cover for me, and I would go do nature hikes because I was going feral.” (Session 4, Captain)

“As a Battalion Chief, I’ve had guys collapsing on the floor [after a workout] and I’ve had to talk to them and say you can’t do that. I’m counting on you running, so no puking or out here on the assault bike seeing who can go the longest and fastest...when that bell drops, I want you out of the station.” (Session 3, Battalion Chief)

Occupation-specific PA Barriers. Factors surrounding *work demand* such as call volume, training or meeting days, and other job-related priorities (e.g., maintenance, studying for promotions) played a role in both motivation and physical fatigue during a shift, with some highlighting being physically active earlier in the day was nearly impossible:

“We’re in and out all day, you just don’t have the energy. We do our laundry...cook and stuff like that – by the time we cook, it’s going to be 5pm then 5:30 by the time we eat. You just start feeling a little overwhelmed by the end of the day.” (Session 3, Captain)

“The most consistently inconvenient thing, and again it's your choice, is when we're studying for promotion. A lot of times when you study for promotions, you don't even touch the gym, you go right back to your room or in the office and you just study...all your PRs will go down, your cardio goes down, and you feel like shit you think you should go in there. Then usually the people study for several months leading up to a promotional test, so there will be minimal working out. They study on-duty as well as off-duty, so they probably aren't working out off-duty either, or very much.” (Session 5, Driver)

Others said ***fatigue or lack of sleep*** as a result of their occupational demands (e.g., overnight calls, disrupted sleep, workload) can affect their motivation going into their off day: *“I would say occasionally, if we just have a long night at work, if I just feel crappy and tired, I probably won't work out that next day, but those days [I feel] are pretty few and far in between.”* (Session 1, Firefighter).

Physical Resources and Environment. When participants were asked about their physical resources within each fire station, participants mentioned the department prioritized a designated space and invested in a variety of fitness equipment including aerobic (e.g., treadmill, assault bikes) and strength equipment (e.g., barbells, dumbbells). Although there were available physical resources in each station, there were concerns surrounding the ***gym space characteristics*** and ***equipment quality & availability*** including small gym spaces leading to dreary, unmotivating environments forcing personnel to stagger workouts outside of their designated time or move equipment to the truck bay for it to be functional. This participant's quote highlights some of the nuances in space and resource availability:

“We’ve done a great job in the last couple years of kind of getting [equipment] guys want... like this assault bike, treadmills, weights, these cable machines which are really useful, so I really like a lot of the equipment but usually I think just the size [of the space] is the only let down. Usually, it’s a little cramped in there sometimes but overall, it’s like tripping over each other. It’s like ‘yeah, I’ll come back later,’ then they’re done and it’s 4:30.”

(Session 3, Captain)

Another participant highlighted when gym aesthetics were less than ideal; it created a challenge: *“The area is a dungeon [with low ceilings and no windows]. If you want to be motivated, don’t go down there. That’s the hardest obstacle.”* (Session 2, Captain). Participants highlighted their **desired improvements** involving specific physical features of gym spaces they’d like to have to potentially enhance the enthusiasm to engage in PA:

“A station in [different city] that was new, and the back wall was a garage door of their gym, and the front wall had large windows, and it overlooked the truck room...I would feel more motivated to go in there than I do here.” (Session 1, Captain)

Community Level Influences

Community Facilities. Participants mentioned **access to local gyms** and recreational centers that they commonly used for off-duty PA due to their proximity and amenities: *“I live right by [local gym], so I walk there quite a bit and go there”* (Session 3, Captain), with another mentioning the benefit of child-care access:

“For a lot of years, I just pretty much worked out at work...[but] because they have childcare at the [local] gym that is important to my wife. I’m gone 24 hours at a time so she can still go workout. The whole family is on that plan, so I use it and just started to do that [helped] motivate me too.” (Session 1, Captain)

The subtheme *use of municipal/city-owned spaces* highlighted that city-owned facilities including City Hall’s recreational courts and gyms and the fire station exercise spaces provided accessible options for off-duty PA. Participants expressed City Hall’s courts were commonly used for recreational sports and viewed as a cost-effective and practical choice compared to having a gym membership at a local facility: “[We] can use any fire station or City Hall gym when off-duty...like you don't have to have a gym membership to exercise in a gym while you're off-duty.” (Session 1, Captain). However, many described these spaces as suboptimal, citing equipment limitations, outdated facilities, or logistical challenges that reduced their usability. One participant mentioned, “The city hall one is like everything that nobody wants. They took a 1970’s gym and stole all their equipment so it’s available and better than if you didn’t have anywhere else [to go].” (Session 2, Driver) Residence’s location also influenced off-duty utilization of municipal resources as some firefighters emphasized relying on on-duty opportunities:

“I mainly [use] the station’s weight room [while on-duty] but days off, since I live 30 miles away in [a rural area], I don’t really come back into town to use much of the parks or trails or anything I guess.” (Session 7, Driver)

Built Environment. Participants commonly mentioned the public resources in their community influencing their PA as their *access to parks and trails* and having *valuable and walkable outdoor spaces*. The variety and availability of public parks within the region provided participants with opportunities for personal or family-based PA: “We go to [local park] a fair amount, just take the dog out there and go hike a little bit my kids love going up and down the little rock steps... we spend a lot of time at parks.” (Session 1, Captain). Participants mentioned their neighborhood location and walkability were important factors for everyday life and while some

preferred a gym setting for their PA, others mentioned outdoor activities are their go-to, highlighting Kansas's specific opportunities:

“Moving around and walking [is important] which is why my wife, and I bought a house down here [center of town] because we can walk everywhere...We live right behind [a grocery store] so just walking to the store is getting out – it's a good thing for us.” (Session 1, Driver)

“I am more of an outdoor recreation kind of guy. I think – most especially for Kansas – I think [the city] does a good job, better than most, for the open public spaces for what we have but we're fortunate we have kind of landscape to do it...We have all the public rec facilities now that they've built in the last few years, those are pretty cool.” (Session 4, Captain)

Policy Level Influences

Existing Policies. Participants commented on their current perception of the department's health and fitness policies including their allotted exercise time, annual health physicals, and physical performance assessment (PPA, i.e., a series of physically demanding job tasks such as hose pulls, victim drags, and stair climbs performed in full gear under time completion). The department's annual physicals and the PPA were viewed as *policies to motivate PA* and encouraged participants to pay attention to their health and fitness, with some viewing it as a competition with their peers, while others were more concerned with simply passing these screenings:

“It's [PPA] competitive... you know guys are trying to beat the guys on their whole shift and that'll really test you too because if you went your hardest and you're a minute behind

a guy on your crew, now you're mad about it so you're going to work a little harder to not be that way next year.” (Session 2, Firefighter)

Some participants were motivated to be physically active regardless of their workload and viewed it as “*getting paid to work out*”, and others noted the allotted time provided the opportunity they needed. Participants also mentioned several **constraints for how policies are implemented** and recalled having a different time-of-day preference compared to their department’s usual exercise time:

“I enjoy [working out during the] mornings more.... By the time the [end of the] day gets here, I've got paperwork to get turned in. I've got everything else going on, so it's really tough for me to go down to the [station's] gym at 3:30 in the afternoon – that's my biggest downfall.” (Session 3, Battalion Chief)

Another adding, “*I wish they would just say ‘you got an hour and a half to work out – fit it into your schedule’*” (Session 2, Driver), supporting a flexible approach. Others criticized the PPA time limit as being excessive: “*I have said it for a long time, ‘why is it 25 minutes?’ I mean if the point of it is to see if you can do the job and it takes you 25 minutes; that's not actually an adequate time.” (Session 1, Captain)*

Programs. Participants mentioned having access to a wellness program offered through their city’s health insurance and expressed several **benefits** including offering family-centered health promotion, ways to monitor behavior, and if tracked, participants could receive job-related perks like paid time off. However, others emphasized the **drawbacks** like financial penalties and jumping through hoops to see any benefits: “*Everyone on the [health] insurance gets a free physical every year, whether that's my daughter or my wife...[but] if you don't do their surveys, they charge you \$100/month fee.” (Session 3, Battalion Chief)*

“It’s all about points, [after] you get so many; it’ll take so much money off your insurance bill. They make it so hard to do unless you have all the time in the world, like watch or go through two [educational] classes a month.” (Session 4, Driver)

Desired Policies. The desire for additional support was illustrated by participants describing various *financial incentives and support* related to reimbursements and discounted gym memberships.

“I think other things could be like a benefit, where you get reimbursed for buying running shoes or exercise equipment on your own or something like that. We also have the Firefighter’s Relief Association, and I know that in [different city] if you buy a wellness thing and turn in the receipt, you can get a refund up to a certain amount. I think running shoes [are] the best example.” (Session 1, Captain)

Participants also highlighted a desire for *purposeful fitness standards & evaluations*, seeking additional ways to track or evaluate health beyond their traditional annual physical and support for defined performance standards.

“I think just having some little [fitness] benchmarks kind of built in you know, maybe not more tests or anything per se, just some good numbers set that are kind of standards that are realistic and achievable for everyone. We have all different shapes and sizes of people...It’s just not me there, it’s a team effort, because one person can probably do something I can’t.” (Session 3, Captain)

Discussion

This mixed methods study examined firefighter’s on- and off-duty PA and explored various influences on firefighters’ on- and off-duty PA across levels of the SEM. Based on self-reported PA, participants were engaging in high levels of moderate and vigorous PA in both duty status

contexts and were considered to be meeting PA guidelines. Although this exploratory study was conducted with a relatively small sample size, the quantitative results revealed some indications of weak to moderate associations between EMI-2 subscales stress management, revitalization, and enjoyment with on-duty moderate PA. Similarly, enjoyment and self-efficacy were associated with off-duty vigorous PA. Interestingly, the social WEIS and friend social support were negatively associated with moderate PA while off-duty, which warrants additional exploration. Additionally, through the focus group discussions, participants described ways in which peer dynamics, leadership support, departmental culture, and available resources and policies have either facilitated or inhibited their PA behavior.

Physical Activity Practices

The PA levels in this sample were similar to prior literature in firefighters (Agostinelli et al., 2023; Gendron et al., 2020) as participants reported enough PA to meet guidelines. Consistent with these findings, Gendron et al. (2020) found firefighters who exercise on shift accumulated more weekly PA and had greater equipment availability compared to those who did not. Thus, on-shift exercise and resources may contribute to supporting adequate PA levels. Agostinelli et al. (2023) similarly reported that a majority of firefighters had allotted exercise time and access to equipment in their sample. However, other studies using self-reported measures have found that a majority of firefighters do not meet PA recommendations (Barry et al., 2019; Durand et al., 2011; Ras & Leach, 2022). These discrepancies may reflect different departments' PA resources, opportunities, or policies, however, participants in the present study were recruited from a single fire department which limits the variability in these influences. Moreover, PA data could also indicate some firefighters are very active on-duty, whereas others accumulate much of their activity off shift. Nevertheless, it's important to note that the PA estimates in this study may be

inflated as the IPAQ is prone to overreporting and there was limited distinction between physical job-related trainings, exercise, and PA. Additionally, convenience sampling may have introduced sample bias as firefighters who participated may have been more interested in health and fitness. Future research should recruit more fire departments from different regions and aim to increase overall sample size to improve the generalizability of findings, in addition to incorporating objective PA assessments or targeting specific assessments or targeting specific PA domains, such as occupational-focused (e.g., emergency response training drills) or leisure time PA (e.g., structured or informal exercise performed at the fire station).

Similar to Agostinelli et al. (2023), strength training and aerobic activities were mentioned as common forms of exercise among participants. The type and structure of PA participants indicated they typically engaged in were predominately influenced by shift status. Particularly, participants highlighted the value of relying on quick and efficient workouts to reduce the likelihood of interruptions from emergency response calls. Additionally, participants were frequently concerned with exercise intensity while on-duty as it may negatively impact job performance or lead to injury, which has been echoed in previous research (Gold et al., 2022; Jahnke et al., 2012; Lovejoy et al., 2015). These concerns potentially led to less intense forms of PA as participants minimally mentioned high-intensity exercises (e.g., CrossFit), and therefore, may limit the benefits towards physical fitness (e.g., cardiorespiratory fitness) (Barry et al., 2019; Durand et al., 2011). Comparatively, off-duty PA focused on household or leisure activities and primarily centered around the participant's family or children. This pattern may reflect challenges related to time management and family responsibilities, which are well-established barriers (Melton et al., 2019; Shah et al., 2024). Secondary occupations are common for firefighters, as one study found over half of firefighters had another job (Gendron et al., 2020). Thus, it may be

considered a barrier to off-duty PA as participants expressed having second jobs that were physically demanding which further limited their time and motivation for PA. This emphasizes the need for the fire service to prioritize on-duty opportunities as it may be the only consistent opportunity for firefighters to engage in adequate PA (Gendron et al., 2020).

On-Duty Physical Activity Influences

Across the SEM levels, participants primarily highlighted facilitators surrounding a culture of PA and fitness within their department, which stemmed from individual motives, social reinforcement, and was embedded within the department's culture and practices. At the individual level, a range of intrinsic motives were described as participants found PA to be central to their professional identity, ability to serve the community effectively, and beneficial to their overall physical and mental well-being. PA was also viewed as important to their roles as parents and peer firefighters, aligning with previous research (Long et al., 2014). Quantitative finding indicated similar results as stress management, revitalization, and enjoyment were associated with on- and off-duty PA, consistent with evidence linking intrinsic (and autonomous) motivation to higher PA levels and adherence (Teixeira et al., 2012). While intrinsic motives for PA were predominantly highlighted, participants also mentioned extrinsic motives revolving around positive peer pressure and their performance on, and ability to pass, their annual physical performance assessment (PPA). Participants recalled some personnel would increase their PA as it got closer to that time of year, whereas others were more enticed by the competition among crew members and for their personal health insights. Given that participants were achieving high levels of PA, relying on both intrinsic and extrinsic motives has potential to contribute to habitual PA (Geller et al., 2018), although social support may be essential for on-duty PA engagement in this population.

Interpersonal influences including camaraderie and peer expectations, as well as peer modelling, played a central role in cultivating a positive social environment surrounding PA and reinforcing engagement. Previous studies have highlighted camaraderie, peer interactions, and friendly competition can serve as sources of motivation (Lane et al., 2022; Long et al., 2014; Mabry et al., 2013) and encourage participation (Lane et al., 2022), while peer modeling can facilitate PA engagement in firefighters (Cheskin et al., 2014). In the present study, participants described how peers would provide both emotional and logistical support, by offering words of encouragement, constructive peer pressure, or scaling workouts to meet individual needs. Additionally, participants emphasized taking advantage of the safety supports, such as having a “spotter” during workouts, and listening or following peers they considered knowledgeable and highly motivated. As supervision and professional instruction has been shown to lead to enhanced health and fitness outcomes (Mazzetti et al., 2000), relying on peer support may serve as an alternative mechanism for firefighters to achieve adequate amounts of PA and promote overall health. Furthermore, captains played a pivotal role in prioritizing their crew’s workout time by reorganizing daily tasks and emphasizing the importance of PA through leading by example. A previous qualitative study echoed similar themes as participation in and adherence to on-duty exercise relied predominately on the crew’s captain leading by example (Dobson et al., 2013). As such, captains may have the ability to create a social climate that normalizes PA and potentially can be a mechanism to translate policy into daily norms for crews. Additionally, prior research in firefighters has shown leadership engagement and peer fitness champions are helpful to exercise while on-shift and maintain fitness (Lane et al., 2022). Thus, policy implementation could utilize captains or other “crew leaders” as key influencers to bridge the gap between formal guidelines and daily practices.

Participants also shared how changes in department culture and administrative support surrounding PA and fitness over the years have reshaped workplace expectations in day-to-day operations. Many noted a generational shift in attitudes about PA, reflected in organizational changes such as restructuring the Academy, adopting exercise-related policies, and improving fitness infrastructure. Additionally, many firefighters attributed this shift to younger personnel having increased acceptance, knowledge, and expectation of exercise, as well as increased awareness surrounding adverse health effects, including injury, cardiovascular disease and cancer. Similarly, the Academy was also mentioned to be a catalyst for this shift as structured workout expectations begin on day one for new recruits, in contrast to earlier cohorts having minimal exercise requirements. While Dobson et al. (2013) focused on exercise behavior rather than PA broadly, their findings similarly suggest age and generational differences influence engagement in exercise-related activities and younger firefighters may be considered more health conscious.

It is important to acknowledge that participants discussed how various physical environments and resources in their department which were influential towards their on-duty PA behavior, as a lack of facilities has previously been identified as a key barrier to exercise among firefighters (Kwon et al., 2022). In the present study, participants noted that every station had a designated area for PA with a variety of aerobic and strength training equipment. Accessibility may be sufficient to influence activity levels, as Agostinelli et al. (2023) found firefighters who had various high-quality equipment available while on shift were more likely to engage in exercise. While participants in the present study praised their department's investment in equipment, there were concerns about some spaces being small, cramped, or poorly lit, which created an unmotivating atmosphere. Additionally, cramped gym spaces often required crew members to either work out alone, stagger their sessions, or move equipment into the truck bay, which could

expose firefighters to additional environmental hazards (e.g., diesel exhaust) or lessen the social connection and camaraderie typically present during shared activity. Previous qualitative studies identified poor quality and maintenance of PA facilities promoted sedentary behavior (Keegan et al., 2016) and hindered individual motivation (Long et al., 2014). Thus, fitness equipment and space may be important components for fire departments to consider when investing in and allocating these spaces and resources to encourage on-duty use.

Various organization-level barriers were highlighted that hindered firefighters' ability to engage in PA. Operational demands including required training, high call volume, and fatigue reduced motivation for PA particularly during busy shifts, and these effects often carried into days off. Sleep disruption from 24-hour shifts and the anticipation of overnight calls further compounded this issue. Previous research has highlighted how sleep disturbances related to shift work contribute to negative health consequences including obesity (Sun et al., 2018) and can lead to poor work performance and injury (Stout et al., 2021). Moreover, Jahnke et al. (2012) found similar themes with participants highlighting lack of sleep due to overnight calls, poor sleep quality at the station, and sleep difficulties typically carrying into their home life. Therefore, lack of sleep and chronic fatigue due to the occupational demands of firefighting, coupled with competing responsibilities on days off (e.g., family, a second job), may further limit motivation and energy to engage in PA.

Further, administrative practices at times conflicted with the department's cultural emphasis on health and fitness. While captains were permitted to adjust established workout times, some participants felt that overscheduled workdays with training (e.g., physical and educational) or other job-related tasks reduced exercise opportunities and left them fatigued later in the shift. Additionally, exercising during downtime was perceived as informally discouraged by upper

leadership (i.e., Battalion Chiefs, Administration). The disconnect between policy perception, intent, and daily practice echoes prior research that inconsistent messaging can erode the perceived organizational support toward firefighter health and wellness initiatives (Long et al., 2014).

A potential reason for contrasting views and perceptions relating to PA policies and practices is that expectations may vary across stations and shifts within a single department (Long et al., 2014). On-duty PA seemed to be shaped by a crew's social dynamics and the station's physical environment. For instance, captains who modelled PA or prioritized it were perceived to have stronger buy-in with their crew, and peer emotional and logistical support further emphasized this. If leadership or peers are less forthcoming to provide such support and establish a culture around PA that aligns with formal policy, firefighters may have to rely on individual motivation, or self-efficacy and self-regulatory skills to engage in PA. Additionally, the physical location of the station and certain characteristics of the PA spaces (e.g., small, gloomy, poor quality) were suggested to negatively influence one's motivation. In those instances, participants mentioned relying on peer support, which may be crucial to PA engagement in such environments.

Aside from differing policy expectations, participants saw value in and had appreciation for the opportunities their department provided in regard to allotted exercise time and the availability of equipment on shift, as well as annual health and performance assessments, which were viewed as indicators of the department's intent to invest in and support firefighters' overall health. Despite these positive outlooks, participants offered several suggestions to enhance buy-in and adherence, including improved equipment and facilities, flexible workout times, discounted or department-funded memberships, and the inclusion of incentives or reimbursements. Prior research echoes these findings, as autonomy in programming, equipment choices, and flexibility in scheduling workouts for firefighters may affect exercise motivation (Long et al., 2014). Given

that facility characteristics and organizational support vary across stations, addressing these factors may be critical for strengthening adherence (Melton et al., 2023). Incorporating a reward system or leveraging captains, who were suggested to be primary sources of influence on crew practices, may help promote long-term adherence to such policies.

Off-Duty Physical Activity Influences

The present results underscored the importance of self-efficacy and enjoyment in supporting off-duty PA as they were related to vigorous PA, indicating firefighters who find PA rewarding and feel confident in their ability may engage in more high-intensity activity on their own time. Moreover, as participants reported more median minutes of vigorous PA while off-duty, participants may be more willing to perform higher intensity activity during their free time to maintain required levels of performance. Prior research echoes this as firefighters may choose not to engage in vigorous exercise on-duty to avoid feeling fatigued (Gold et al., 2022). As a result, the previously mentioned individual-level factors may compensate for any external pressures that limit off-shift activity. Given that self-efficacy has consistently been identified as a leading factor for adherence (Grimaud et al., 2025), fostering intrinsic motives and competence may help sustain firefighters' PA engagement without relying on accountability or peer involvement.

Friend social support and social aspects of the work environment were negatively associated with off-duty moderate PA. Although unexpected, this finding may reflect overlapping sources of support, particularly the distinction between coworkers and non-work friends, with participants potentially receiving more support at work. Nevertheless, coworker support has shown to be a strong correlate of PA participation (Sarkar et al., 2016), potentially transcending to PA outside of the work environment due to participants' high PA level while also off-duty. For some participants, family support facilitated engagement by helping balance time and providing

encouragement on their days off. However, participants also mentioned household or family responsibilities, and other competing demands may limit opportunities for activity while off shift. When families were involved, PA often took the form of shared or family-based activities (e.g., recreational sports, going to the park). Although beneficial for overall PA and family cohesion, this may reinforce the importance of engaging in more structured PA while on-duty, as on-shift opportunities may be more feasible and consistent for maintaining fitness given the competing priorities firefighters face at home.

Access to community resources, including parks, trails, and fitness facilities were predominant places for off-duty PA. Participants valued their neighborhood's walkability and outdoor spaces for routine and family-based PA, consistent with research linking access to appealing green spaces and walkable neighborhoods to promote PA, especially when perceived as safe and accessible (Salvo et al., 2018). Nearby commercial gyms were essential for convenience and family needs, with childcare access helping parents overcome a common barrier to PA (Mailey et al., 2014). City-owned facilities, including recreational courts, gyms, and station-based fitness areas, were available for use during their days off. Although these resources were viewed as cost-effective alternatives, participants also characterized them as limited, outdated, or inconsistent in quality, reflecting prior evidence that perceived quality and usability can influence engagement even when resources exist (Keegan et al., 2016). Firefighters living farther from town and in more rural areas faced additional physical barriers, reinforcing the importance of robust on-duty resources (Agostinelli et al., 2023; Gendron et al., 2020). Strategic partnerships between fire departments and local fitness centers may help bridge these environmental gaps, particularly for off-duty exercise, although program effectiveness may depend on accessibility, incentives, and scheduling (Lane et al., 2022).

Strengths & Limitations

There are several important strengths of this study to mention. First, the use of a mixed methods approach provided a consistent story of firefighters' PA influences between the quantitative and qualitative data, and allowed for nuanced, rich insights to be identified. Second, utilizing the SEM as a framework allowed for the complex overlap between various levels of influence to be apparent among firefighters. Third, the assessment of both on- and off-duty PA influences in firefighters had been limited prior to this study. However, the limitations of this study are important to consider as the generalizability of these findings may be limited due to the small, homogenous sample, increasing the risk of type II error (i.e., false negative). Future research should broaden recruitment efforts to include more fire departments of various sizes (e.g., career and volunteer) and within different regions (e.g., rural, urban) as there may be variability in cultures and resources across the United States. Additionally, a few subscales within the survey also showed low internal consistency (e.g., work environment within WEIS, EMI-2 positive health) and should be interpreted cautiously. Lastly, over-reporting is a common concern with the IPAQ (Lee et al., 2011), potentially due to recall and social desirability bias. Moreover, as participation was completely voluntary, there is a risk for sample bias to contribute to the high PA levels (i.e., those who are interested or more physically active were more likely to participate). To address limitations associated with self-reported PA, future studies should incorporate objective measures to complement self-reported data and more comprehensively examine other domains of PA (e.g., occupational, leisure, household) to accurately capture firefighters' PA patterns

Conclusions

Reflecting broader evidence that the work environment is a major determinant of PA adherence (Grimaud et al., 2025), the qualitative findings identified firefighters' participation in

PA appeared to be shaped by peer and family dynamics, departmental norms, operational demands, and their physical environment and resources. These contextual factors seem to influence both opportunities and motivation towards PA, warranting the development of a standardized tool to effectively evaluate their current organizational, environmental, and policy supports. Qualitative findings indicated that off-duty PA is heavily impacted by time constraints and access to facilities, which may have led to more family-based PA in the participants' communities. Fire departments aiming to support PA and long-term adherence may benefit from strengthening supportive leadership practices, promoting flexible scheduling, having equitable access to equipment and spaces, and establishing clear policy expectations to develop a department culture that prioritizes firefighter health and wellness.

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Chapter 3 - The Adaptation and Reliability Testing of a Fire Department Multilevel Exercise Supports Audit Tool

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Abstract

Engaging in regular physical activity (PA) and exercise is important for firefighters' occupational performance and overall health. Occupational settings are common for PA initiatives and audit tools provide an objective assessment of the environment to inform these initiatives. Current audit tools may not be relevant to identify present exercise supports fire departments; therefore, the purpose of this study is to adapt a workplace PA audit tool to develop the Fire Department Multilevel Exercise Supports (FD-MES) audit tool and assess its inter-rater reliability among firefighters. **Methods:** The tool adaptation was a three-step process: 1) tool selection, 2) tailored adaptation to the fire service context, and 3) pilot reliability testing. Three career fire departments from small- and mid-sized; Midwestern cities participated in pilot testing. **Results:** The FD-MES is composed of a total of 104 items across five domains. A total of 58 participants from three fire departments participated in the study for pilot testing. Across all inter-rater comparisons, the tool demonstrated mixed reliability with a small portion of items demonstrating fair to perfect reliability, ranging between 19.2% and 38% depending on rank comparisons (e.g., captain vs firefighter), and other items require revision to enhance reliability. Several items that performed well reflected items assessing messaging, communication, coworker support, social climate, physical environment, and programs or policies. **Conclusions:** This study serves as a necessary first step for tool development. Fire captains may be better suited to complete FD-MES sections requiring insider knowledge of department resources, whereas firefighter-rank personnel are likely better positioned to report on their social environment. Although improvements are needed, fire department administrators can use this tool as a needs assessment and identify gaps across various levels of influence including knowledge, social support, or policy perception to inform implementation of exercise-related programs and resources.

Introduction

Firefighters are required to perform strenuous, physically demanding tasks in life-threatening situations (Al-Zaiti et al., 2015), which require a high level of physical fitness, including cardiorespiratory fitness, and muscular strength and endurance (Ras et al., 2022). Despite these occupational requirements, firefighters exhibit high rates of physical inactivity and overweight or obesity (Barry et al., 2020; Durand et al., 2011; Poston et al., 2011), which may compromise job performance (Ras et al., 2022) and increase the risk for cardiovascular disease and other comorbidities (Poston et al., 2011). Therefore, engaging in regular physical activity (PA) and structured exercise can help ensure firefighters are physically prepared and fit for duty (Gendron et al., 2020; Gledhill & Jamnik, 1992), as well as reduce overexertion injuries (Ras et al., 2023).

Increasing PA and exercise supports for fire departments has become a priority for the U.S. Fire Service. The National Fire Protection Association (NFPA), a non-profit organization, developed health, safety, and fitness standards to enhance operational readiness and reduce risk for disease, injury, and premature death among firefighters (National Fire Protection Association, 2015, 2018). However, these standards (e.g., annual medical evaluations, fitness programs and assessments) are considered voluntary for fire departments to adopt, in addition to having no nationally mandated fitness or PA requirements. As a result, ways in which PA and exercise are supported across departments may vary, and consequently, there is considerable variability in fitness levels between firefighters (Banes, 2014).

Occupational settings are common contexts for health promotion programs, and PA interventions can help improve PA behavior (Howlett et al., 2019) and fitness-related outcomes (e.g., cardiorespiratory fitness) (Conn et al., 2009; Prieske et al., 2019). However, there remains a

need for the fire service to implement fitness and health initiatives (e.g., fitness programs, annual fitness and health assessments, dedicated exercise time every shift) (National Fire Protection Association, 2021; Wohlgemuth et al., 2024). Given the variability in how strategies are implemented across contexts, fire departments represent a particularly critical occupational setting for identifying modifiable factors that can support effective strategies for PA and exercise promotion. Within this population, previous research has identified a range of determinants associated with exercise behavior, including individual (e.g., self-efficacy, motivation), interpersonal (e.g., peer support, social cohesion), and environmental factors (e.g., physical resources) (Banes, 2014; Brin, Heinrich, et al., 2026). Additionally, organizational initiatives such as providing access to fitness equipment and mandated exercise time during shifts have shown firefighters to be more likely to engage in exercise (Agostinelli et al., 2023) and engage in higher weekly PA (Gendron et al., 2020). However, despite the availability of these opportunities (e.g., equipment, time), access to exercise resources alone may not ensure sustained exercise participation and compromise a firefighter's ability to maintain adequate fitness levels (Melton et al., 2021). As such, there seems to be a complex interplay of individual, social, and environmental factors among firefighters (Golden & Earp, 2012).

Frameworks like the Social Ecological Model (SEM) are commonly used to identify multilevel determinants across individual, interpersonal, organizational, community, and policy levels. The SEM assumes these levels interact (McLeroy et al., 1988) and provides a pragmatic approach for behavior change to guide the development of effective interventions, programs, and policies (Golden & Earp, 2012). Similarly, the use of audit tools can facilitate a systematic evaluation to identify gaps, track progress, and foster evidence-based practices for health behaviors in workplaces (Loitz et al., 2021; Roemer, 2020), schools (Ajja et al., 2015), and within

communities (Besenyi et al., 2016; Ivy et al., 2006). A previous review of existing workplace PA audit tools found that only one-third of tools used a theory/framework; and of those that did, the SEM was identified to be the most common (Loitz et al., 2021). Audit tools aligned with the SEM are optimal to inform the development of multilevel interventions and programs to better support an individual's health and provide practical mechanisms for behavior change (Golden & Earp, 2012; Loitz et al., 2021). Moreover, audit tools may be a practical resource for fire departments to use as a needs assessment to identify various areas for improvement and eventually develop targeted initiatives that address context-specific barriers and leverage existing supports.

Given that fire departments represent a unique occupational setting that differs substantially from traditional workplace settings (e.g., offices), existing audit tools may neglect to capture exercise-specific supports relevant to physically demanding occupations like firefighting. As a result, fire departments require a setting-specific, firefighter-relevant tool to identify present exercise supports that incorporate social, organizational, and environmental factors. Therefore, the purpose of this study is to adapt a workplace physical activity audit tool to develop the Fire Department Multilevel Exercise Supports Audit tool and assess its inter-rater reliability among firefighters of different ranks.

Methods

Overview of Study Design

This study comprised several steps to develop an environmental assessment using an existing tool to assess exercise supports within the fire service, including 1) tool selection, 2) adaptation to the fire service, and 3) pilot reliability testing. To pilot the tool, career fire departments in small- and mid-sized cities within 150-mile radius of the study setting were invited

to participate, and the departments who expressed interest were subsequently recruited from. All procedures were approved by the university's institutional review board (protocol #1396).

Tool Selection Process

A targeted search of the literature was conducted to identify existing workplace audit tools assessing physical activity or exercise supports. Electronic databases (e.g., Google Scholar, PubMed) and grey literature sources (e.g., organizational reports, workplace health resources) were searched using combination of search terms including “workplace audit”, “physical activity audit”, and “worksite assessment”. Identified tools were evaluated against predefined selection criteria: 1) included multilevel assessment (e.g., individual, interpersonal, organizational, environmental, and policy-level factors), 2) had theoretical foundation, 3) was informed from existing literature, and 4) was suitable to adapt for the fire service context. Tools that solely focused on the physical or built environment (e.g., facilities, equipment) were not considered as they did not also account for social support, organizational practices, or policies within occupational settings. Several existing audit tools were reviewed and compared against the predefined selection criteria described above before selecting the most appropriate tool. A majority of the tools were for an office setting, and none were identified to be specific for a fire department; therefore, adaptation of a previously developed tool was most suitable. Based on the previously described criteria, the Active Workplace Audit Tool (Gorman et al., 2019) was selected.

The Active Workplace Audit Tool (Appendix Figure B.1.) was originally developed to assess the factors that influence workplace physical activity (PA) and sedentary behaviors. According to the developers, the Centre of Active Living located in Alberta, Canada, this tool was informed by the Increasing PA and Decreasing Sedentary Behavior in the Workplace Systematic Review (Johnston et al., 2015), the Workplace PA Framework (Plotnikoff et al., 2003), and an

environmental scan for office workplace settings (Loitz et al., 2021). The tool is composed of a total of 28 questions (106 items) across five domains: A) Awareness and Education, B) Social Support, C) Organizational Support, D) Community Assets and Partnerships, and E) Programs and Policies.

The Awareness and Education domain consisted of 15 total items assessing the sub-domains of PA messaging (6 items), communication strategies (4 items; e.g., message content, dissemination channels), and education opportunities (5 items; e.g., personal development, self-regulation skills). The Social Support domain included seven total items across various levels of the workplace, including employees (2 items), management (2 items), and top management (3 items). Items assessed if these individuals were perceived as role models, helped shape practices, or cultivated a positive PA culture. Organizational Support was assessed using 43 items capturing staffing and committee structures (4 items; e.g., wellness champions, committee budgets), social climate (21 items; e.g., organizational planning, workplace norms), and indoor physical environment (18 items; e.g., fitness and recreation support, stair accessibility). The Community Assets and Partnerships domain included 9 total items pertaining to the outdoor environment features (7 items), and community organization or facility partnerships and external resources for PA promotion (2 items). Finally, the Program and Policies domain used two ‘select all that apply’ questions to assess those offered within the workplace for a total of 32 items.

Responses to items within each domain are summed for a total domain score. Most items are scored using dichotomous (i.e., yes/no) responses, while nine items use ‘check all that apply’ responses to assess specific organizational planning considerations, supportive social climate elements, indoor and outdoor resources, and workplace programs and policies related to PA. Each domain score is calculated by summing all items scored as “yes” within that domain; scores are

calculated separately for PA and sedentary behavior. Scores are categorized into four progress levels: needs attention (i.e., few supports), fair, good, and outstanding (i.e., variety of supports). An overall audit score can be derived by calculating the average of all domain scores for PA and sedentary behavior independently. A higher score indicates greater support for PA and/or reduced sedentary behavior.

Audit Tool Adaptation Process

The adaptation process relied on preserving the five original domains and tailoring each item to the fire service. Given that the original audit tool assessed various sources of support for increasing PA and decreasing sedentary behavior, the purpose of the tool was modified to assess various influences that enable on-duty planned, structured exercise within a fire department. This change to target exercise rather than PA broadly was specific to align with recommendations from leading fire organizations, such as the National Fire Protection Association, and the Fire Service Joint Wellness Fitness Initiative which emphasize exercise and fitness to maintain occupational readiness. To maintain alignment with the adapted purpose of the tool, which focuses on exercise-specific influences, sedentary behavior items, and as an outcome, were removed from the tool.

Previous focus groups (Brin, Heinrich, et al., 2026) and interviews with fire department leadership (e.g., captains, battalion chiefs) were used to adapt the tool's language and add items to align with fire departments including their peer and organizational supports, fitness spaces or resources, and department-specific programs or policies. Additionally, the lead researcher visited each department to observe their physical resources and environmental features (e.g., fitness equipment, exercise spaces), which were used to refine tool items.

Once a draft of the adapted tool was developed, experts including four academic researchers with expertise in firefighter health and wellness, PA promotion, and built environment

assessment were contacted to individually review and provide feedback on item clarity, relevance, and applicability to the fire service. Recommendations included clearer operational definitions of organizational levels (e.g., department-wide versus leadership) and to consider peer influence and an individual's resistance to fitness participation (e.g., peer pressure) more explicitly. Then, three fire department administrators reviewed the tool to provide further feedback and clarification on items, including department-specific funding allocation, wellness committee responsibilities, facilities, and program opportunities. These suggestions were implemented to enhance clarity and applicability of the tool to the fire service.

Participants & Procedures

Participants were recruited from three Midwest career fire departments via an in-person recruitment meeting, department email listservs, and flyers posted throughout department stations. Those who were interested in participating provided their work or personal email address. Department-provided work email addresses were the preferred method of distribution since emails could only be accessed within the workplace environment, ensuring the responses were completed within the intended occupational context. However, location where the tool was accessed or completed was not monitored or enforced. Participants were sent a link to the adapted audit tool via Qualtrics and directed to screening questions to determine eligibility criteria. The inclusion criteria consisted of 1) currently assigned to a division or company that engages in emergency and non-emergency responses (e.g., medical, fire suppression, rescue) and 2) physically able to engage in fire emergency tasks (e.g., search and rescue, fighting fires, climbing ladders). Administrative, training, and support personnel were excluded from this study. Eligible participants provided informed consent, then proceeded to complete basic demographics and the adapted audit tool.

Participants were instructed to answer all yes/no or ‘check all that apply’ questions and if unsure, were recommended to refer to departmental resources (e.g., fitness program guidelines) or select ‘no’. Operational definitions for firefighter personnel, officers, department leadership, and command staff were provided to prevent misinterpretation of specific items across respondents. For station-specific questions, participants were directed to assess their assigned station, while department-level questions reflected organizational practices, leadership, and culture. As there is a hierarchical, rank structure within fire departments, leadership-related items were answered according to participants’ experiences across various hierarchical levels (e.g., captains, battalion chiefs, assistant fire chief, administration) as there may be differing influences of support. For instance, Captains are company-level officers typically responsible for day-to-day work tasks and supervision of a crew (i.e., made up of driver engineers and firefighters), whereas Battalion Chiefs oversee several stations within the same shift and communicate directly with the captains on shift. To ensure participants responded to all items, a force-response was applied. Tool completion time was approximately 20 to 30 minutes.

Statistical Analyses

To examine the audit tool’s reliability, Cohen’s kappa (Landis & Koch, 1977) and percent agreement (Fleiss et al., 2004) were used to examine inter-rater reliability among paired ratings of the same fire station based on firefighter rank (e.g., captain-to-captain, captain-to-firefighter, firefighter-to-firefighter). Cronbach’s alpha (Cronbach, 1951) was used to measure internal consistency of the tool’s subdomains. Reliability statistics were calculated for items with at least two pairs of ratings available across the sample of fire stations from participating departments, and we randomly selected captain- and firefighter-ranked raters. Those who were ranked lower than a captain (i.e., driver, firefighter, probationary firefighter) were pooled together and randomly

selected to be considered as the “firefighter” rater for their respective fire station. Percent agreement was also calculated for every item within each fire department independently to assess within-department reliability. Criterion validity could not be assessed because most tool items required insider knowledge, making it difficult to identify an independent gold-standard rater for comparison.

Guidelines established by Landis and Koch (1977) were used to interpret kappa statistics: 0.81-1.00 = almost perfect to perfect agreement; 0.61-0.80 = substantial agreement; 0.41-0.60 = moderate agreement; 0.21-0.40 = fair agreement; 0.00-0.20 = slight or poor agreement. When kappa could not be calculated, percent agreement statistics were evaluated using the following criteria: 75-100% = excellent; 60-74% = moderate; and less than 60% = poor (Saelens et al., 2006). Cronbach’s alpha criteria included $<.60$ = poor/unacceptable, 0.70-0.80 = acceptable, 0.81-0.90 = good, and 0.91-1.00 = excellent (Cronbach, 1951).

Results

Adapted Fire Department Multilevel Exercise Supports (FD-MES) Audit Tool

To align with the study’s purpose of the tool, the term *physical activity* was changed to *exercise* throughout to improve clarity and reflect planned or structured activity intended to enhance occupational readiness. The lead researcher added or revised the wording of items to align closely with the fire service and streamline terminology. The term *workplace* was replaced with *fire department* or referred to the participant’s assigned *fire station* depending on the context of the question. *Employees* were substituted with *fire personnel*, *management* was replaced with *officers*, and *top management* was changed to *command staff*. Item descriptions and examples were modified based on feedback from the expert review to provide clarity, reduce respondent confusion, and improve relevance to firefighters. For instance, clarifying language was added to

the existing social climate subdomain ‘select all that apply’ questions to distinguish the various support formally included in the department’s organizational plan, thereby differentiating those that are encouraged in the department’s social climate in the subsequent question. The adapted tool included a total of 31 questions (104 items) across the five domains.

The total number of items within the Awareness and Education domain remained the same as the original tool (i.e., 15 items). Questions pertaining to the *messaging, communication, and education* subdomains captured mechanisms by which exercise-related information is shared and communicated from Command Staff, and what educational opportunities are offered to personnel. Items were revised to be directed from the department’s command staff or leadership directly, rather than the workplace as a whole and examples for each item were adapted to fit the fire service. For instance, an item asking if exercise-related messages have a clear and relevant call to action included the following examples: prompts to fit in a quick workout between calls, use downtime for mobility or stretching, and incorporate movement into daily routines at the station (Figure 3.1).

Figure 3.1. Messages subdomain item example.

Do exercise-related messages in the fire department include:	Yes	No
A clear and relevant call to action for exercise during the workday (e.g., "fit in a quick workout between calls," "use downtime for mobility or stretching," "incorporate movement into daily routines at the station")?	☐	☐
Appropriate language and literacy level for exercise?	☐	☐
Appropriate content that is inclusive for firefighters at various fitness and readiness levels to engage in exercise (e.g., new to structured exercise, returning after injury, regularly engaging in high-intensity exercise, or preparing for physically demanding job tasks like a ladder raise)?	☐	☐
Positive messaging around exercise – avoiding shame, appearance-based goals, or punitive framing (e.g., instead of "you need to get in shape," using messages like "staying active helps you perform and recover better")?	☐	☐
Information that is relevant, interesting, and relatable to firefighting personnel (e.g., examples tied to job performance, recovery, teamwork)?	☐	☐

Under the Social Support domain, four items were added for a total of 11 items to assess if firefighters create social pressure to exercise, if exercise is culturally normalized among peers, if officers foster a culture where exercise is expected, and if command staff actively create and support a culture that normalizes exercise (Figure 3.2). The item assessing coworker social pressure was reverse scored (yes=0, no=1) to ensure higher social support scores indicated greater support for exercise.

Figure 3.2. Coworker support subdomain item example.

Firefighter personnel are actively involved in shaping practices, systems, or methods to engage others in exercise (e.g., peer leadership, mentorship, feedback on department policies, scheduling input).	Firefighter personnel may create social pressure or discourage participation in exercise (e.g., newer members feeling judged for exercising on duty, teasing or negative comments when participating or not participating, subtle exclusion from group activity).
☐ Yes	☐ Yes
☐ No	☐ No

Within the Organizational Support domain, nine items from the *social climate* ‘select all that apply’ question were omitted due to targeting sedentary behavior (e.g., office layout, use of stairs). Five of these items were replaced with broad and occupation relevant options including encouraging peer competition, recognition, participation in PA events, regular use of fitness equipment, and participation in job-based tasks as a form of exercise. Therefore, the domain increased to a total of 45 items (staffing and committee=4 items, social climate=21 items, and indoor environment=20 items) (Figure 3.3).

Figure 3.3. Social Climate subdomain item examples.

The fire department has a social climate that encourages... Consider what is encouraged or happens in day-to-day department life, regardless of formal policy. <i>Select all that apply:</i> ☐ Active commuting to work (personally supported by peers). ☐ Regular use of fitness equipment. ☐ Standing desks in offices/administrative spaces (used in practice). ☐ Walking meetings when appropriate. ☐ Standing meetings (e.g., briefings, check-ins, informal meetings) ☐ Use of on-site fitness facilities. ☐ Exercise during designated time, between calls, or before/after work (actual practice). ☐ Use of on-site fitness facilities. ☐ Exercise during designated time, between calls, or before/after work (actual practice). ☐ Use of local fitness and/or recreation facilities. ☐ Participation in community physical activity events (e.g., 5Ks, mud runs, firefighter challenges, 9/11 stair climb). ☐ Participation in job-related physical tasks or hands-on training as an option when traditional exercise isn't feasible.	Does the fire department command staff implement the following in their organizational plans? Consider what is officially planned or supported by command staff through policies or schedules. <i>Select all that apply:</i> ☐ Active commuting to work (formal encouragement or incentives). ☐ Availability and/or support for standing workstations in office/administrative areas. ☐ Standing meetings (officially scheduled). ☐ Use of on-site exercise spaces and equipment. ☐ Provide a specific time for exercise while on shift (formal plan). ☐ Allow flexibility in shift schedule for exercise time. ☐ Use of local fitness and recreation center or facilities (formal access or membership support). ☐ Encourage peer-led fitness initiatives or friendly competitions (e.g., firefighter-led workout groups, shift vs. shift challenges). ☐ Recognition of physical activity and exercise participation or achievements. ☐ Participation in community physical activity events (e.g., 5Ks, mud runs, firefighter challenges, 9/11 stair climbs).
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Two items were added to the question pertaining to the fire station's exercise environment within the *indoor environment* subdomain, including “fire station has a designated space for exercise” and “equipment can be used in different areas of the station” (Figure 3.4). An additional, single ‘select all that apply’ question was added to assess their fire station's exercise space characteristics, with nine response options including type of exercise equipment, appearance, maintenance, adequacy of the space, etc.

Figure 3.4. Indoor environment item example.

Does your fire station have the following exercise supports...

Select all that apply:

☐	Fitness equipment.
☐	Variation in the types of equipment (e.g., various skill or fitness levels, body types, goals, or preferences).
☐	Designated space or room for exercise.
☐	Equitable access to fitness equipment and facilities across all stations
☐	Formally or informally allow personnel to access fitness areas outside of designated workout times (e.g., before/after shifts or off-duty).
☐	Flexible spaces for warm-ups, mobility, recovery, and equipment stowage (e.g., portable equipment that can be moved and used in different parts of the station).
☐	Shower and change room facilities.

Under the Community and Partnership domain, the single *outdoor environment* question remained as a ‘select all that apply’ assessing the environmental characteristics surrounding the fire station, and the number of response options increased from seven to eight as the public transit option was removed and replaced with two occupation-relevant items: 1) facilities for physical training available on-site and 2) reliance on off-site resources for exercise (Figure 3.5). The examples for the *partnership* subdomain items to assess the various sources of external information or resources were revised to fire-specific and general health organizations including the National Fire Protection Association, Fire Rescue Fitness, and the Centers for Disease Control and Prevention (Figure 3.6).

Figure 3.5. Outdoor environment item example.

The fire station is located in an area that...

Focus on the outdoor environment surrounding your fire station.

Select all that apply:

- ☐ Is safe from crime.
- ☐ Is safe from automobile traffic and active transportation commuters (e.g., speed, volume, driveways, crosswalks).
- ☐ Has universally accessible sidewalks (i.e., well paved, cleared of any snow or debris, free of obstacles or construction in path, well lit).
- ☐ Has enough sidewalks or other pedestrian walkways for a 10-minute walk.
- ☐ Allows outdoor or informal spaces available for physical activity or exercise (e.g., parking lots or driveways for drills/workouts, open spaces, walking paths, playing fields, or courts).
- ☐ Is aesthetically pleasant (e.g., presence of trees, shrubs, clean, graffiti-free).
- ☐ Includes job-relevant facilities for physical training (e.g., training towers, drill yards, outdoor equipment).
- ☐ Relies primarily on off-site resources for exercise (e.g., community recreation or fitness centers, parks or trails).

Figure 3.6. Partnership subdomain item example.

Does the fire department collaborate with or have partnerships with community-based facilities or services to provide opportunities for exercise?

☐ Yes

☐ No

Does the department use information or resources from outside sources (e.g., International Association of Fire Fighters, Centers for Disease Control, Fire Rescue Fitness) **for promotion, programming, or policies related to exercise?**

☐ Yes

☐ No

The Programs and Policies domain retained two ‘select all that apply’ questions, although the number of items for each differed compared to the original. The *programs* subdomain had five responses removed as it aligned with targeting sedentary behavior, reducing the total to 8 responses, compared to the original 13. The *policy* subdomain question was revised by removing all sedentary behavior-specific items, adapting the remaining physical activity items to reflect firefighter-specific exercise supports, and adding fire service-relevant policy items, including department-specific exercise policies (e.g., policies address variations in daily operations, department offers incentive programs, personnel can engage in exercise on shift, recreational sports are allowed, firefighters have annual health physicals, etc.). These revisions resulted in a 15-item subdomain, compared with the original 19 items. (Figure 3.7).

Figure 3.7. Policy subdomain item examples.

Does the fire department have the following policies?					
	Yes	No		Yes	No
Officers are recognized for supporting exercise (e.g., staff and team recognition).	☐	☐	Financial and material resources are allocated for exercise in the budget (e.g., budget for new equipment, funding for wellness programs or events).	☐	☐
Firefighter personnel are recognized for participating in exercise (e.g., staff and team recognition).	☐	☐	Sponsorship opportunities for department sports teams or events (e.g., walks, running races, or cycling challenges).	☐	☐
Fire department wellness benefits exist to financially support exercise (e.g., stipend for exercise clothes or shoes, discounted or fully funded gym memberships, or paid fitness coordinator/liaison).	☐	☐	Incentive programs or recognition of exercise participation or achievements (e.g., free or subsidized gym memberships, compensatory time off, annual awards for top performers, department-wide challenges).	☐	☐
Status reports of exercise initiatives are reported to command staff or city administration (feedback from personnel is provided to command staff or upper leadership).	☐	☐	Active transport initiatives (e.g., free or subsidized bus passes or tickets, bike share).	☐	☐
Policy statements exist supporting exercise in the department (e.g., dress down, designated or flexible time).	☐	☐	Personnel can engage in exercise during duty hours.	☐	☐
The department has policies supporting inclusive and accessible exercise opportunities.	☐	☐	Firefighter personnel can engage in recreational sports during duty hours (e.g., team-based games or activities that the crew can play together, such as basketball, volleyball, or softball, within the station or on department property).	☐	☐
Exercise policies address variations in personnel's operations (e.g., shift work, training, daily tasks).	☐	☐	Firefighter personnel have annual health assessments.	☐	☐
			Firefighter personnel have annual fitness assessments that adequately assess occupational tasks, including job-related physical ability tests (e.g., CPAT, annual SCBA drills) and other measures relevant to firefighter duties.	☐	☐

The original tool had a vague categorization system of progress levels for domain and subdomain scores as “needs attention” was operationalized as having “few or no supports in place”, “fair” was considered as having “some”, “good” represented a “foundation of support”, and “outstanding”

included a “variety of support”. Thus, we modified the scoring process to improve standardization and aid in interpretation. Scores were calculated as a percentage of the maximum possible score and these percentage-based progress levels were used to descriptively characterize the availability of exercise supports within departments: needs attention (<25%), fair (25–49%), good (50–74%), and outstanding ($\geq 75\%$) to aid in interpretation.

Participant Characteristics

A total of 58 participants participated in the study (Fire Department 1 [FD1] =20, Fire Department 2 [FD2] =19, Fire Department 3 [FD3] =19). Most participants were male (n=4 female; 6.9%) and identified as white (91.4%), with few participants identifying as Hispanic (n=3; 5.2%), African American (n=1; 1.7%), and Hawaiian Native/Pacific Islander (n=1; 1.7%). On average, participants were considered overweight or obese in terms of BMI. Many respondents held the rank of captain (34.5%) or firefighter (31%). Participant characteristics are summarized by each fire department in Table 3.1.

Table 3.1. Participant characteristics by department (N=58)

Variable	<i>FD1 (n=20)</i>		<i>FD2 (n=19)</i>		<i>FD3 (n=19)</i>	
	M $\pm$ SD	N (%)	M $\pm$ SD	N (%)	M $\pm$ SD	N (%)
Age (years)	37.6 $\pm$ 9.1		37.7 $\pm$ 8.4		37.1 $\pm$ 8.4	
Gender						
Male		20 (100%)		16 (84.2%)		17 (94.7%)
Female		0 (0%)		3 (15.8%)		1 (5.3%)
Race						
White		20 (100%)		16 (84.2%)		17 (89.5%)
African American		--		1 (5.3%)		--
Hispanic		--		2 (10.5%)		1 (5.3%)
Native Hawaiian or Pacific Islander		--		0 (0%)		1 (5.3%)
BMI (kg/m²)	27.2 $\pm$ 2.7		29.1 $\pm$ 3.7		30.9 $\pm$ 5.1	

Normal Weight (18.5–24.9 kg/m ²)	4 (20%)	3 (15.8%)	3 (15.8%)
Overweight (25–29.9 kg/m ²)	13 (65%)	9 (47%)	5 (26.3%)
Obese (≥30 kg/m ²)	3 (15%)	7 (36.8%)	11 (57.9%)
Years of service			
Less than 1 year	0 (0%)	0 (0%)	0 (0%)
1 - 5 years	2 (10%)	4 (21.1%)	5 (26.3%)
6 - 10 years	4 (20%)	4 (21.1%)	4 (21.1%)
11 - 15 years	5 (25%)	5 (26.3%)	2 (10.5%)
16 - 20 years	5 (25%)	3 (15.8%)	4 (21.1%)
More than 20 years	4 (20%)	3 (15.8%)	4 (21.1%)
Rank			
Probationary Firefighter	0 (0%)	2 (10.5%)	0 (0%)
Firefighter	3 (15%)	10 (52.6%)	5 (26.3%)
Driver Engineer	8 (40%)	4 (21.1%)	5 (26.3%)
Captain	9 (45%)	3 (15.8%)	8 (42.1%)
Battalion Chief	0 (0%)	0 (0%)	1 (5.3%)
Fire Department scheduled hours worked per week	59.4 ± 6.5	62.3 ± 22.6	61.6 ± 18.0
Overtime hours worked per week	4.1 ± 5.0	9.6 ± 12.6	5.4 ± 8.9

Note: Dashes (--) = not applicable; Prob. Firefighter = Probationary firefighter (<1 year of experience).

The FD-MES audit tool collected information regarding 104 distinct items. Originally, participants were recruited from a sample of 13 fire stations across the three departments (FD1: 5 total fire stations; FD2: 2 total fire stations; FD3: 6 total fire stations). However, three stations (FD1: Station 4; FD3: Station 2 and Station 6) lacked enough responses to be included in analysis. For captain-to-captain inter-rater reliability, paired ratings were available for seven fire stations. Nine fire stations had paired captain-to-firefighter ratings, and eight fire stations had a paired rater for firefighter-to-firefighter reliability. FD3 had the only Battalion Chief in the sample, and a single

respondent did not indicate which fire station they were assigned to, therefore, neither were included in the reliability analysis (FD3; n=17). Participant distribution by department and rank for reliability is shown in Table 3.2.

Table 3.2. Total participant distribution by rank and station for reliability testing.

	FD1 (n=20)		FD2 (n=19)		FD3 (n=17)	
	Captain	Firefighter	Captain	Firefighter	Captain	Firefighter
Station 1	2	5	2	7	2	3
Station 2	2	4	1	9	1	0
Station 3	3	2	--	--	2	3
Station 4	0	0	--	--	1	1
Station 5	2	0	--	--	1	3
Station 6	--	--	--	--	0	1

Notes: Probationary firefighters, firefighters, and drivers were pooled together to be randomly selected for the 'firefighter-rater' in the reliability analysis. Dashes (--) = not an applicable fire station for the department.

With respect to captain-to-captain reliability, over 38% of items demonstrated fair or moderate to perfect reliability. Specifically, kappa statistics between the captain-ranked raters demonstrated moderate to perfect kappa for 21.2% of items, fair reliability for 17.3% of items, and poor reliability for 14.4% of items. For 41 items, kappa could not be calculated or was inappropriate because responses demonstrated little variability, as the item was consistently reported as either present or absent. For those items, on average, there was an 89% agreement between raters. Great disagreement (i.e., negative kappa) was also demonstrated for 14% of items. See Table 3.3 for a complete breakdown by kappa categories (Appendix Table B.1 has a table of kappa and percent agreement by item across reliability comparisons).

Table 3.3. Captain-to-captain inter-rater reliability of tool items.

Tool domains & subdomains	Total items	Disagr- eement (0.0 to -1)	Poor (0.00- 0.20)	Fair (0.21- 0.40)	Moder- ate (0.41- 0.60)	Substa- ntial (0.61- 0.80)	Almost perfect (0.81- 1.00)	Not appli- cable	>70%	<70%

Awareness & Education										
<i>Messages</i>	6	0	1	4	0	1	0	0	1	5
<i>Communication</i>	4	0	1	1	0	1	0	1	3	1
<i>Education</i>	5	1	0	3	1	0	0	0	2	3
Social Support										
<i>Coworkers</i>	4	1	0	1	0	0	0	2	3	1
<i>Officers</i>	3	1	0	0	0	0	0	2	3	0
<i>Command staff</i>	4	0	1	1	1	0	0	1	2	2
Organizational Support										
<i>Staffing & committees</i>	4	1	0	1	0	0	2	0	2	2
<i>Social climate</i>	21	0	1	2	2	1	2	13	20	1
<i>Indoor enviro.</i>	20	5	1	3	0	1	0	10	13	7
Community & Partnership										
<i>Outdoor enviro.</i>	8	2	0	1	3	0	0	2	5	3
<i>Partnership</i>	2	1	0	0	0	1	0	0	1	1
Program & Policies										
<i>Programs</i>	8	3	0	0	1	0	0	4	7	1
<i>Policies</i>	15	0	3	1	3	1	1	6	12	3
Total	104	15	8	18	11	6	5	41	74	30

Note: Enviro. = environment; Final two columns show percent agreement.

For captain-to-firefighter inter-rater reliability, kappa statistics demonstrated fair or moderate to perfect reliability for only 22.1% of items. Roughly 10% of items were considered to have poor reliability, and 29.8% of items demonstrated a negative kappa (i.e., great disagreement) between ranks. In the remaining 40 tool items that were unable to calculate kappa due to lack of

variability, all but five items demonstrated moderate to excellent percent agreement exceeding 70%, with most items well above 80% (Table 3.4).

Table 3.4. Captain-to-firefighter inter-rater reliability of tool items.

Tool domains & subdomains	Total item s	Disagreement (0.0 to -1)	Poor (0.00- 0.20)	Fair (0.21- 0.40)	Moderate (0.41- 0.60)	Substant- ial (0.61- 0.80)	Almost perfect (0.81- 1.00)	Not appli- cable	>70%	<70%
Awareness & Education										
<i>Messages</i>	6	1	3	2	0	0	0	0	0	5
<i>Communication</i>	4	2	1	0	1	0	0	0	1	3
<i>Education</i>	5	3	0	1	0	0	0	1	2	3
Social Support										
<i>Coworkers</i>	4	1	1	0	0	0	0	2	3	1
<i>Officers</i>	3	3	0	0	0	0	0	0	1	2
<i>Command staff</i>	4	4	0	0	0	0	0	0	1	3
Organizational Support										
<i>Staffing & committees</i>	4	0	0	0	2	0	0	2	4	0
<i>Social climate</i>	21	3	1	5	1	0	0	11	15	6
<i>Indoor enviro.</i>	20	3	3	1	1	1	1	10	12	8
Community & Partnership										
<i>Outdoor enviro.</i>	8	2	0	2	3	0	0	1	4	4
<i>Partnership</i>	2	2	0	0	0	0	0	0	0	2
Program & Policies										
<i>Programs</i>	8	2	0	0	0	0	0	6	7	1
<i>Policies</i>	15	5	1	1	0	1	0	7	10	5
Total	104	31	10	12	8	2	1	40	60	43

Note: Enviro. = environment; Final two columns show percent agreement.

Firefighter-to-firefighter inter-rater reliability similarly showed kappa statistics could not be calculated for 45 items (43.3%); for these items, a percent agreement was reported. For those items, 42 of 45 (93.3%) demonstrated greater than 70% of agreement between firefighter-ranked raters, and 35 items (77.8%) showed greater than 80% of agreement. Among items where kappa was calculated, 19.2% demonstrated fair or moderate to perfect agreement. However, 24% of items had negative kappa values, indicating substantial disagreement between raters (Table 3.5).

Table 3.5. Firefighter-to-firefighter inter-rater reliability of tool items.

Tool domains & subdomains	Total item s	Disagreement (0.0 to -1)	Poor (0.00- 0.20)	Fair (0.21- 0.40)	Moderate (0.41- 0.60)	Substant- ial (0.61- 0.80)	Almost perfect (0.81- 1.00)	Not appli- cable	>70%	<70%
Awareness & Education										
<i>Messages</i>	6	5	0	0	1	0	0	0	1	5
<i>Communication</i>	4	2	0	0	1	0	0	1	2	2
<i>Education</i>	5	2	0	0	0	0	0	3	4	1
Social Support										
<i>Coworkers</i>	4	1	0	0	0	0	0	3	4	0
<i>Officers</i>	3	0	0	1	1	0	0	1	2	1
<i>Command staff</i>	4	2	0	0	1	0	0	1	2	2
Organizational Support										
<i>Staffing & committees</i>	4	1	1	0	1	0	0	1	2	2
<i>Social climate</i>	21	2	4	1	1	1	0	12	15	6
<i>Indoor enviro.</i>	20	5	3	2	0	1	0	9	10	10
Community & Partnership										
<i>Outdoor enviro.</i>	8	1	3	2	1	0	1	0	4	4
<i>Partnership</i>	2	1	0	0	1	0	0	0	2	0
Program & Policies										

<i>Programs</i>	8	1	0	0	0	0	0	7	8	0
<i>Policies</i>	15	2	3	2	0	0	1	7	9	6
Total	104	25	14	8	8	2	2	45	65	39

Note: Enviro. = environment; Final two columns show percent agreement.

For percent agreement by fire department, over 70% of items were considered to have moderate to excellent agreement, with most items over 80%. Comparatively, across the fire stations within FD1, FD2, and FD3, participants' percent agreement was 76.9%, 71%, and 72.1%, respectively. Three items (i.e., one item for messaging subdomain and two items for command staff support subdomain) were considered to have a poor percent agreement across all three fire departments. Across the three fire departments, only 24 items had an average percent agreement below 60% (Appendix Table B.2).

Concerning the tool's internal consistency, the subdomains messages (6 items; $\alpha=.87$), officer (3 items; $\alpha=.82$) and command staff support (4 items; $\alpha=.81$), and indoor environment (20 items; $\alpha=.80$) indicate good internal consistency, and social climate (21 items; $\alpha=.71$) was considered to be acceptable. The education (5 items; $\alpha=.68$), staffing/committees (4 items; $\alpha=.64$), and programs (8 items; $\alpha=.64$) subdomains showed to have borderline acceptable internal consistency. However, if item four from education subdomain (e.g., does command staff provide personnel with education to understand department programs/policies that support exercise?) and item eight under programs subdomain (e.g., does the department have prompts and reminders to exercise and be active) are deleted, the subdomains would increase to have good ($\alpha=.81$) and acceptable internal consistency ($\alpha=.74$), respectively. The remaining subdomains demonstrated poor or unacceptable internal consistency regardless of any items getting deleted: communication (4 items; $\alpha=.49$), coworker support (4 items; $\alpha=.25$), outdoor environment (8 items; $\alpha=.51$), partnership (2 items; $\alpha=.43$), and policies (15 items; $\alpha=.47$).

Discussion

Health promotion efforts within occupational settings are common and can potentially address barriers to exercise (e.g. lack of time, access to facilities) (Virtanen et al., 2025). A growing body of literature reveals that fire departments' physical resources and policies can facilitate firefighters' PA and exercise habits (Agostinelli et al., 2023; Brin et al., 2026; Melton et al., 2023) and enhance their overall health (Wohlgemuth et al., 2024). As audit tools are crucial to evaluate workplaces and need to be context-specific, the creation of a multilevel audit tool to capture various exercise-specific supports and resources within fire departments can facilitate health promotion efforts and provide valuable insights for fire department administrators. Given prior evidence that workplace physical activity and sedentary behavior audit tools lacked any form of reliability or validity evidence (Loitz et al., 2021), the present study represents an important step toward the development and preliminary testing of an innovative tool which will inform item and tool refinement.

The FD-MES audit tool provides a novel contribution to the existing body of audit tools by including fire departments as an occupational setting and appears to be practical for fire personnel to use. As fitness and health are inherently important goals of the fire service, exercise as the target health behavior was a purposeful adaptation for the tool, rather than using the term PA broadly. Additionally, including relevant occupational features (e.g., training towers, exercise equipment, facilities), social structures (e.g., hierarchical rank), and policies and programs encouraged by the NFPA or the Fire Service Joint Labor Wellness-Fitness Initiative (e.g., on-duty time to exercise, exercise programs, peer fitness trainers) (International Association of Fire Fighters International Association of Fire Chiefs, 2018) facilitate real-world application as it aligns with the occupational environment. Moreover, the utilization of the SEM was essential to identify

context-specific strengths and needs, whether that was a specific domain (i.e., SEM level) which requires more support or capturing meaningful discrepancies between policies and how they are implemented or perceived in practice by fire personnel.

Across all rater comparisons, a small portion of items demonstrated fair or moderate to perfect reliability for Cohen's kappa. Several items that performed well by either kappa or percent agreement across raters reflected items assessing communication and messaging, coworker support, social climate, physical environment, programs and policies. The expert review and systematic modification process of existing items provided preliminary support for content validity of the FD-MES, as items were reviewed and adapted to be relevant to the fire service, such as considerations of firefighter roles, organizational structures, and workplace practices (e.g., alignment with NFPA recommendations). Conversely, comparisons between captains and firefighters revealed to have the highest proportion of poor agreement and overall disagreement (i.e., negative kappa), indicating systematic disagreement of items. Many of the items with poor reliability across inter-rater comparisons were subjective and poorly operationalized or used vague terms, with several items potentially requiring insider knowledge to answer appropriately. Additionally, two items that were considered to objectively assess the fire station's indoor environment (i.e., Have a designated space or room for exercise, Gym space is equipped with mats or space for stretching) showed poor reliability. However, it is important to acknowledge this may reflect meaningful differences in station infrastructure within the participating departments. Exercise resources in fire departments can range from limited aerobic and strength equipment to a comprehensive on-site gym. Some stations may have designated areas, whereas others may have multipurpose areas (e.g., truck bay, outdoors) which could have led to inconsistent reporting. Nevertheless, prior research has shown accessibility to fitness equipment and functional facilities

is important to influence exercise habits (Agostinelli et al., 2023; Brin, Heinrich, et al., 2026; Keegan et al., 2016), and therefore, these resources are still necessary for departments to assess and consider.

Our findings are similar to other built and physical environmental audit tools as items that were subjective and lacked explicit definitions or were ambiguous, which relied more on the auditor's judgement, may demonstrate greater challenges in agreement (Besenyi et al., 2016; Brownson et al., 2004; Hales et al., 2013; Pikora et al., 2002). Subjective items often required firefighters to rely on their personal perceptions, preferences, or judgements of quality (i.e., Exercise-related messaging information is relevant, interesting, and relatable, Officers are role models for increasing exercise, Is the fire station's exercise space appealing to use?). More detailed guidance or explicit definitions for ambiguous terms could improve the accuracy of the firefighters' answers. Likewise, items that consisted of abstract or interpretive concepts (i.e., Is the fire station's exercise space used regularly by personnel? Does the department offer or support firefighter participation in the following programs: group exercise classes?) were an issue for agreement between captains and firefighters. Adding cues, specific definitions, or aligning the question to be closer to an objective item (e.g., group exercise classes are organized by the department) may help the rater understand what is being asked. Additionally, several items consisted of information that may not be privy to all personnel (i.e., The wellness committee has a budget for exercise, The fire department has an organizational plan that addresses exercise time, separate from training, for firefighter personnel), which were more difficult for firefighters to agree on. Similarly, evaluating whether a resource, program, or policy was "supported" or "accessible" was an issue among firefighter-raters potentially due to the limited knowledge or lack of operational definitions. While many of these items included specific examples, and the tool's

instructions urged participants to rely on peers or department resources if they were unsure, having an additional reminder of instructions or an “I don’t know” response may have been beneficial to improve reliability and provide additional context on a potential knowledge gap between those of firefighter rank.

On the other hand, captain-to-captain comparisons had a larger portion of items considered to have acceptable reliability. Many of these were items that reflected organizational- or policy-level, including education, staffing, partnerships, and policies, potentially reflecting captains’ involvement in more managerial aspects of department operations. As fire departments are hierarchical organizations, captains or personnel in leadership roles may be more suitable to complete such items, especially those requiring specific knowledge and awareness. For instance, Captains and Battalion Chiefs may have contextual information to understand the ins-and-outs of formal policies, programs, local partnerships, or have access to educational resources and messaging-related content as part of their responsibilities. These patterns may also highlight the importance of having a well-informed, trained auditor to complete this tool to enhance reliability and eventually measure validity. As captains seem to play a pivotal role in firefighters’ daily routines (Dobson et al., 2013), including engagement in exercise during shifts, they may be important in communicating departmental policies and expectations to lower rank personnel (Brin, Heinrich, et al., 2026).

Firefighter-to-firefighter raters typically were more consistent for items which reflected their daily practices and social norms (e.g., social climate, officers as role models), and as such, firefighters may be better positioned to complete items evaluating their department’s social support or social climate, which in turn can provide feedback from a frontline perspective. Regardless, the discrepancy between captains and firefighters may reflect a lack of transparency, awareness, or

knowledge of departmental policies between ranks. Prior qualitative studies with firefighters have suggested these perceptions can vary between personnel (Brin, Heinrich, et al., 2026; Long et al., 2014). Awareness of policies that enable exercise (e.g., flexible exercise time, targeted information dissemination) and employees' perceptions of social and organizational support (e.g., leadership endorsement, clear communication) are important to consider (Blunt & Hallam, 2010) and may enhance participation in health promotion programs (Hoert et al., 2018; Long et al., 2014; Lucove et al., 2007). To limit perception variability across ranks, exercise policies, programs, and local partnerships should be put in writing and consistently implemented across shift and department leaders (Bailey et al., 2018; Long et al., 2014).

Internal consistency for many of the FD-MES subdomains was considered borderline to acceptable (i.e., officer and command staff support, indoor environment, social climate), while several other subdomains showed low internal consistency, including communication, coworker support, outdoor environment, partnership, and policies. Although Cronbach alpha expects items to be highly correlated and reflect the same underlying construct, some subdomains may capture broad or multidimensional concepts. Additionally, the partnerships subdomain only had two items which may not have produced a suitable reliability estimate in this instance. As the FD-MES subdomains were designed to capture different types of support and resources within a fire department setting, some items may have unintentionally overlapped concepts with other subdomains, potentially contributing to the low alpha. Future research should address these issues by further evaluation and determine if items should be revised, removed, or reorganized into more specific subdomains. Moreover, alternative validity and reliability approaches (e.g., test-retest reliability, content or construct validity) may provide additional insights regarding the performance of these subdomains.

The strengths of this study include the development and testing of a novel, fire service-specific audit tool to assess multilevel influences on exercise, which can provide relevance in real-world implementation efforts for fire departments. Additionally, the rank-focused reliability comparisons allowed for patterns in perceptions of SEM-aligned items to be discussed. However, there are several limitations worth mentioning. First, the sample size is relatively small as only three fire departments participated, with roughly one-quarter of eligible personnel participating from each department. Future research should pilot this tool with larger sample sizes (i.e., more fire departments, stations, firefighter personnel) to enhance generalizability and applicability of the tool. Second, there was no “gold standard” rater, which unfortunately prevented validity from being evaluated. Further, participants did not get training prior to completing the tool which may have influenced the reliability of the results. Future studies should incorporate a brief tool training for firefighters and attempt to identify an individual to be considered a gold standard rater in the fire department to enhance reliability and assess validity. Third, although we received feedback from an expert panel after initially adapting the tool, we did not assess content or face validity extensively. This may have helped determine if items were relevant or needed to be clarified as many of the items that had poor reliability were either subjective, abstract, or poorly operationalized. As a result, future research should conduct key informant interviews from fire departments to identify weaknesses of specific tool items (e.g., if they were hard to understand, poorly written, not relatable) and recommend any items to omit. Additionally, future iterations of the tool should include external resources or actionable steps targeting specific domains to enhance the type of support and resources for exercise in fire departments (e.g., organizing department-wide exercise challenges and competitions to strengthen social climate and organizational support).

Conclusion

The main purpose of this study was to create an exercise audit tool specific for fire departments. Additionally, it serves as a pilot to get preliminary reliability results from a small sample size as a necessary first step. Captains, or those in leadership roles, may be more adept to complete certain domains of the FD-MES tool due to many items requiring insider-knowledge of various resources and supports, while firefighters may be better positioned to report on their individual and department's social environment. Overall, these findings suggest that the FD-MES is promising but requires substantial item refinement before it can be considered reliable across fire service raters. Additionally, it appears to be practical for fire personnel to use. Aside from being context-specific, the high completion rate of the tool among those who participated and the use of an online platform (i.e., Qualtrics) to complete the tool are promising and may facilitate broader dissemination and acceptability. Additional work is needed to refine the tool, such as removing or revising items that consistently performed poorly across raters. An important next step is to assess the tool's predictive validity using objective PA measures. Nevertheless, the audit tool was designed with real-world application in mind, where it could be both understandable and interpretable (i.e., low domain or subdomain scores indicate low support) for non-researchers, such as department leadership and administrators. The practicality and usability of the FD-MES audit tool may still be beneficial for departments to complete and has potential to inform decision-making and guide targeted changes within fire departments as it can recognize factors of various levels of the SEM that may be unintentionally overlooked.

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Chapter 4 - Examining Multilevel Exercise Supports and Objectively Measured Physical Activity in Career Firefighters

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Abstract

Firefighters exhibit high rates of physical inactivity and obesity, yet few workplace tools exist to assess exercise and physical activity (PA) support across multiple ecological levels in this population. Therefore, the purpose of this study was to explore multilevel exercise supports using an adapted audit tool for fire departments and objectively measure PA behaviors among firefighters. **Methods:** Firefighters ($N = 58$) from three career fire departments participated in the study. The newly adapted Fire Department Multilevel Exercise Supports (FD-MES) audit tool was used to explore differences in fire departments' exercise supports across five domains: A) Awareness & Education, B) Social Support, C) Organizational Support, D) Community Assets & Partnerships, and E) Programs & Policies. A subset of participants ($n = 44$) wore accelerometers for 7 consecutive days to examine PA across various intensities. **Results:** There were significant differences between the three fire departments for the Community Assets & Partnership domain ($p = .006$) and several subdomains including communication, coworker support, officer support, staff & committees, indoor environment, outdoor environment, and partnership ($p < .05$). Participants accumulated an average of 56.10 minutes of moderate-to-vigorous PA per on-duty day, with few differences in PA intensities observed between departments. No significant associations were observed between on-duty PA and FD-MES domain or subdomains scores, while on-duty sedentary behavior demonstrated weak negative associations with Organizational Support ($r_s = -.327, p = .038$) and Policy & Programs domains ($r_s = -.331, p = .030$). **Conclusions:** The FD-MES may be a valuable tool for departments to identify opportunities to better support exercise and PA. Although differences in PA were minimal, organizational and policy level supports were related to sedentary activity, underscoring the importance of multilevel, behavior-specific approaches within fire departments to optimize health and wellness.

Introduction

Firefighting is a hazardous profession that requires significant physical and psychological demands. Routine job tasks, such as fire suppression, forcible entry and search and rescue, are typically completed under extreme conditions while wearing heavy personal protective equipment, which increases firefighters' risk of injury and fatality (Ras et al., 2022). Under these circumstances, firefighters must maintain a high level of physical fitness (e.g., cardiorespiratory, muscular strength) to safely and effectively perform job-related tasks in life-threatening situations (Ras et al., 2022). To ensure firefighters are fit-for-duty and maintain overall health, engaging in physical activity (PA) and structured exercise regularly is highly encouraged (Durand et al., 2011; Piercy et al., 2018). Unfortunately, many firefighters may not meet the recommended activity levels (Barry et al., 2020; Durand et al., 2011; Ras & Leach, 2022) or maintain the needed levels of physical fitness (Phillips et al., 2017; Poplin et al., 2016; Smith, 2011).

Current PA guidelines recommend doing at least 150 minutes of moderate-intensity aerobic activity, or 75 minutes of vigorous-intensity aerobic activity, or a combination of both, and doing at least two days of muscle-strengthening activity per week (Piercy et al., 2018). While PA and exercise often are used interchangeably, exercise is considered a subset of PA that is structured and aimed at improving fitness (American College of Sports Medicine, 2014). Previous research has shown that engaging in regular exercise improves firefighters' physical readiness by enhancing aerobic capacity and muscular strength and endurance, while also reducing the risk of injury and cardiovascular disease (Andrews et al., 2019; Chizewski et al., 2021). To support these outcomes, the National Fire Protection Association (NFPA) has established standards to guide fire department fitness programs, such as qualified health and fitness instructor, annual fitness assessments, and providing resources and time for exercise while on shift (National Fire Protection

Association, 2015). Unfortunately, the adoption and enforcement of these standards are voluntary across departments (Kales et al., 2003; Soteriades et al., 2011), leading to inconsistent implementation and fitness levels between firefighters (Haddock et al., 2011). Thus, firefighters continue to face a variety of unique social, environmental, and policy level obstacles, ultimately influencing their engagement in exercise.

Prior research has highlighted the unpredictability of firefighters' work shifts and operational demands (e.g., training, high call volume, fatigue) may negatively impact firefighters' ability and motivation to regularly engage in exercise (Brin, Heinrich, et al., 2026; Dobson et al., 2013; Lovejoy et al., 2015). Conversely, supportive social relationships between co-firefighters, as well as with their superiors, appear to shape and motivate on-duty exercise through modeling behaviors, friendly competition, and by providing emotional and logistical support (Brin, Heinrich, et al., 2026; Lane et al., 2022; Long et al., 2014). Dobson et al. (2013) suggests that on-duty exercise adherence is largely dependent on the crew's captain modeling the behavior. Additionally, similar to the general population, constraints related to time and facility availability continue to challenge regular participation among firefighters (Kwon et al., 2022; Melton et al., 2021). Further complicating this issue, fitness equipment and facilities vary between and within fire departments, and as a result, both the quality of equipment and physical characteristics of available facilities may be meaningful to consider in influencing activity levels among firefighters (Agostinelli et al., 2023; Brin, Heinrich, et al., 2026; Long et al., 2014). In line with NFPA standards, policies surrounding on-duty time, whether allotted or flexible, to exercise are beneficial for firefighters to engage in exercise regularly (Agostinelli et al., 2023; Gendron et al., 2020). However, policy views and expectations may vary across stations and shifts within a single department (Brin, Heinrich, et al., 2026; Long et al., 2014), suggesting on-duty exercise may be heavily shaped by crew-level

social dynamics, the station's physical environment, and formal policies. Therefore, identifying these multilevel factors may be critical for strengthening adherence to exercise in fire departments (Melton et al., 2021).

Despite growing recognition of the individual, interpersonal, environmental, and policy level influences on firefighters' PA and health (Agostinelli et al., 2023; Dobson et al., 2013; Gendron et al., 2020; Kwon et al., 2022; Long et al., 2014; Melton et al., 2021; Poston et al., 2013), no studies have utilized an audit tool to examine these multilevel factors. Audit tools are beneficial to systematically assess present support for PA, identify any gaps, and lead to evidence-based solutions in occupational environments (Lang et al., 2020; Loitz et al., 2021). This approach may be particularly valuable where social norms, resources, and policies can vary widely within and between departments. A previously developed audit tool, the Fire Department Multilevel Exercise Supports (FD-MES) (Brin, Besenyi, et al., 2026) has potential for comprehensively evaluating fire department resources and supports across five domains: Knowledge and Awareness, Social Support, Organizational Support, Community Assets and Partnerships, and Policies and Programs. However, the extent to which perceived sources of support (e.g., domains and subdomains) differ between fire departments and correspond to exercise behavior has yet to be examined. Understanding these relationships is critical to validate this tool and for department leadership and administrators to use as a resource to inform decision-making when aiming to promote exercise, and PA more broadly. Additionally, previous studies assessing PA in firefighters have predominantly used self-reported measures, which can be influenced by recall and social desirability bias, and ultimately lead to over-reporting (Lee et al., 2011). Using device-measured PA can add a level of objectivity and validity to the data. Therefore, the purpose of this study was to examine multilevel exercise supports (using the FD-MES tool) and objectively measured

movement behaviors, including PA intensities and sedentary behavior, among firefighters. Specifically, the aims were to: 1) assess which domains have the greatest amount of support across fire departments, 2) compare total score, domain score, and subdomain scores across departments, 3) assess differences in PA intensities between departments, and 4) examine relationships between FD-MES scores and PA intensities. Given the direct and frequent interaction firefighters have with coworkers and organizational leadership and their department's physical environment, we hypothesize that the social and organizational support domains will demonstrate the strongest associations with moderate-to-vigorous PA. Additionally, we hypothesize moderate-to-vigorous PA (MVPA) will be different between fire departments.

Methods

Participants

Prior to study initiation, meetings were held with leadership personnel of various fire departments to determine interest in participation and to discuss existing departmental characteristics and health or fitness-related policies and resources (see Table 4.1). Following department approval, participants were recruited from three Midwest career fire departments via an in-person recruitment meeting at each department, department email listservs, and flyers posted throughout department stations. Those who were interested in participating provided their email address and were sent a survey link via Qualtrics and directed to screening questions to determine eligibility criteria prior to completing the audit tool. The inclusion criteria consisted of 1) currently assigned to a division or company that engages in emergency and non-emergency responses (e.g., medical, fire suppression, rescue) and 2) physically able to engage in fire emergency tasks (e.g., search and rescue, fighting fires, climbing ladders). Administrative, training, and support personnel were excluded from this study. Eligible participants provided informed consent, then

proceeded to complete self-reported basic demographics (e.g., age, height, weight, rank) and audit tool items. Subsequently, participants were asked if they were interested in completing the accelerometer portion of the study and if interested, the lead researcher sent a follow up email to schedule their wear period. All procedures were approved by the university's institutional review board (protocol #1396).

Table 4.1. Career fire department characteristics.

	Fire Department 1	Fire Department 2	Fire Department 3
Community population ^a	54,673	22,583	39,595
Number of firefighter personnel ^b	72	52	93
Estimated annual call volume ^c	3,300	3,504	6,500
On-duty exercise permitted	Yes	Yes	Yes
Dedicated exercise time provided	1.5 hour/shift, scheduled	1 hour/shift, scheduled	1 hour/shift, no formal time
Allowed to exercise at off-site facilities during duty hours	No	No	Yes
Physical ability assessment	Yes, annually	No	Yes, annually
Medical evaluation	Yes, annually	Yes, annually	Yes, annually

Notes: ^a Community population based on the 2025 U.S. Consensus QuickFacts estimates; ^b Firefighters assigned to a division or company who engage in emergency and non-emergency response; ^c Estimated annual call volume obtained from city public records.

Procedures

Fire Department Multilevel Exercise Support (FD-MES) Audit Tool. The FD-MES audit tool is composed of 104 items across five domains to assess exercise supports within fire departments: A) Awareness & Education (messaging, communication, and education subdomains; 15 items), B) Social Support (coworkers, officers, and command staff; 11 items), C) Organizational Support (staffing and committees, social climate, and indoor environment; 45 items), D) Community Assets & Partnerships (outdoor environment, partnerships; 10 items), and

E) Programs & Policies (programs, policies; 23 items). Most tool items were dichotomous (i.e., yes/no), whereas eight questions used ‘check all that apply’ responses (i.e., organizational planning, social climate, indoor and outdoor environment, and fire department programs and policies). Subdomain and domain scores were calculated by summing all item scores within their respective categories and classified into four progress levels based on maximum possible score: needs attention (<25%), fair (25-49%), good (50-75%), and outstanding (>75%). An overall audit score can be derived by calculating the average of all domain scores, with a higher score indicating greater support for exercise. Further details regarding this instrument are described elsewhere (Brin, Besenyi, et al., 2026).

Accelerometers. Firefighters’ physical activity levels were assessed using an Actigraph GT3X+ (ActiGraph Corp, Pensacola, FL, USA) accelerometer. Firefighters wore the accelerometer on their right hip for a total duration of 7 days, capturing 3 days on-shift and 4 days off-shift, and were instructed to wear them during waking hours and to avoid wearing during water activities (e.g., showering, swimming). Firefighters completed a sleep log to report their sleep (i.e., when they went to bed) and wake up times (e.g., when they got out of bed). Intensity of activity was classified as sedentary, light PA (LPA), moderate PA (MPA), vigorous PA (VPA), and moderate-to-vigorous (MVPA). For inclusion in the final data analysis, firefighters were required to wear the accelerometer for at least 4 days, with a total of at least 10 hours of wear time per day (Matthews et al., 2002, 2012). Freedson (1998) cut points were used along with Choi (2011) non-wear time algorithm to classify PA intensity levels.

Exercise Logs. Participants completed a 7-day structured exercise log via paper while wearing the accelerometer to self-report their daily exercise (Appendix Table C.1). Participants self-reported their activity type (e.g., aerobic, strength, flexibility), duration (e.g., start and stop

time), and intensity of any structured bouts of occupational and leisure-time exercise. Exercise intensity was measured using Borg's rate of perceived exertion (RPE) scale (Borg, 1982), ranging from 6 (no exertion) to 20 (maximal exertion). If multiple exercise sessions were reported on the same day, exercise durations were summed, and exercise intensity was calculated as an average. An additional 'notes' box was provided to allow details the participant wished to add (e.g., equipment used, completed solo or in a group, any barriers). If no structured exercise or formal activity was completed for the day, participants were instructed to write 'N/A'.

Statistical Analysis

Shapiro-Wilk's tests and histograms were used to assess the normalcy of the data. Descriptive statistics were described using mean, standard deviation ($\pm$ SD), and frequency. One-way ANOVAs were conducted to examine mean differences in domain and subdomains scores between departments and were employed to examine differences in PA durations across intensity levels between departments. Due to the exploratory nature of the study, correlations were conducted to examine the relationship between tool domains and subdomains with all on-duty PA intensities. All analyses were performed in SPSS 24 (IBM Corp., Armonk, NY, USA).

Results

Participant Characteristics

A total of 58 participants participated in the study (Fire Department 1 [FD1] = 20, Fire Department 2 [FD2] = 19, Fire Department 3 [FD3] = 19). Most participants identified as male ($n = 4$ female) and identified as white, with few participants identifying as Hispanic ($n = 3$), African American ($n = 1$), and Hawaiian Native/Pacific Islander ($n = 1$). On average, participants were considered overweight or obese in terms of BMI. Many respondents held the rank of Captain

(34.5%) or firefighter (31%). Participant characteristics are summarized by each fire department in Table 4.2.

Table 4.2. Participant characteristics by department.

Variable	<i>FD1 (n=20)</i>		<i>FD2 (n=19)</i>		<i>FD3 (n=19)</i>	
	M ± SD	N (%)	M ± SD	N (%)	M ± SD	N (%)
Age (years)	37.6 ± 9.1		37.7 ± 8.4		37.1 ± 8.4	
Gender						
Male		20 (100%)		16 (84.2%)		17 (94.7%)
Female		0 (0%)		3 (15.8%)		1 (5.3%)
Race						
White		20 (100%)		16 (84.2%)		17 (89.5%)
African American		--		1 (5.3%)		--
Hispanic		--		2 (10.5%)		1 (5.3%)
Native Hawaiian or Pacific Islander		--		0 (0%)		1 (5.3%)
BMI (kg/m²)	27.2 ± 2.7		29.1 ± 3.7		30.9 ± 5.1	
Normal Weight (18.5–24.9 kg/m ²)		4 (20%)		3 (15.8%)		3 (15.8%)
Overweight (25–29.9 kg/m ²)		13 (65%)		9 (47%)		5 (26.3%)
Obese (≥30 kg/m ²)		3 (15%)		7 (36.8%)		11 (57.9%)
Years of service						
Less than 1 year		0 (0%)		0 (0%)		0 (0%)
1 - 5 years		2 (10%)		4 (21.1%)		5 (26.3%)
6 - 10 years		4 (20%)		4 (21.1%)		4 (21.1%)
11 - 15 years		5 (25%)		5 (26.3%)		2 (10.5%)
16 - 20 years		5 (25%)		3 (15.8%)		4 (21.1%)
More than 20 years		4 (20%)		3 (15.8%)		4 (21.1%)
Rank						
Probationary Firefighter		0 (0%)		2 (10.5%)		0 (0%)
Firefighter		3 (15%)		10 (52.6%)		5 (26.3%)

Driver Engineer	8 (40%)	4 (21.1%)	5 (26.3%)
Captain	9 (45%)	3 (15.8%)	8 (42.1%)
Battalion Chief	0 (0%)	0 (0%)	1 (5.3%)
Fire Department scheduled hours worked per week	59.4 ± 6.5	62.3 ± 22.6	61.6 ± 18.0
Overtime hours worked per week	4.1 ± 5.0	9.6 ± 12.6	5.4 ± 8.9

Note: Dashes (--) = not applicable; Prob. Firefighter = Probationary firefighter (<1 year of experience).

FD-MES Tool Descriptives

Mean and standard deviations of FD-MES tool domains and subdomain scores are presented in Table 4.3 and their associated progress levels in Table 4.4. Across all three departments, domain scores related to Social and Organizational Support had higher mean scores relative to the possible range, with subdomains of coworker and officer support, and indoor environment contributing to a large proportion of their respective domain scores. Conversely, lower domain scores were consistent with Awareness & Education and Programs & Policies across fire departments.

Table 4.3. FD-MES tool descriptives.

<i>Domain (range)</i>	FD1 (n=20)	FD2 (n=19)	FD3 (n=19)	<i>p-value</i>
<i>Subdomain (range)</i>				
<i>Awareness & Education (0-14)</i>	3.85 ± 4.17	4.74 ± 3.68	3.63 ± 3.56	.641
Messaging (0-6)	1.75 ± 2.31	2.58 ± 2.24	1.95 ± 2.20	.423
Communication (0-3)	0.75 ± 0.91	1.05 ± 0.97	0.42 ± 1.02	.025**
Education (0-5)	1.35 ± 1.57	1.11 ± 1.24	1.26 ± 0.93	.736
<i>Social Support (0-11)</i>	7.10 ± 1.97	5.63 ± 2.79	6.79 ± 1.81	.107
Coworker Support (0-4)	3.40 ± 0.50	2.53 ± 0.70	2.79 ± 0.71	<.001*, .025†
Officer Support (0-3)	2.44 ± 0.99	1.79 ± 1.23	2.84 ± 0.69	.002**
Command Staff Support (0-4)	1.30 ± 1.42	1.32 ± 1.53	1.16 ± 1.42	.882

<i>Organizational Support (0-45)</i>	24.05 ± 4.11	24.37 ± 4.49	17.53 ± 4.72	.101
Social Climate (0-21)	7.10 ± 1.89	8.26 ± 3.45	7.68 ± 2.93	.641
Staffing & Committees (0-4)	1.40 ± 1.23	0.11 ± 0.32	0.63 ± 0.90	<.001*
Indoor Environment (0-20)	15.55 ± 2.99	16.00 ± 2.19	12.84 ± 3.67	.013**, .036†
<i>Community Assets & Partnerships (0-10)</i>	6.20 ± 1.47	5.53 ± 1.31	4.53 ± 1.84	.004†
Outdoor Environment (0-8)	6.05 ± 1.36	4.84 ± 1.17	3.95 ± 1.78	.044*, <.001†
Partnerships (0-2)	0.15 ± 0.49	0.68 ± 0.75	0.58 ± 0.69	.024*
<i>Programs & Policies (0-23)</i>	7.20 ± 2.31	6.16 ± 3.06	5.79 ± 1.96	.191
Programs (0-8)	0.75 ± 1.12	1.00 ± 1.67	0.37 ± 0.60	.529
Policies (0-15)	6.45 ± 1.76	5.16 ± 2.03	5.42 ± 1.61	.145
Total score (max of 20)	13.84 ± 2.98	13.41 ± 3.09	11.88 ± 3.24	.130

Notes: Mean ± Standard deviation; Domain scores were analyzed using one-way ANOVAs. Subdomain scores were analyzed using Kruskal–Wallis H tests due to non-normality. *Significant difference between FD1 and FD2; **Significant difference between FD2 and FD3; and †Significantly different between FD1 and FD3.

Table 4.4. Domain and subdomain progress levels.

<i>Domain (range)</i>	FD1	FD2	FD3
<i>Subdomain (range)</i>			
<i>Awareness & Education (0-14)</i>	<i>Fair</i>	<i>Fair</i>	<i>Fair</i>
Messaging (0-6)	Fair	Fair	Fair
Communication (0-3)	Fair	Fair	Needs attention
Education (0-5)	Fair	Needs attention	Fair
<i>Social Support (0-11)</i>	<i>Good</i>	<i>Good</i>	<i>Good</i>
Coworker Support (0-4)	Outstanding	Good	Good
Officer Support (0-3)	Outstanding	Good	Outstanding
Command Staff Support (0-4)	Fair	Fair	Fair
<i>Organizational Support (0-45)</i>	<i>Good</i>	<i>Good</i>	<i>Fair</i>
Social Climate (0-21)	Fair	Fair	Fair
Staffing & Committees (0-4)	Fair	Needs attention	Needs attention
Indoor Environment (0-20)	Outstanding	Outstanding	Good

<i>Community Assets & Partnerships (0-10)</i>	<i>Good</i>	<i>Good</i>	<i>Fair</i>
Outdoor Environment (0-8)	Outstanding	Good	Fair
Partnerships (0-2)	Needs attention	Fair	Fair
<i>Programs & Policies (0-23)</i>	<i>Fair</i>	<i>Fair</i>	<i>Fair</i>
Programs (0-8)	Needs attention	Needs attention	Needs attention
Policies (0-15)	Fair	Fair	Fair
<i>Total Score (0-20)</i>	<i>Good</i>	<i>Good</i>	<i>Good</i>

Notes: <25% = needs attention, 25-49% = fair, 50-74% = good, ≥75% = outstanding.

Across departments, several items, or supports, showed similar patterns in reporting. Items regarding educational opportunities from Command Staff (e.g., learning about exercise benefits, developing physical skills) were generally low (<20%), whereas the item “*does command staff provide education to understand department programs and their policies*” was moderately reported among participants across departments, ranging between 57.9% and 73.7%. Additionally, a majority, if not all, of participants agreed their coworkers were supportive toward exercise participation (94.7%-100%) and that exercise participation was culturally normalized among peers (89.5%-100%). When it came to Command Staff, however, perceived support was much lower with under half of respondents (42.1%-47.4%) reporting that their Command Staff openly supported exercise policies, and few perceived them as role models (5.3%-15.8%). Several Organizational Support domain items were also similar across departments as most participants reported their department’s organizational plans addressed exercise time (>78%) and included on-site fitness equipment (>75%). Basic fitness amenities (e.g., showers, cardio equipment, free weights) were commonly available across departments. However, respondents less frequently reported their fire station’s fitness spaces as visually appealing (36.8%-47.4%).

Despite formal organizational support being present, broader initiatives promoting PA and exercise were consistently limited across departments. Supports such as standing meetings,

recognition for exercise participation, and involvement in community exercise events were infrequently reported (<16%). These trends also extended to the Community Assets & Partnership domain, with the only highly reported items relating to the fire station's outdoor environment. Across departments, firefighters commonly perceived their stations as being in safe areas and having outdoor spaces conducive to engage in exercise. Structured exercise programs and wellness partnerships were also limited across departments. Items identifying programs that supported exercise opportunities such as organized sports teams, tracking tools (e.g., fitness apps, logs), or having incentives were infrequently reported or absent in at least one fire department. In contrast, most participants indicated their department had policy statements supporting exercise participation, with all three departments demonstrating a high endorsement of policies allowing exercise during duty hours (>94%) and annual health assessments (>84.2%). Regardless of the similarities, notable differences emerged in reporting between fire departments, especially among communication methods, coworker and leadership support, their department's social climate, indoor environment, and reporting certain department policies. Leadership communication through various formats such as emails, newsletters, or in-person were more frequently reported in respondents from FD2. Additionally, over half of FD2 participants indicated these messages used positive framing (57.9%) and provided a clear call to action (52.6%), whereas substantially lower frequencies were reported from FD1 (25% and 35%, respectively) and FD3 (26.3% and 36.8%, respectively). Perceptions of social pressure to exercise also varied across departments, with almost half of FD1 (45%) reporting peer-related pressures compared to 10% of both FD2 and FD3. Similarly, items relating to officer support were less frequent from FD2 as just over half of participants perceived officers to acknowledge others' exercise participation (52.6%) and promote a culture supportive of exercise (57.9%) compared to over 80% for both FD1 and FD3.

Although most participants indicated their department has a social climate, a physical environment, and policy statements that support exercise participation and opportunities, how these were implemented, as well as specific features of the indoor environment, seemed to vary by department. For instance, a majority of FD1 (100%) and FD2 (84.2%) reported a specific time for exercise was included in their department's plans, whereas FD3 predominantly reported these plans allow flexibility in shift schedule for exercise instead (78.9%). For their department's indoor features, FD3 consistently reported lower frequencies for items such as having a designated space for exercise (57.9%), equitable access to equipment across stations (42.11%), and being equipped with mats (47.4%) compared to FD1 and FD2 (all over 75%). Lastly, while allotted exercise time and health assessments were commonly reported policies across departments, annual fitness assessments appeared to be less consistently implemented in FD2 (5.3%) and FD3 (57.9%). Participants' awareness of other policy-related items also differed across departments including if they were allowed to engage in recreational sports while on-duty (FD1 = 55%; FD2 = 73.7%; FD3 = 15.8%) and having a budget towards exercise resources like fitness equipment (FD1 = 60%; FD2 = 5.3%; FD3 = 26.3%). Frequencies for all tool items by department are available in Appendix Table C.2.

One-way ANOVAs of domain and subdomain scores revealed there was a significant difference between departments for the Community Assets & Partnership domain ($F(2, 55) = 5.71$, $p = .006$, $\eta^2 = .172$). The Bonferroni post-hoc test indicated that FD1 had a significantly higher score compared to FD3 ($p = .004$). All other FD-MES domains were not statistically significant between departments. Subdomain scores were non-normal; therefore, Kruskal-Wallis H tests were employed to examine differences between fire departments. Several subdomains were observed to be significantly different between departments including Communication ($H(2, 58) = 7.021$, $p =$

.030), Coworker Support ($H(2, 58) = 15.636, p < .001$), Officer Support ($H(2, 58) = 11.215, p = .004$), Staff & Committee ($H(2, 58) = 17.532, p < .001$), Indoor Environment ($H(2, 58) = 9.691, p = .008$), Outdoor Environment ($H(2, 58) = 15.273, p < .001$), and Partnership ($H(2, 58) = 8.232, p = .016$). There were no significant differences between groups for the remaining subdomains: Messaging, Education, Command Staff, Social Climate, Programs, and Policies ($p > .05$).

Post-hoc comparisons using Dunn's method with a Bonferroni correction revealed the mean rank of FD1 was significantly higher than FD2 for Coworker Support ($p < .001$), Staff & Committee ($p < .001$), and Outdoor Environment ($p = .044$), whereas FD2 demonstrated significantly greater supports in Partnership compared to FD1 ($p = .024$). FD1 also showed significantly higher subdomain scores for Coworker Support ($p = .025$), Indoor environment ($p = .036$), and Outdoor Environment ($p < .001$) compared to FD3. Lastly, FD2 scored significantly higher than FD3 for Communication ($p = .025$) and Indoor Environment ($p = .013$), while FD3 demonstrated significantly higher Officer Support ($p = .002$) compared to FD2.

Physical Activity

Of the original sample, a subsample of 44 participants (FD1 = 14; FD2 = 16; FD3 = 14) completed the accelerometer portion of the study; however, one participant from FD3 was excluded from analyses due to not meeting minimum wear inclusion criteria (FD3 = 13). Descriptive statistics of PA intensities per day for on- and off-duty days by department are presented in Table 4.5. Collectively, participants accumulated an average of 56.10 minutes of moderate-to-vigorous PA per on-duty day. Participants were classified as meeting the daily moderate-to-vigorous (MVPA) recommendation if they averaged at least 30 minutes of MVPA during their on-duty days and off-duty days, respectively. A majority of participants from each department were considered meeting minimum PA recommendations. One-way ANOVAs

revealed a significant difference for on-duty moderate PA ($F(2,40) = 4.818, p = .013$), with post-hoc analyses indicating participants from FD1 engaged in significantly more on-duty MPA compared to FD2 ($p = .012$). Differences between departments' average MVPA per on-duty day and total MVPA for on-duty days were trending towards significant but was not statistically significant ($p = 0.065$ and $p = 0.055$, respectively). There were no significant differences between departments for sedentary (SED), light (LPA), vigorous (VPA), or MVPA for on- or off-duty periods, as well as off-duty moderate PA (MPA).

Table 4.5. On- and off-duty physical activity intensities by department.

PA	FD1 (n=14)		FD2 (n=16)		FD3 (n=13)	
	On-Duty M $\pm$ SD	Off-Duty M $\pm$ SD	On-Duty M $\pm$ SD	Off-Duty M $\pm$ SD	On-Duty M $\pm$ SD	Off-Duty M $\pm$ SD
SED	651.28 $\pm$ 84.78	667.53 $\pm$ 83.33	671.55 $\pm$ 86.11	690.47 $\pm$ 70.50	658.76 $\pm$ 117.17	673.43 $\pm$ 73.22
LPA	179.09 $\pm$ 40.13	227.53 $\pm$ 53.13	181.12 $\pm$ 43.00	197.35 $\pm$ 53.40	187.79 $\pm$ 46.79	225.68 $\pm$ 50.43
MPA	59.17 $\pm$ 25.67*	59.50 $\pm$ 27.39	36.22 $\pm$ 16.46*	41.25 $\pm$ 30.14	50.36 $\pm$ 18.55	51.52 $\pm$ 21.87
VPA	6.86 $\pm$ 6.79	1.23 $\pm$ 1.42	7.16 $\pm$ 12.09	2.40 $\pm$ 2.82	5.81 $\pm$ 6.90	4.21 $\pm$ 7.57
MVPA	66.84 $\pm$ 29.40	60.91 $\pm$ 28.34	44.58 $\pm$ 23.32	44.29 $\pm$ 30.18	58.70 $\pm$ 23.64	57.75 $\pm$ 25.43
Met PA Guidelines n (%)	12 (85.7%)	13 (92.9%)	12 (75%)	10 (62.5%)	10 (76.9%)	11 (84.6%)

Note: Mean (M) and standard deviations (SD) are listed in minutes for PA intensities per day. SED = sedentary behavior; LPA = light physical activity; MPA = moderate physical activity; VPA = vigorous physical activity; MVPA = moderate-to-vigorous physical activity; Met PA Rec. = met PA recommendations. *Significant difference between departments ($p < .05$).

Exercise Logs

From the exercise logs, similar exercise patterns were observed across departments and duty status (Table 4.6). FD1 reported the highest proportion of shifts involving exercise (80.9%), whereas FD2 reported the lowest (68.8%). On average, on-duty exercise sessions were generally characterized by longer duration and higher reported intensity compared to off-duty sessions. Strength (e.g., free weights, circuit training) and aerobic (e.g., walking, running, biking) activities were common among participants, regardless of department or duty status. Mobility exercises (e.g., yoga, stretching) were also reported, and typically combined with another form of exercise. Occupational-focused activities were infrequently reported and were typically mentioned as a substitute for exercise while on-shift, while physically demanding second jobs (e.g., farming, lumber work) were reported during their off-duty days. Despite high reports of exercising during shifts, participants identified several barriers to participation including low motivation, busy shifts, competing priorities (e.g., studying exams, paramedic coursework), feeling fatigued, and prioritizing recovery.

Within each department, participants reported no exercise during roughly half of off-duty days (50–56.3%). Primary reasons for not engaging in exercise during their days off revolved around time constraints related to family obligations, second jobs, or competing priorities (e.g., studying for promotion exam). Similar to on-duty constraints, participants mentioned fatigue from the previous shift or chose not to exercise due to needing a recovery day. In some instances, participants reported not engaging in a “structured workout” on their off-duty days but were still physically active and mentioned going for a walk or having a laborious second job. Additionally, participants had isolated reports of engaging in recreational activities, including golf and basketball.

Table 4.6. Exercise log summary by department and duty status.

Variable	FD1 (n=14)		FD2 (n=16)		FD3 (n=13)	
	On-Duty	Off-Duty	On-Duty	Off-Duty	On-Duty	Off-Duty
	M ± SD	M ± SD	M ± SD	M ± SD	M ± SD	M ± SD
Duration per day	54.3 ± 14.5	46.9 ± 37.3	55.9 ± 34.5	95.0 ± 100.5	50.9 ± 28.3	39.3 ± 40.8
Intensity per workout	11.8 ± 4.5	9.0 ± 6.6	11.5 ± 5.2	9.5 ± 5.0	11.6 ± 4.2	6.4 ± 5.6
Exercise Modality, n (%)						
Aerobic	22 (52.4%)	24 (42.9%)	25 (52.1%)	17 (26.6%)	15 (38.5%)	20 (38.5%)
Strength	28 (66.7%)	14 (25%)	25 (52.1%)	12 (18.8%)	11 (28.2%)	19 (36.5%)
Mobility	7 (16.7%)	5 (8.9%)	6 (12.5%)	4 (6.3%)	5 (12.8%)	5 (9.6%)
Occupational	1 (2.4%)	2 (3.6%)	2 (4.2%)	10 (15.6%)	2 (5.1%)	1 (1.9%)
No exercise reported	8 (19%)	31 (55.4%)	15 (31.3%)	36 (56.3%)	8 (20.5%)	26 (50%)

Notes: Average duration per day in minutes; Intensity = RPE (range of 6-20). Duration and intensity mean and standard deviation. Percentages represent the frequency of reported exercise occurrences relative to the total number of logged on- and off-duty shifts within each department. Exercise modalities are not mutually exclusive.

Tool & PA Correlations

Domains and subdomains scores from the total sample were non-normally distributed; therefore, Spearman's rank correlations were applied. No significant associations were observed between on-duty LPA, MPA, VPA, and MVPA with FD-MES domain or subdomains scores. However, on-duty sedentary behavior demonstrated weak negative associations with domains Organizational Support ($r_s = -.317, p = .038$) and Programs & Policies ($r_s = -.331, p = .030$) (Table 4.7). On-duty sedentary behavior also had weak negative associations with messaging ($r_s = -.332, p = .029$) and policy ($r_s = -.329, p = .031$) subdomain scores. Correlation table with on-duty PA and FD-MES subdomains are shown in Appendix Table C.3.

Table 4.7. FD-MES domains & PA Spearman's correlations (r).

Variable	Awareness & Education	Social Support	Organizational Support	Community & Partnerships	Programs & Policies
SED	-.273	-.218	-.317*	-.297	-.331*
LPA	-.211	-.150	-.080	-.076	-.197
MPA	-.199	.042	-.110	-.020	-.064
VPA	-.103	.113	-.029	-.053	.016
MVPA	-.167	.065	-.068	.030	-.003

Notes: SED = sedentary; LPA = light physical activity; MPA = moderate. *Correlation is significant ($p < .05$).

Discussion

This exploratory study sought to evaluate the newly developed FD-MES tool by examining domain and subdomain differences between three fire departments, in addition to their respective PA levels across various intensities. Fire departments appeared to offer the most support within the interpersonal, organizational, and community/environmental levels. Participants perceived high levels of support from their coworkers and officers, while organizational strengths stemmed from their department's social climate and indoor environment. Community-level support was evident throughout their outdoor environment. At the same time, other organizational and policy level support seem to be lacking. Organizational mechanisms including awareness and education, leadership communication and support, and formal partnerships and programs were among the weakest FD-MES scores. Based on accelerometers, most participants from all fire departments met PA guidelines during both on- and off-duty periods. Our hypothesis for PA comparisons was supported as MVPA was not significantly different between departments for both on- and off-duty days. Interestingly, only on-duty MPA was found to have a meaningful difference between FD1 and FD2. On the other hand, our initial hypothesis for examining the relationships between tool domain/subdomain scores and MVPA was not upheld.

Across the participating fire departments, support at the firefighters' interpersonal level was a shared strength, with coworker and officer support scoring relatively high according to the FD-MES progress levels. Specifically, most participants reported their coworkers are supportive of exercise participation and normalized exercise on shift, with FD1 reporting significantly higher Coworker Support compared to the other departments. Prior research emphasizes peer encouragement, interaction, and camaraderie in shaping exercise habits and motives in firefighters (Lane et al., 2022; Long et al., 2014). Moreover, friendly competition between firefighters is a common source of exercise motivation and shown to increase camaraderie which may reflect the team-oriented environment of the profession (Long et al., 2014; Mabry et al., 2013). Building on this concept, potential strategies to reinforce both social and organizational support such as department-wide competition initiatives between shifts or stations and receiving recognition for exercise participation may strengthen long-term exercise adherence and overall fitness (Mabry et al., 2013), both of which were seldomly reported across departments. Similarly, leadership (e.g., officers, captains) support may be critical in prioritizing exercise within a fire company as captains have been shown to influence participation in and adherence to on-duty exercise (Brin, Heinrich, et al., 2026; Dobson et al., 2013; Lane et al., 2022), particularly by being a role model and setting expectations within crews. In the present study, FD2 scored significantly lower on the Officer Support subdomain compared to FD3, and less frequently perceived their superiors as role models, normalizing exercise, or acknowledging others who exercise. Variability in leadership approaches may create inconsistencies between shifts, stations, or crews regarding exercise expectations and participation (Brin, Heinrich, et al., 2026; Long et al., 2014), thus, this difference may have contributed to lower on-duty MPA in FD2 compared to the other departments.

Conversely, participants in the present study less frequently perceived their Command Staff (e.g., Battalion chiefs, administration) to model, communicate, and openly encourage and normalize on-duty exercise. Lack of or minimal administrative participation or support may inadvertently affect adherence to training and firefighters' fitness levels (Brin, Heinrich, et al., 2026; Long et al., 2014) and inhibit the success of fitness initiatives (Buick et al., 2018; Putnam, 2015). Moreover, there were limited reports of support through organizational mechanisms such as Command Staff sharing or communicating exercise-related information and providing educational opportunities for personnel (i.e., Awareness and Education domain). While prior research has highlighted fire department administration as being "pro health and fitness" (Melton et al., 2021), there are concerns of a disconnect between communication and daily practices (Brin, Heinrich, et al., 2026; Long et al., 2014; Mabry et al., 2013). For example, if firefighters have allotted exercise time that is considered flexible each shift but are also informally discouraged by their superiors to move the time around based on their daily schedule, this can inadvertently weaken perceived organizational support towards health and wellness initiatives (Long et al., 2014). Additionally, as the present departments have exercise-related policies already in place, it may be important for upper leadership to ensure there is consistent communication to reinforce and sustain fitness policies. However, it is important to note that Command Staff may be more hands-off or too far removed to provide tangible support compared to frontline personnel. Regardless, administration can provide support by sharing positive messaging, communicating the importance of exercise, or reiterating policy expectations (Bailey et al., 2018; Grimaud et al., 2025). While no association was observed between objectively assessed PA and the Social Support domain in the present study, the social environment plays an important role in establishing daily norms towards exercise engagement, particularly including coworkers and

officers. Previous research has suggested interpersonal relationships among firefighters may be more effective in shifting individual motives and departmental norms compared to top-down mandates (Buick et al., 2018; Mabry et al., 2013). However, consistent and supportive practices from Command Staff may strengthen frontline perceptions that they value and support personnel exercising on shift.

At the organizational level, considering the physical environment of a fire station, such as the indoor facilities or the surrounding built environment (e.g., outdoor spaces, sidewalks, nearby exercise resources), may be important for a firefighter's engagement in exercise and PA more broadly (Agostinelli et al., 2023; Parise, 2020). In the present study, most participants reported having fitness equipment; however, perceptions of available spaces were mixed, especially for FD3, and many participants also reported that their exercise space was not appealing to use. Perceptions of fitness facilities as being small or cramped may result in un motivating atmospheres and ultimately discourage exercise participation (Brin, Heinrich, et al., 2026), leading firefighters to exercise in non-traditional areas of the station (e.g., truck bays) or rely more on outdoor spaces and external facilities. Additionally, the variability in perceptions may reflect differences in station design, as some areas may be converted from existing spaces, while newer stations may have preplanned fitness rooms. This can create inconsistent exercise environments across stations and may explain the significantly lower indoor environment scores for FD3. Notably, it is important to consider that FD3 permits personnel to use off-site fitness facilities during duty hours, which may have indirectly influenced their perceptions of their station's environment. Nevertheless, previous qualitative findings identified poor facility quality and maintenance may contribute to sedentary behavior in working adults (Keegan et al., 2016). Therefore, investing in quality, as well as the quantity, of fitness equipment and spaces are important for fire departments

to enable firefighters' accessibility to exercise (Agostinelli et al., 2023) and to enhance both their exercise participation (Agostinelli et al., 2023; Banes, 2014) and motivation to be active (Long et al., 2014).

The features in outdoor spaces may vary considerably from station to station. In the present study, FD1 scored significantly higher in the Outdoor Environment subdomain compared to the other fire departments, which may have largely contributed to their differences observed with FD3 for the Community Assets & Partnership domain. The built environment plays an important role in shaping opportunities to and participation in exercise and PA, particularly for leisurely walking (McCormack & Shiell, 2011; Parise, 2020). Features including sidewalks, green space availability, safety from crime or traffic, and aesthetics can support PA participation (McCormack & Shiell, 2011; Salvo et al., 2018). These features were more frequently reported in FD1, suggesting that the station's surrounding built environment may provide firefighters on-duty opportunities beyond the station itself, and be a promising setting to be active. While no relationships were observed between the Community Assets & Partnerships domain or Outdoor Environment subdomain and any of the PA intensities, the workplace continues to be recognized as an important sector for promoting exercise. For instance, firefighters working in environments they perceive as accessible, walkable, or safe may be more willing to engage in brief bouts of activity during downtime or between calls, as walking and running were commonly reported forms of exercise in the present study. As fire stations within a single department are typically distributed throughout a city, each station may have distinct built environment features, potentially leaving firefighters located in less walkable or pedestrian-friendly areas to face additional barriers. Since modifying the broader outdoor environment may depend on community infrastructure or policy decisions, and firehouses

may not be outfitted with a gym, it may be more practical for fire departments to support exercise participation by utilizing adaptable outdoor station spaces or creating partnerships with local gyms.

Partnerships with local or community facilities and using external resources (e.g., International Association of Fire Fighters, Centers for Disease Control, Fire Rescue Fitness) for exercise information or programming was inconsistently reported within each department. Strategic partnerships may provide firefighters with exercise opportunities and resources regardless of duty status and be especially important for departments who may not have an ideal indoor environment (Lane, et al., 2022). In the present study, FD2 had a significantly higher score for the partnership subdomain compared to FD1; however, the subdomain only contains two items and may not fully or effectively capture a department's community partnerships. Additionally, as previously mentioned, FD3 had the ability to use local fitness facilities, which may have been a benefit for some participants if their physical environment did indeed create additional challenges. However, there were a few caveats to this partnership and policy. Anecdotally, gym memberships were not department-funded, participation often depended on the availability and willingness of the entire crew, and personnel had to consider call coverage responsibilities from neighboring stations or crews before leaving the station to exercise. Although partnerships may bridge an environmental gap, effectiveness may be situational and depend on accessibility and scheduling (Lane et al., 2022). Regardless of these logistical challenges, fire departments should strive to develop mutually beneficial partnerships with local fitness facilities to provide equitable opportunities for all personnel or find avenues to invest in the current exercise spaces within their fire department to encourage exercise participation on shift.

Programs and Policies that support exercise and health were considered “fair” according to progress levels across departments. Annual health assessments and on-duty exercise time were

well-established practices in the participating departments and have been suggested to be encouraging initiatives for firefighters to pay attention to their health and engage in PA (Brin, Heinrich, et al., 2026). However, differences in implementation for exercise time are worth noting. FD1 and FD2 have a 1-hour to 1.5-hour time block for exercise every 24-hour shift, while FD3 primarily utilizes a flexible approach, and may reflect other fire departments across the nation. Time has been considered a critical organizational barrier to exercise (Lane et al., 2022; Melton et al., 2019; Shah et al., 2025), and while both allotted and flexible approaches are recommended for fire departments to consider, flexibility in exercise scheduling may increase autonomy and adherence to accommodate operational demands or individual preferences (Long et al., 2014; Melton et al., 2021). Regardless, maintaining participation may be challenging as a previous study in rural firefighters found only 12.5% complied with the department's exercise policy (Melton et al., 2021), reinforcing the importance of fitness programs and a departmental culture that normalizes exercise to support long-term adherence.

Implementing physical performance assessments, such as a series of physically demanding job tasks (e.g., hose pulls, victim drags, and stair climbs) performed in full gear under time completion, is one of the recommended components by the NFPA 1583 standard for health-related fitness programs (National Fire Protection Association, 2015). Aside from assessing occupational readiness, physical performance or fitness assessments may be an effective approach to encourage fitness and be a source of motivation using friendly competition, even when other exercise policies and resources are in place (Lane et al., 2022; Long et al., 2014; Mabry et al., 2013). FD1 and FD3 implement such practices, whereas FD2 does not. Additionally, FD2 demonstrated significantly lower MPA compared to FD1. While these findings are exploratory, physical performance assessments have been suggested to influence individual PA and the

department's overall culture towards health and wellness (Brin, Heinrich, et al., 2026). Moreover, firefighters want to be recognized for their participation (Lane et al., 2022) but fire departments may rarely include it as a formal practice outlined in their organizational plan or programs. Fire departments implementing a reward system or having incentives (e.g., friendly competitions, paid time off, department recognition) can encourage participation and adherence to exercise programs (Lane et al., 2022). If these are not plausible options, leveraging captains or peer fitness champions to develop daily workouts or specific fitness programs may be a strategy to maintain fitness and bridge formal policy with daily practices (Brin, Heinrich, et al., 2026; Lane et al., 2022). An additional finding was that while FD2 did not formally require a fitness assessment, three participants (15.8%) still reported the presence of some type of fitness evaluation, potentially reflecting differences in individual interpretation or varying crew practices. Nonetheless, other factors besides departmental policies, such as social or leadership support and environmental features, may be particularly important to consider in supporting firefighters' exercise behavior.

Regardless of the variability between fire departments in terms of domain and subdomain scores, each department was considered "good" for their total FD-MES score. This similarity may have been translated to their respective PA levels as there were no differences in firefighters' MVPA, whereas meaningful differences were observed for on-duty MPA between FD1 and FD2. Additionally, firefighters engaged in higher amounts of vigorous PA while on-duty compared to off-duty; however, these levels remained minimal overall, and the pattern appeared consistent across departments. This may reflect similarities related to the vigorous nature of the occupation, the tasks and required training being standardized, or high-intensity tasks occurring intermittently. On the other hand, firefighters may avoid high-intensity exercise while on-duty due to the unpredictability of the job and to avoid feeling fatigued for a call (Gold et al., 2022). While not

necessarily a barrier to exercise all together, it may lead firefighters to train at lower intensities (Agostinelli et al., 2023; Long et al., 2014). Firefighters in the present study engaged in higher amounts of LPA and MPA while on-duty, with average self-reported exercise intensity considered to be “light”, suggesting low- and moderate- intensity exercise may be a common and more sustainable exercise intensity while on the job. Despite this, the minimal levels of vigorous-intensity activity both on- and off-duty may warrant further attention given the physical demands of the job and importance of maintaining fitness levels.

Compared to prior studies observing firefighters’ on- and off-duty PA behavior using accelerometers (Barry et al., 2020), the present findings differ slightly as firefighters engaged in similar amounts of MVPA during on- and off-duty periods. In contrast, Barry et al. (2020) found firefighters were more active on-duty compared to off-duty, and only about half of firefighters met PA guidelines while on-duty. These differences may be explained by contextual factors that were not explicitly assessed in prior research (Barry et al., 2020). For instance, while MVPA was similar across duty contexts in the present study, participants less frequently reported a workout while off-duty, and of those who did, walking was a common activity. This may indicate that off-duty activity was more unstructured or leisure-based (e.g., golf, walking) and potentially influenced by time constraints (e.g., family responsibilities, second jobs). Additionally, many participants reported having a secondary job (e.g., construction, lawn care), which may have contributed to more incidental activity during their days off rather than structured exercise. However, in line with Barry et al. (2020) and Vancampfort et al. (2023), firefighters in the present study also engaged in high amounts of sedentary time regardless of duty status. Given that roughly 60% of a firefighter’s shift may be spent being sedentary (Barry et al., 2020), departments should aim to incorporate fitness and wellness programs to help firefighters reduce prolonged sedentary periods

and engage in more vigorous forms of PA and structured exercise (Hard et al., 2019; National Fire Protection Association, 2015).

In the present study, weak negative associations were observed between sedentary behavior and the Organizational Support and Programs & Policy domains, in addition to the messaging and policy subdomains. These findings suggest organizational support and policies alone may not explain PA levels in firefighters and may instead identify opportunities that enable firefighters to reduce sitting throughout the workday. In the present study, each department frequently identified access to equipment and exercise spaces as presently available in their department, suggesting these environmental resources may be important factors to support physical activity and exercise. Additionally, messaging, particularly from Command Staff, may reinforce its importance. For instance, if messaging from leadership is positive (e.g., emphasizing the benefits of PA) it may shape attitudes and subjective norms towards being more physically active (Jiang et al., 2026). Lastly, policies such as allowing personnel to engage in exercise or recreational sports and providing time during each shift may support discretionary activity by further reducing logistical barriers related to participation. Furthermore, the health and fitness assessments may act as an external reward system and encourage participation by increasing motivation (Lane et al., 2022).

While no associations were found between FD-MES domains or subdomains with MVPA, this is potentially due to PA still being heavily driven by individual factors, such as motivation, rather than organizational or policy level support alone. Intrinsic motivation (e.g., enjoyment) is important for long-term adherence to exercise (Teixeira et al., 2012) and firefighters may be driven by their professional identity to participate in exercise (Long et al., 2014; Vancampfort et al., 2023); yet extrinsic factors such as fitness assessments, incentives, and recognition may also be important to consider for habitual exercise (Geller et al., 2018). Regardless, this finding should be

interpreted cautiously given the small sample size and limited statistical power to detect associations. Future studies with larger sample sizes are needed to further examine relationships between multilevel departmental exercise support and firefighter PA outcomes.

Strengths & Limitations

There are several strengths of this study that are worth mentioning. First, this study utilized a novel Fire Department Multilevel Exercise Supports (FD-MES) tool, allowing for the examination of exercise supports across interpersonal, organizational, environmental, and policy levels. Second, the FD-MES tool addressed an important gap in assessing the fire service environment and allowed comparisons across different departments. Comparisons between three fire departments provided preliminary insights into factors firefighters currently have and what is limited or missing. Third, objective measures of PA were collected, strengthening the validity and reliability of activity estimates. However, the limitations are important to acknowledge due to the exploratory nature of this study and the potential influence of unmeasured departmental and operational factors. While the FD-MES tool is novel, the tool is still undergoing refinement as a few subscales showed low internal consistency (e.g., communication, coworker support, outdoor environment) and should be interpreted cautiously. Future research should refine tool items to address concerns of reliability and internal consistency. Additionally, the sample size is relatively small as only three fire departments participated in the study and were located within the same region of the United States. Because of this, it is difficult to determine whether differences reflect true department effects, station-level practices, sample characteristics, shift patterns, call volume, or other unmeasured operational factors. Future research should pilot this tool with larger sample sizes (i.e., more fire departments, stations, firefighter personnel) in varying regions of the U.S. to enhance generalizability and applicability. Lastly, firefighters' accelerometer data were only

assessed during their waking hours for both on-and off-duty hours. Moreover, while accelerometers are beneficial for collecting objective data and differentiating PA intensities, they are unable to capture the context in which activity occurs. The exercise logs were supplemental to provide some of this context, but we did not use the self-reported duration or intensity for any of the analyses as it was beyond the scope of the study. Thus, occupational or leisure-time PA and structured exercise were unable to be differentiated explicitly.

Conclusion

In sum, the FD-MES tool captures the strengths and weaknesses towards supporting exercise in individual fire departments and may serve as a promising preliminary measure, although additional refinement and evaluation are needed to establish its utility as a reliable and valid tool. The participating departments possess foundational interpersonal, organizational, and environmental supports which seem to provide firefighters opportunities and a social climate that may facilitate their exercise participation, although may be missing sustainable programs and initiatives for long-term engagement. Firefighters across departments engaged in similar amounts of PA regardless of differing domain and subdomain scores, and although the FD-MES tool was not related to higher intensity exercise (e.g., MVPA) in this sample, the relationship with sedentary behavior suggests a dual-approach to PA promotion may be warranted (i.e., target reducing sedentary behavior and actively facilitate structured PA). Organizational strategies such as implementing periodic movement breaks or having leadership communicate and reinforce the importance of PA may reduce prolonged sedentary periods, while environmental resources (e.g., fitness equipment, facilities, sidewalks) and department policies (e.g., protected time, fitness assessments, incentives) may facilitate their exercise opportunities and enhance individual motivation to be physically active and exercise. Likewise, interpersonal relationships may

inherently strengthen the objectives of these initiatives by enhancing the social norms and climate within the fire department. With further refinement and validation, the FD-MES tool may help fire departments self-evaluate their exercise-related resources and identify multilevel strategies to create initiatives that support firefighter health and fitness.

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Chapter 5 - Conclusions

The studies presented in this dissertation represent contributions to the growing literature on firefighter physical activity (PA) and exercise behavior by highlighting that their PA may not solely be shaped by individual factors, but rather by a combination of interpersonal, organizational, and environmental factors. Additionally, by addressing a gap in existing workplace audit tools to include fire departments as a unique occupational setting, this body of work provides an initial foundation for identifying departmental exercise-related supports and potentially strengthening opportunities for firefighters' exercise participation. Although engaging in PA and exercise is critical for health and occupational performance, firefighters continue to face challenges and barriers to entry. In Chapter 2, several themes emerged from focus groups, such as their peer support, leadership modeling, access to physical resources, and the department's culture and policies. These contextual factors seemed to shape both firefighters' motivation and opportunities to be physically active. For some, on-duty opportunities to engage in PA were more practical than off-duty. The discussion of these overlapping influences led to the realization that there was no current instrument to identify various sources and resources to support exercise within such a unique setting

In Chapter 3, we adapted a workplace PA audit tool to create the Fire Department Multilevel Exercise Supports (FD-MES) tool to bridge this gap. Results from this study highlighted that fire departments may have varying perceptions of the type and sources for exercise based on rank. These may also differ based on station infrastructure, reinforcing consistent communication and expectations across shifts and crews, and the value of assessing their work environments. Although item refinement is needed to improve tool reliability, this study was an important first step towards tool development and shows promise as a practical tool for future use.

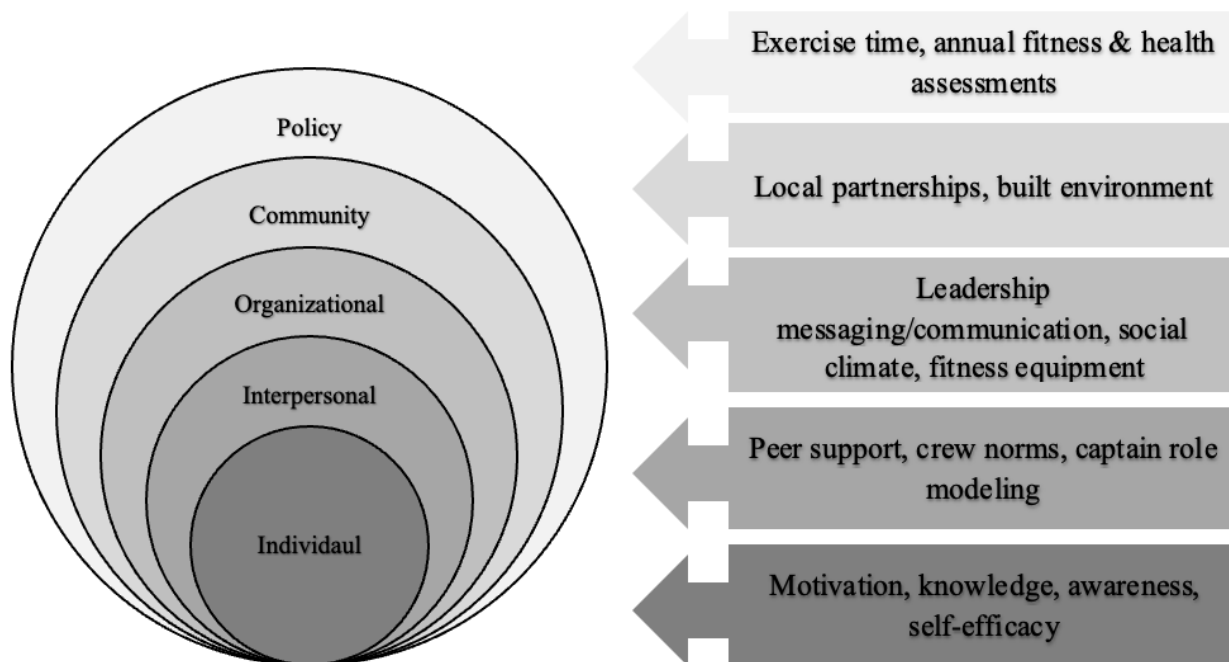
This study led us to investigate differences in tool domain and subdomain scores in three fire departments, as well as differences in objectively measured PA levels, and the relationships between these variables.

Chapter 4 applied the FD-MES tool and identified meaningful differences in interpersonal, organizational, and environmental level exercise supports between three fire departments. While tool domain and subdomain differences were observed between departments, many firefighters were meeting daily PA recommendations both on- and off-duty across departments. PA differences were found in firefighters' moderate-intensity on-duty PA between two departments, suggesting that some of the contextual factors identified earlier may help explain these differences. For instance, if peer or leadership support is stronger in one department than the other, exercise may be expected or considered more of a norm within a crew. Additionally, organizational and policy subdomain relationships with sedentary behavior suggest future research should investigate sedentary behavior as a unique target behavior among firefighters. Further, the FD-MES tool identified domain and subdomain differences between departments regardless of similar policies, total FD-MES scores, and PA levels; emphasizing fire departments are not "one size fits all". As a result, this tool may be a beneficial future resource for individual fire departments to identify deficits at various ecological levels, prioritize limited resources, and establish a baseline when wanting to improve health and fitness initiatives. The FD-MES may also provide fire departments with empirical support to justify funding allocation towards identified areas of need, leading to impactful future implications.

Figure 5.1 visually represents this dissertation's overarching findings. Each level highlights factors that influence firefighters' PA and exercise behavior. Interpersonal and organizational influences may shape peer norms and departmental culture to normalize exercise, while physical

resources and fitness and wellness policies can alleviate logistical barriers (e.g., time, resources). Thus, potentially providing firefighters with ample opportunities to be physically active. The interconnectedness of these influences warrants further investigation in firefighters yet may ultimately shape their beliefs, motivation, and self-efficacy towards PA participation (McLeroy et al., 1988). As such, this dissertation recognizes that individual PA behavior both influences and is influenced by the interpersonal, organizational, community, and policy contexts, consistent with the Social Ecological Model (McLeroy et al., 1988).

Figure 5.1. Conceptual Social Ecological Model for firefighter PA behavior.



There are several strengths of this dissertation research. Various methodological strategies were implemented in this body of work to understand and assess firefighters' PA behavior. The use of a mixed methods approach in Chapter 2 provided a consistent and complementary understanding of PA influences across quantitative and qualitative data. This approach generated nuanced insights that may not have emerged from using a different study design. Additionally, using the Social Ecological Model (SEM) as a guiding framework highlighted the complexity and

interconnectedness of these influences across multiple levels. Chapter 3 led to the development of a novel audit tool which addressed an important gap in firefighter health promotion research. Reliability testing, including the rank-based comparisons, provided insight into how firefighters and officers perceive their work environments. Application of the FD-MES tool in Chapter 4 to three fire departments enabled comparisons of exercise-supportive environments, insight to existing supports, and identified opportunities for improvement. Lastly, examining firefighters' on- and off-duty PA in this body of work extends previous research (Barry et al., 2020; Durand et al., 2011; Smith, 2011) and provided a well-rounded picture of firefighters' activity patterns in conjunction with the factors shaping behavior throughout their work and personal lives. Additionally, the inclusion of objectively measured PA strengthens the validity and reliability of activity estimates, which is limited within firefighter research.

However, the limitations of this body of work are worth mentioning. The presented studies were largely exploratory in nature and involved relatively small sample sizes from a limited number of fire departments. Additionally, firefighters were from the same geographical region in the United States. As such, the results of this dissertation should be interpreted with caution and may not be generalizable to all fire service settings. The second study, Chapter 3, had no 'gold standard rater' for the FD-MES tool which prevented criterion validity to be evaluated, and participants did not receive training prior to completing the tool which may have influenced the tool's reliability. Further, content or face validity for the tool was not extensively assessed regardless of having an expert panel and may have otherwise enhanced tool items that were considered subjective or abstract. Lastly, while widely accepted in PA research, the first study (Chapter 2) relied on self-reported PA data and may have been susceptible to recall bias, resulting in over-reporting (Lee et al., 2011). To counteract this concern, objective measures were used in

Chapter 4 to measure PA as previously mentioned. However, reactivity bias is still a concern that warrants consideration.

This dissertation adds to the information currently available to firefighters and highlights several areas for future research. The FD-MES tool requires further item refinement to clarify subjective wording, remove or add items to improve internal consistency of tool subdomains and address the variability in inter-rater reliability. Future validation efforts should evaluate the revised FD-MES tool and diversify recruitment efforts to include fire departments of various sizes and in different geographical regions of the United States. Additionally, future research should continue to examine whether fire department fitness policies translate into improved performance and fitness outcomes in firefighters (Melton et al., 2021). Multilevel intervention research is also needed to examine effective strategies for improving firefighter health and fitness. Interventions may benefit from being peer-led and incorporating behavior change theories, such as the Social Cognitive Theory (Bandura, 1998), to target key determinants of PA behavior as peer relationships, role modeling, and environmental influences were heavily discussed in the present studies. The potential implications from this dissertation provide a foundation for informing future intervention efforts aimed at creating exercise-supportive social, organizational, and physical environments and promoting firefighter health and fitness.

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Chapter 6 - Appendices

Appendix A - Chapter 2 Supplemental Materials

Appendix Figure A.1. Semi-structured interview guide

Interviewer clarification:

During today's session, *physical activity* refers to any movement of the body, including exercise or sports during leisure time, as well as activity at work, at home, or for transportation.

Individual level

1. Please describe your current physical activity during a typical week.
 - a. What types of activities do you usually do?
 - b. How often and for how long?
2. Can you describe differences in your physical activity when you are on-duty compared to off-duty?
 - a. Probes: What are some differences in activity type, intensity, or duration?
3. How would you describe your current physical fitness level?
 - a. Do you feel like you are in good shape?
 - b. Are there areas you would like to improve related to fitness or overall health?
4. If you are regularly physically active, what primarily motivates you to be active?
5. If you are not as physically active as you would like to be, what barriers or obstacles make it difficult?
6. What makes it difficult to be physically active while off-duty or while at home?

Interpersonal level

7. How do your support systems (e.g., family, friends, peers) influence your physical activity?
8. In what ways do your coworkers support your physical activity while on shift?
 - a. Probe: Do coworkers encourage or motivate you to be active?
 - b. Probe: How do you engage in physical activity together?
9. In what ways do coworkers create barriers to physical activity?
10. In what ways does your family support your physical activity?
11. What physical activities do you and your family typically do together?
12. In what ways do family or life responsibilities make fitting in physical activity difficult?

Organizational level

13. In what ways does your department support physical activity?
14. What organizational or departmental factors prevent your ability to engage in physical activity?
15. While on shift, you have access to a fitness area and an allotted time for its use. How would you describe your personal use of this space?
 - a. Probe: Please walk me through a typical workout session.
16. What do you like about this fitness space?
17. What do you dislike about this space?
18. What changes would you make to improve it?
19. Do you typically use the full allotted exercise time? Why or why not?
 - a. How do individuals facilitate physical activity among peers during this allotted time?
20. Are there ways in which physical activity is interrupted or inhibited among peers during this time?
 - a. Please describe an example.

Community level

21. What resources are available in your neighborhood or community (e.g., fitness facilities, parks, trails) to support physical activity?
 - a. Do you use these resources? Why or why not?
 - i. Probe: Which community resources do you commonly use with family or friends?
 - ii. Probe: What types of activities do you typically engage in at these resources?
 - iii. Probe: How do these resources influence your PA behavior?

Policy level

22. How does allotted exercise time, equipment, and space influence physical activity while on shift?
23. What policy changes would better encourage you or others to use the designated fitness space/equipment? What about the allotted exercise time?
24. Please describe your department's physical fitness or performance requirements.

- a. Which aspects of these requirements help assess your ability to perform your job?
 - b. Which requirements do not seem relevant to job performance?
 - c. How could these requirements be improved?
25. How do other department wellness policies (e.g., fitness assessments, performance assessments, designated exercise time) promote physical activity and overall wellness?
26. Which wellness policies are most effective or motivating for you personally (e.g., performance assessments, health screenings, allotted exercise time)?
- a. What do you like and dislike about these policies?
27. Are there assessments or any requirements you wish were included?
- a. What changes would you recommend?

Appendix Table A.1. Correlation table of all survey variables.

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1. On-duty VPA	1.0																				
2. On-duty MPA	.42*	1.0																			
3. Off-duty VPA	.26	.40*	1.0																		
4. Off-duty MPA	.41*	.47**	.17	1.0																	
5. Family SS	-.28	-.10	.08	-.03	1.0																
6. Friend SS	.004	-.15	.07	-.38*	.37	1.0															
7. Stress Management	.23	.41*	.33	.04	.02	.18	1.0														
8. Enjoyment	.28	.37*	.36*	.16	-.12	-.05	.82**	1.0													
9. Revitalization	.22	.36*	.29	.11	.03	-.01	.86**	.91**	1.0												
10. Challenge	.19	.20	.16	-.04	-.09	-.09	.76**	.83**	.83**	1.0											
11. Social Recognition	.29	.33	.22	.10	-.24	-.05	.52**	.57**	.56**	.63**	1.0										
12. Health Pressure	-.19	.11	.26	-.10	.14	.15	.58**	.28	.26	.34	.40*	1.0									

13. Ill Health	-.12	-.01	.08	.07	.42*	.18	.56**	.46**	.56**	.55**	.29	.39*	1.0								
Avoidance																					
14. Positive Health	-.08	.16	.16	.04	.50**	.30	.69**	.70**	.60**	.53**	.21	.20	.72**	1.0							
15.Strength/Endurance	.12	.23	.26	.04	.15	.04	.78**	.86**	.77**	.75**	.37*	.23	.55**	.79**	1.0						
16. Self-efficacy	.09	.29	.44*	.17	-.01	-.06	.54**	.48**	.51**	.41 *	.22	.38*	.15	.43*	.56**	1.0					
17. MOEES physical subscale	.13	.10	-.03	-.09	-.05	.01	.49**	.56**	.59**	.55**	.40*	-.14	.41 *	.49**	.50**	.001	1.0				
18. MOEES social subscale	.13	.04	.04	.15	-.17	-.07	.47**	.52**	.43*	.57**	.56**	.24	.36*	.26	.26	.11	.39*	1.0			
19. MOEES self-evaluative subscale	.22	.28	.21	.28	-.05	.08	.71**	.70*	.61**	.59**	.59**	.26	.36*	.55**	.51**	.36	.58**	.74**	1.0		
20. WEIS social subscale	-.19	.07	.10	-.40*	-.03	.32	.28	.18	.19	.17	.44*	.27	-.11	-.04	-.02	.03	.14	.26	.19	1.0	
21. WEIS environment subscale	.13	.15	-.12	-.07	-.12	.13	.47*	.25	.37*	.47**	.20	.01	.34	.43*	.50**	.07	.43*	.20	.39*	-.18	1.0

VPA = Vigorous physical activity, MPA = Moderate physical activity, SS = Social Support, MOEES = Multidimensional Outcome Expectations for Exercise, WEIS = Work Environment Impact Scale. * $p < 0.05$; ** $p < 0.01$.

Appendix Table A.2. Final themes from qualitative analysis with representative quotes

<i>Category/Main Theme</i>	<i>Subtheme</i>	<i>Representative Quotes</i>
Physical Activity (PA) Practices		
On-duty PA	<i>Duty status</i>	• “On your days off, you can push yourself at the gym harder. I’m not gonna jeopardize [my performance] you know if we get a demanding call...So [there’s] a lot of variability depending on when you’re at work and then what that activity looks like.” • “I’m more active on my days off than I am here [on-shift]. I’m walking, hunting, and [always] doing something compared to here.” • “I do enough to stay active in this job and not hurt myself so that’s kind of my goal: be able to do the job. It’s kind of what I think about when I do work out. I’m not trying to win any competitions or anything like that or get myself hurt in the weight room and then be off work, so I take it easy here.” • “I do just body-weight stuff [like] calisthenics. I don’t like weights because I’m half metal, so it hurts me to [lift] weights.”
	<i>Crew & PA preference</i>	• “[The type of activity] kind of depends, I mean, you might get a different crew out here, and everybody might be all into weightlifting, that everybody kind of works out together, or it might be a crew out here of all CrossFitters. So, it just kind of depends [on] the day, I mean, who else is here.” • “We stagger [workouts] a little more than most shifts because each of us typically follows a different workout routine and some of us have a workout partner or prefer going solo.”

		• <i>“It varies [by] crew. Some will do a whole circuit together, those who work out on their own, [at] their own pace, and it just depends. It goes in phases, from some kind of cardio and then lifting; you can get bored with something after a few months and change it up.”</i>
Off-duty PA	Seasonal, household, or recreational activities	• <i>“For off-duty days, I stay busy – physically. I also have a toddler, whether it's taking them a walk or just doing things around the house, wherever it might be, I get my steps in as well.”</i> • <i>“I'm pretty active on my days off. Hunting and trapping [animals], finishing my basement, and doing construction work. An actual organized workout is not really my jam.”</i> • <i>“Hiking and fishing, we do that quite often. I'm a bank fisherman, so we might get out of the truck and then walk two miles down the lake and have to walk back while carrying all our stuff.”</i>
	Physically demanding second jobs	• <i>“During my busy time of year, I'm way more physically active on my days off... I'm more tired at the end of the day on my days off just doing my work [second job doing lawn care] than when I am here. That's not to say I don't work out on my days off; I [usually just] walk.”</i> • <i>“[On my] days off it's...either digging holes or something hard with the shovel, so you kind of work pretty hard. My dad's a land surveyor so I help him. We're out...in the middle of a gravel road or something like that or cutting trees, cutting brush.”</i> • <i>“I'm running [a] business on my side, I mow and [cut] trees and stuff like that so this time of year [winter], I'm pretty lazy... then for</i>

		<i>about nine months I basically work every day. I come here [and work], and I don't get home for like 36 hours. I can't sit still... so that's kind of how, if I'm even fit, that's how I stay fit just by moving and working."</i>
Individual Influences		
Motives to PA	Job security & readiness	• <i>"You can't choose fire department A or fire department B. You got us, that's what you get. And so, it's important that we provide a professional, high level of service and a big part of that is being fit. We know the number one killer of firefighters is heart attacks."</i> • <i>"It just makes you better at the job. When I was younger, I used to always think I needed to be in good shape [since] when you're a firefighter you're really like the workhorse of the crew. As I moved up into an officer role, I realized I needed to be an even better shape to have clear thinking...just for the cognitive stuff because your vision just starts to tunnel. When you get tired, it's like fatigue makes cowards of us."</i> • <i>"The job...and it ain't getting easier, so I've got to stay in shape to wear the packs and go up the stairs and pull the ceilings and drag the hoses... For me, it's just trying to make it easy for me to be able to do everything that is asked of us."</i>
	Health & well-being	• <i>"One of my primary reasons [to exercise] is for my mental health. [It] depends on it in some ways; it helps it."</i> • <i>"I feel worse when I don't work out. It's like I just have to, like it drives me nuts. It's harder for me to miss a day than it is to go to the gym."</i>

		• <i>“I think there's a lot like he said before I want to be healthy long-term quality of life as much as quantity. I want to be able to keep up with my kids and hopefully they're active one day and still doing that.”</i>
	Family & peer Responsibility	• <i>“Wanting to do it for my kid, I wouldn't want my son to look back on me and say, ‘oh yeah, my dad was a slug’, you know, I’d want him to say, ‘hey I'm proud of my dad’ and that kind of thing. So that's a strong motivator for me.”</i> • <i>“I don't want to be the weak link on any call especially a fire because at any time it could be me standing between them and serious harm and I don't really want to be that guy.”</i> • <i>“I mean I do it for my kids...it's hard enough to keep up with them. If I let myself go at times and try to run around with them, it's harder. Then they wonder why you can't run around with them.”</i>
	Affective motives & internalized pressures	• <i>“I don't enjoy working out. I don't enjoy it that much, but I enjoy being a fat piece of crap even less, so I work out.”</i> • <i>“I feel almost demoralized when I don't [workout] or when I have to skip the gym to do something. That's just like ‘well three days I haven't gone and I haven't done anything’, so all of a sudden, I just feel down.”</i> • <i>“When I don't exercise, I feel terrible and I get stressed out and it's just a release for me to go to the gym and it does that more than anything else for me.”</i> • <i>“I've been there, feeling unmotivated but going through the motions helps get [me] there. Like when I was in high school, I ran cross-country and there was kind of the mentality of it's better to go run an</i>

		<i>easy three miles [rather] than do nothing. I've had plenty of days where I don't want to be in the weight room... So, I go do something and most of the time I get on the bike and ride for 30 minutes, get 10 miles, call it good."</i>
General Barriers to PA	Competing demands	• <i>"Family life...I got four kids so that takes up a lot of time, whether it's the evening ball games or just playing with the kids or whatever. After working here [on-shift] and going to your off-day job the next day, [by] five o'clock you kind of want to sit down and rest for a few minutes and don't really have the willpower."</i> • <i>"I think just all the things that have to be done at home...life is busy. So, for me that [exercise/PA], it's easy to push that one off. It's easy to push the gym off and I do that probably more than like these guys."</i> • <i>"I have a conflict of free time. Do I go fishing or workout?"</i> • <i>"Our family schedule is killer, like I mean they're all in basketball, got school, they all got a thousand different things, so if you're running them around it's kind of hard to make it to the gym...time is a massive barrier on your off days."</i> • <i>"At home, it just kind of depends. You might have 10 minutes here or 10 minutes there. It's not always a continuous, set time or anything, so I find it's easier to work out here on days that I'm on-duty. A lot less distractions usually..."</i>

	<i>Weather</i>	• <i>"I would say the only thing to keep me inside when it keeps me from mowing the grass or doing something I need to be just the weather. Whether it's too hot or too cold, going outside is therapeutic."</i> • <i>"When it's cold or snowy or whatever we can't go places. It kind of kills our house a little bit because we walk all the time.... so, when it was -10 [degrees], yeah, we're stuck inside."</i>
Interpersonal Influences		
Coworker Norms & Support	<i>Crew-dependent & leadership norms</i>	• <i>"I think you'll find a lot of variances as you talk to other firefighters [of] different ages, different stations; just every crew is different. [Other firefighter] is not part of our crew. His crew does [PA] differently, every crew's different, right, wrong, or whatever."</i> • <i>"The crew goes as the leader goes, but I've been on crews where working out was not a priority. You know, it just depends. It depends on who you're [stationed] with."</i> • <i>"I'm grateful for [shift captain] that he prioritizes [exercise], like 'this is our time... Union got this time for us, and we're gonna use it.' Some captains couldn't care less and it's really nice to push you outside of your comfort zone."</i> • <i>"You get variety [on shift]. You move stations, move shifts, [and] work with different guys. You got CrossFitters, bodybuilders, powerlifters, whatever it is, so that's kind of always fun – especially like the camaraderie of it sometimes."</i>

	Peer support, encouragement, or modeling	• <i>“I would really say just the guys holding each other accountable [and] making sure they can do the job is what I see as a more influencing factor compared to others.”</i> • <i>“We have a group text. There's six or eight of us and one guy will put [in] the CrossFit workout and everybody will post their time, ask ‘did you do it?’, ‘how’d it go?’, that kind of stuff.”</i> • <i>“They’ll adjust the workout and if we have something stupid on the board and it’s been a terrible day or even if we’re just not feeling it.... ‘how about we just dial this back, we’ll cut this out, we’ll adjust this’, and I feel like that helps me more than anything. That’ll keep you honest. You don’t have excuses.”</i> • <i>“I would say again, it’s not really so much admin, or from the top down like making sure we’re staying physically fit. It’s, you know, the guys you’re stationed with and just holding each other accountable that, they’re able to do the job, I guess.”</i> • <i>“Here [at the station] it depends on who you’re with. A lot of it is [when] somebody goes into the gym, it makes you feel like you need to go do something because you don’t want to the guy just sitting on the couch all day.”</i>
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	Peer pressure	• “We’re all competitive, you don’t want to be the guy that peters out. You can get labeled pretty quick and nicknames come up pretty fast.” • “One thing that they do to help me is to pressure me or whatever. This is when it's not bad peer pressure, this is like helping me out to motivate me to go.” • “It's generally very good-natured peer pressure. Like 'I'm about to go do this, are you sure you don't want to?' and just a little bit of ribbing [joking around, making fun of].”
Family Support	Early influences/ foundations	• “Growing up, I mean, I just got pushed into sports...So I've kind of had it in me since I was a kid I guess so that's made it really easy just to keep going, it wasn't something I had to learn as an adult....They were both athletes too so it's always been part of life really.” • “My wife listens to a lot of health podcasts and things like that, so we have a lot of conversations about what's good for us, what we should be doing, and what health protocols are out there and things like that.” • “My wife's also very active. She's also very health conscious so she cooks very clean for us, I guess. I think if people didn't care, I wouldn't be as motivated. I think motivation’s a big factor and just seeing other people around you being healthy, you definitely want to be healthier.”
	Family participation or shared activity	• “As a dad, it's really nice to see my kids enjoying the workout they like to go to the gym with me, they stretch with me, work out at home, like I said wrestle and do sports at home so having that same drive and passion with them is nice. It keeps me going.”

		• “Well, my daughter's nine years old and in about every sport there is... I help coach about everything she's in which is fun, but I mean I guess every dad wants to be there for their wife and they want to be there for their kids.” • “My wife, she's the one that's really about it – going outside and going for a long walk. Otherwise, on my off days, I don't want to do anything...she gets me outside and yeah, it's therapeutic when you get out there. She encourages me in a way that I don't traditionally think of as exercise.”
	Logistical & emotional support	• “Now, I go with them [my kids] to Genesis when they're back in town, they do their lifting, and I do my swimming or go on the elliptical. For instance, [they'll say] ‘Hey Dad come with us’, so there's that support [from the] family. It may not that we're all doing the same activity but we're still going to do stuff.” • “[My spouse] gives me time when I'm home to go [workout] on the weekend. Sometimes I need to get out of the house and [they're] willing to stay home when we have the free time.” • “Just giving me time [to workout]. For saying ‘go’, ‘you need to go’ or whatever, ‘get out of the house’.”
Organizational Influences		
Administrative Support	Flexible implementation of exercise policy	• “I think that they [Battalion Chiefs and Administration] give the captains a lot of leeway, and I feel they leave it in the captain's hand... they'll change up the workout time for us. There's nothing set in stone that we can't move it, which I feel the department has done a very

		good job with, allowing us the opportunity to stay fit.” • “If we're doing training in the afternoon, we might have the morning to kill and then we could work out in the morning, but I mean it's kind of taboo a little bit. They [administration] don't like it.”
	Commitment to firefighter health & wellness	• “We have the health and safety committee... and they meet about well-being essentially as part of the overall health of the department and go over safety, accident reports, stuff like that. So, I think there's some level of getting information to the guys, what we like and don't like, [exercise] machines that we want [to invest in] and stuff like that.” • “When I first came on, we didn't have a workout time. If you wanted to work out, you had to do it after five o'clock and so for me it was a big sign of faith that they actually allowed us to start having a workout time. They also saw the need for wanting to reduce injuries and all that kind of stuff, so on that level having remembered what it was like to not have a workout time, it still rings in my head that they are behind us to stay in shape and want us to do the best job we can for the citizens and for each other.” • “We've had the health and fitness committee where they'll kind of put out surveys, like ‘what kind of equipment do you need at your station?’ or whatever and they'll try to get what you need. We just recently got some treadmills for some of the other stations... our Union purchased assault bikes for us. I mean there's a little bit everything there [in the gym] so.”

Fire Department Cultural Norms	Buy-in & culture change	• “We didn’t get the contract working out time until like let’s just say ~20 years ago... The guys that I came on with that were older...they certainly didn’t grow up in that culture... They didn’t need to, or at least in their mind, they didn’t need to work out because they thought it was stupid.” • “I think part of why guys work out here is A) it’s part of the Union contract and B) it’s a young community that has a lot of educated people integrated into the department.” • “I would say [about] five years ago it was a different story. A lot more guys were holding the couch down, but I think that certainly changed.”
	Academy development as a catalyst	• “It’s been a transition...when I came on, during our Academy you never worked out. Now, there’s required workouts during our Academy for new hires...so that culture has changed over the last probably seven years or so... [It] has changed the culture in the firehouse.” • “...the department [has] really done [well] developing the Academy...when I started, we didn’t do any work; we ran like a mile and stuff but that was it. Now, these guys are doing CrossFit workouts. I mean they’re getting them prepared, setting expectations immediately the first day on the job.” • “We start in Academy, and we’re not going to get you in Academy and make you run & do stuff, and then once you get on shift say ‘yeah, we don’t have time for that’.”
	Station-dependent norms	• “As long as we stay under control, we’re allowed to go play games...like basketball or ultimate

		<i>frisbee. There's been some injuries in the past."</i> • <i>"The motivation [to exercise] is really low out there [at a specific station]. You can either take it one way or another...work out a bunch out there or not at all because you're ready to go home as soon as you show up. You can also get into bad habits."</i> • <i>"You can be tight [close knit] no matter where you're at, but obviously there are personalities involved and I'm the type of person that where I'm at affects my personality too, like at station [X]... [other firefighter] would come get me, some guy would cover for me, and I would go do nature hikes because I was going feral."</i> • <i>"I would say again, it's not really so much admin, or you know from the top down like making sure we're staying physically fit. It's, you know, the guys you're stationed with and just holding each other accountable that, they're able to do the job, I guess."</i> • <i>"As a Battalion Chief, I've had guys collapsing on the floor [after a workout] and I've had to talk to them and say you can't do that. I'm counting on you running, so no puking or out here on the assault bike seeing who can go the longest and fastest...when that bell drops, I want you out of the station."</i>
Occupation-specific Barriers	Work demand	• <i>"I mean the main barrier I think would be the days that it's all like sit down, classroom meetings. Where we have a class in the morning, that's a lot of lecture, or captain's or officer meetings where there's a lot of hurry up and wait, and then your motivation just tanks. We got plenty of days like that. We just don't feel like doing anything</i>

		<i>because you've done nothing. It just the cycle of itself."</i> • <i>"The most consistently inconvenient thing, and again it's your choice, is when we're studying for promotion. A lot of times when you study for promotions, you don't even touch the gym, you go right back to your room or in the office and you just study...all your PRs will go down, your cardio goes down, and you feel like shit you think you should go in there. Then usually the people study for several months leading up just a promotional test. So there will be a minimum of working out and they study on duty as well as off duty, so they probably aren't working out off-duty either, or very much."</i> • <i>"Training, any PR event that we may have going on...the PR events from 5 – 7pm but you leave here, you know getting ready and leaving here 4:15-4:30. So that would cut into it."</i> • <i>"I mean if you're always on the go whether it's here or at home, you're gonna lose a little bit of motivation to get in the weight room or go out for a jog or whatever. Today wasn't a high motivation day for getting in the gym because we're pretty busy all day. We didn't really slow down this afternoon... It's a little bit harder to find the same motivation. Then when you have a little bit slower day, you're like 'I just want to go do something'. So that and we're getting ready to go on, starting tomorrow, we get four days off, so it's kind of the end of our week."</i>
	<i>Fatigue or lack of sleep</i>	• <i>"I would say occasionally if we just have a long night at work, then if I just feel crappy and tired, I probably won't work out that next day, but</i>

		<i>those days [I feel] are pretty few and far in between.</i> • <i>“I was gonna say lack of sleep [as a barrier to PA]. I don't sleep well here [at the fire station], never have been. In fact, [on] the last shift we had two calls at night, and I bet I slept 30 minutes the whole 24-hour shift.</i> • <i>“I [will] say occasionally if we just have a long night at work, then if I just feel crappy and tired, I probably won't work out that next day.”</i>
Physical Resources & Environment	<i>Gym space characteristics</i>	• <i>“After that culture shift happened, the newer spaces now have windows to the outside, there's a lot of windows in the station.”</i> • <i>“I would say that X station[s] has a dungeon kind of feel to the workout space. It doesn't make you feel happy to be in there; it's tucked away with concrete walls. This one has no windows.”</i> • <i>“You asked what our barriers are to working out at work; that's actually one of them. The spaces at three of the stations are really bad. They're just old and not inviting.”</i>
	<i>Equipment quality & availability</i>	• <i>“We've done a great job in the last couple years of kind of getting [equipment] guys want... like this assault bike, treadmills, weights, these cable machines which are really useful, so I really like a lot of the equipment. But usually I think just the size [of the space] is the only let down... it's a little cramped in there sometimes but overall, it's like tripping over each other. It's like 'yeah I'll come back later', then they're done and it's 4:30pm.”</i> • <i>“I think we have quality equipment for the most part. I mean some departments you go to they have very minimal workout equipment, so I</i>

		<i>think we're fortunate with what we have."</i> • <i>"I mean we got pretty much about everything a person that needs to work out... but you get more than three or four people in there it gets crowded especially if everybody's kind of doing their own thing. If you're doing it as a group, you're kind of going through a rotation, I guess, but sometimes you have to wait on a piece of equipment."</i>
	<i>Desired improvements</i>	• <i>"A station in [different city] that was new, and the back wall was a garage door of their gym, and the front wall had large windows, and it overlooked the truck room...I would feel more motivated to go in there than I do here."</i> • <i>"The space was prioritized. Every station has a gym, but maybe the thought of like 'are people gonna use it?' There was no thought of how people will use it or what the effect is on people."</i> • <i>"It's just the station's been here for so long, it didn't have a weight room before, so it made the weight room down there gloomy. The space was [originally] for student firefighters."</i>
Community Influences		
Community Facilities	<i>Access to local gyms</i>	• <i>"I live right by [local gym], so I walk there quite a bit and go there".</i> • <i>"For a lot of years, I just pretty much worked out at work...[but] because they have childcare at the gym that's important to my wife. I'm gone 24 hours at a time, so she can still go workout. The whole family is on that plan, so I use it and just started to do that [helped] motivate me too."</i>

		• <i>“Even though we have gyms here [at the station], they’re small and we’re limited on what we have, so I actually use work [days] as a rest day... my lifting buddy and I, we’ll go to [a local] gym and we lift on our off days together.”</i>
	<i>Use of municipal/city-owned spaces</i>	• <i>“[We] can use any fire station or City Hall gym when off duty...like you don't have to have a gym membership to exercise in a gym while you're off duty.”</i> • <i>“Sometimes we go over there [City Hall] just because the gym is a little bigger, it kind of has iffy equipment that depends but you can use.”</i> • <i>“City hall has a gym that if you didn't want to pay for a gym membership you could go there on your off day and use it, but most guys will come back in here [the station] if they want to work out.”</i>
Built Environment	<i>Access to parks & trails</i>	• <i>“We go to [local park] a fair amount, just take the dog out there and go hike a little bit, my kids love going up and down the little rock steps... we spend a lot of time at parks.”</i> • <i>“My wife and I walk on [park] trails all the time since there's several of them around here.”</i> • <i>“Parks are used quite a bit, [my kids are] getting back to soccer so using that... I know we got guys that go walk stairs [at local facilities] ... [local] park gets used...there is opportunity that you don't have to be a member of a gym just to get it [a workout] done.”</i>
	<i>Valuable & walkable outdoor spaces</i>	• <i>“I’m more of an outdoor recreation kind of guy. I think – most especially for Kansas – I think [the city] does a good job, better than most, for the open public spaces for what we have but we're fortunate we have kind of landscape to do it... We have all the public rec facilities now that they’ve</i>

		<i>built in the last few years, those are pretty cool.”</i> • <i>“If the weather is nice, we're outside. Either walking, riding the bike, or walking the dog. I've got wood stoves so a lot of splitting wood, just a lot of [those] types of things I enjoy.”</i> • <i>“Moving around and walking [is important] which is why my wife, and I bought a house down here [center of town] because we can walk everywhere... We live right behind [a grocery store] so just walking to the store is getting out – it's a good thing for us.”</i>
Policy Influences		
Existing Policies	<i>Policies to motivate PA</i>	• <i>“It's [PPA] competitive... you know guys are trying to beat the guys on their whole shift and that'll really test you too because if you went your hardest and you're a minute behind a guy on your crew, now you're mad about it so you're going to work a little harder to not be that way next year.”</i> • <i>“If we didn't have allotted time for it, I probably would not get in there [the exercise space] as much. It's not that high on my radar but [I'm] also not getting any younger.”</i> • <i>“I think they all kind of go hand-in-hand. Doing your [health] physical every year. Obviously throughout the year you want to try and stay in shape, especially the older you get... it's a lot harder to get back into shape. I think that they're all pretty important, which ultimately, our physical, the PPA, that's going to tell us whether we're going to continue to do our job or not. Whether to go, you know, get on to other programs or something like that. [Then] obviously, the allotted</i>

		<i>time is very important as well too to get your workout in during the day.”</i>
	<i>Constraints for how policies are implemented</i>	• <i>“I enjoy [working out during the] mornings more.... By the time the [end of the] day gets here, I've got paperwork to get turned in. I've got everything else going on, so it's really tough for me to go down to the [station's] gym at 3:30 in the afternoon – that's my biggest downfall.”</i> • <i>“I have said it for a long time, ‘why is it [the PPA] 25 minutes?’ I mean if the point of it is to see if you can do the job and it takes you 25 minutes; that's not actually an adequate time.”</i> • <i>“That's what a lot of people said was weird about contract stuff, working out at the end of the day. You're very tired... it'd probably be more beneficial start the day off that way.”</i>
Programs	<i>Benefits</i>	• <i>“Every once in a while, you have to monitor your steps and after so many steps you get entered to win something like a vacation day or something [via wellness program].”</i> • <i>“There's a deal with [our health] insurance; you get money back if you do all these [things]. There's a whole long list, like you enter every workout. You must have so many points in the quarter, but you have to enter everything, and it has to fall under [a certain amount]. Like you get points if you quit smoking.</i> • <i>“They have incentives for doing things... they just came out this year, but you can get money back for doing these certain things you know. Your spouse is on the plan as well they can do some things as well to get money back.”</i>
	<i>Drawbacks</i>	• <i>“Everyone on the [health] insurance gets a free physical every year,</i>

		<i>whether that's my daughter or my wife...[but] if you don't do their surveys, they charge you \$100/month fee."</i> • <i>"It's all about points, [after] you get so many; it'll take so much money off your insurance bill. They make it so hard to do unless you have all the time in the world, like watch or go through two [educational] classes a month."</i> • <i>"Well, they make it so hard to do, like it would be almost impossible for somebody to get all the points unless that's like all you did, get all the time in the world. You have to watch or go through two classes a month or something. I was like 'this is a good deal. You can take five or six hundred dollars off a year' and then you read into it."</i>
Desired Policies	<i>Financial incentives & support</i>	• <i>"I've heard other departments doing different physical fitness incentives. You know if you can bench press your body weight 10 times. There's either a monitoring incentive or just improving the quality of your workplace incentive."</i> • <i>"I think other things could be like a benefit, where you get reimbursed for buying running shoes or exercise equipment on your own or something like that. We also have the Firefighter's Relief Association, and I know that in [different city] if you buy a wellness thing and turn in the receipt, you can get a refund up to a certain amount. I think running shoes [are] the best example."</i> • <i>"A couple other ideas that have been thrown around over the years would be like if the department paid for a gym membership."</i>

	Purposeful fitness standards & evaluations	• <i>“I think just having some little [fitness] benchmarks kind of built in you know, maybe not more tests or anything per se, just some good numbers set that are kind of standards that are realistic and achievable for everyone. We have all different shapes and sizes of people...It’s just not me there, it’s a team effort, because one person can probably do something I can’t.”</i> • <i>“I personally think it’d be cool to have two tests: one where it’s job-related, like the PPA [with] all the gear on. I’m in the military part-time so coming from the military, I think a PT test too just for general physical preparedness would be good like sit ups, pushups, pull ups, [and] a run of some sort would be very beneficial. Like varying scores based on your age range and stuff like that.”</i> • <i>“[Have] different standards because you’re not expected to perform to the same standard as you know, somebody like the 28- to 35-year-olds. Like I’m not going to run as fast as [someone who is] 18 and a track star.”</i>
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Appendix B - Chapter 3 Supplemental Materials

Appendix Figure B.1. The original Active Workplace Audit Tool.

A1: Messaging		Physical Activity		Sedentary Behaviour	
1.	Does the workplace share messages about <i>physical activity</i> / <i>reducing sedentary behaviour</i> with employees?	☐	☐	☐	☐
		YES	NO	YES	NO
2.	Do workplace active living messages include:				
	A call to action for <i>physical activity</i> / <i>sedentary behaviour</i> (e.g., “take the stairs”, “make your one-on-one meetings a walking meeting”)?	☐	☐	☐	☐
		YES	NO	YES	NO
	Appropriate language and literacy level for <i>physical activity</i> / <i>sedentary behaviour</i> ?	☐	☐	☐	☐
		YES	NO	YES	NO
	Appropriate content for various levels of readiness to engage in <i>physical activity</i> / <i>sedentary behaviour</i> (e.g., new to physical activity, athlete)?	☐	☐	☐	☐
		YES	NO	YES	NO
	Positive messaging for <i>physical activity</i> / <i>sedentary behaviour</i> (e.g., avoid making physical activity about weight loss, shaming people into moving more, or focusing on appearance)?	☐	☐	☐	☐
		YES	NO	YES	NO
	Information that is relevant, interesting, and relatable to employees about <i>physical activity</i> / <i>sedentary behaviour</i> ?	☐	☐	☐	☐
		YES	NO	YES	NO

A2: Communications

	Physical Activity	Sedentary Behaviour
3. Does the workplace communicate information about active living or have a campaign that uses the following communication methods and channels?		
Electronic communications (e.g., emails, intranet / web portal, newsletter articles, social media)	☐ YES ☐ NO	☐ YES ☐ NO
Hard copy communication (e.g., internal office mail, newsletter articles, posters)	☐ YES ☐ NO	☐ YES ☐ NO
In person opportunities (e.g., counselling, face-to-face meetings, employee orientation, wellness committee, events, classes)	☐ YES ☐ NO	☐ YES ☐ NO
4. Does the workplace have a communications plan to promote <i>physical activity / reducing sedentary behaviour</i> time?	☐ YES ☐ NO	☐ YES ☐ NO

A3: Education

	Physical Activity	Sedentary Behaviour
5. Does the workplace provide employees with education or personal development to:		
Learn about the benefits of <i>physical activity / reducing sedentary behaviour</i> time?	☐ YES ☐ NO	☐ YES ☐ NO
Develop organizational skills (e.g., planning, scheduling) and a behavioural plan for <i>physical activity / reducing sedentary behaviour</i> time?	☐ YES ☐ NO	☐ YES ☐ NO
Develop physical skills and practices in <i>physical activity / reducing sedentary behaviour</i> time (e.g., ergonomic set up of standing desks, sit-stand breaks, exercise activities).	☐ YES ☐ NO	☐ YES ☐ NO
Maintain optimal levels of <i>physical activity / reducing sedentary behaviour</i> time?	☐ YES ☐ NO	☐ YES ☐ NO
Understand organizational programs and policies on <i>physical activity / reducing sedentary behaviour</i> time?	☐ YES ☐ NO	☐ YES ☐ NO

B1: Employees

	Physical Activity	Sedentary Behaviour
6. Employees are supportive of others' participation in <i>physical activity/reducing sedentary behaviour</i> time (e.g., ask other employees to walk during breaks, accommodate standing during meetings).	☐ YES ☐ NO	☐ YES ☐ NO
7. Employees are actively involved in shaping practices, systems, or methods to engage others in <i>physical activity/ reduce sedentary behaviour</i> time.	☐ YES ☐ NO	☐ YES ☐ NO

B2: Management

	Physical Activity	Sedentary Behaviour
8. Management is a role model for <i>increasing physical activity/ reducing sedentary behaviour</i> time.	☐ YES ☐ NO	☐ YES ☐ NO
9. Management recognizes employees who adopt <i>physical activity/ reduce sedentary behaviour</i> time.	☐ YES ☐ NO	☐ YES ☐ NO

B3: Top Management

	Physical Activity	Sedentary Behaviour
10. Top management communicates their commitment to a culture that supports <i>physical activity / reducing sedentary behaviour</i> time.	☐ YES ☐ NO	☐ YES ☐ NO
11. Top management is a role model for <i>increasing physical activity/ reducing sedentary behaviour</i> time.	☐ YES ☐ NO	☐ YES ☐ NO
12. Top management openly supports policies and programs to <i>increase physical activity / reduce sedentary behaviour</i> time.	☐ YES ☐ NO	☐ YES ☐ NO

C1: Staffing and Committees

	Physical Activity		Sedentary Behaviour	
13. The workplace has a wellness champion(s) supporting employees' <i>physical activity</i> / <i>reduction of sedentary behaviour</i> time.	☐ YES	☐ NO	☐ YES	☐ NO
14. The wellness champion is recognized for their work in <i>physical activity</i> / <i>reducing sedentary behaviour</i> time.	☐ YES	☐ NO	☐ YES	☐ NO
15. The workplace has an established wellness committee that has a mandate to address <i>physical activity</i> / <i>reducing sedentary behaviour</i> time.	☐ YES	☐ NO	☐ YES	☐ NO
16. The wellness committee has a budget for <i>physical activity</i> / <i>reducing sedentary behaviour</i> time (e.g., paid position for wellness coordinator; funding for equipment, programs, or services; etc.).	☐ YES	☐ NO	☐ YES	☐ NO

C2: Social Climate

	Physical Activity		Sedentary Behaviour	
17. An organizational plan exists that addresses <i>physical activity</i> / <i>reducing sedentary behaviour</i> time.	☐ YES	☐ NO	☐ YES	☐ NO

18. Does the workplace consider the following in their organizational plans (select all that apply):

- ☐ active commuting to work
- ☐ active commuting to external meetings
- ☐ standing desks
- ☐ walking meetings
- ☐ standing meetings
- ☐ taking the stairs rather than the elevator
- ☐ use of on-site fitness/recreation centre or facilities
- ☐ physical activity during breaks, lunches or before/after work
- ☐ use of local recreation facilities
- ☐ participation in community physical activity events

19. The organization has developed a social climate that encourages (select all that apply):

- ☐ active commuting to work
- ☐ active commuting to external meetings
- ☐ standing desks
- ☐ walking meetings
- ☐ standing meetings
- ☐ taking the stairs rather than the elevator
- ☐ use of on-site fitness/recreation centre or facilities
- ☐ physical activity during breaks, lunches or before/after work
- ☐ use of local recreation facilities
- ☐ participation in community physical activity events

C3: Indoor Physical Environment

20. Does the workplace have the following facilities to support active transportation (select all that apply):

- ☐ safe bike lock up (e.g., bike room, bike racks or rails, bike cages, bike lockers)
- ☐ shelters or covers if outside
- ☐ shower and change room facilities for active commuters
- ☐ lockers or storage facility

21. Does the workplace have the following physical activity supports (select all that apply):

- ☐ fitness equipment
- ☐ variation in the types of equipment (e.g., different skill levels, body types, preferences)
- ☐ affordable access fees to facility (e.g., free or low rate)
- ☐ convenient hours of access to facility
- ☐ shower and change room facilities

22. If the workplace has indoor stairs, are the stairs (select all that apply):

- ☐ easy to find with clear wayfinding signs
- ☐ safe (e.g., no obstacles, well-lit)
- ☐ unlocked and accessible on all or most floors
- ☐ appealing to use (e.g., painted, decorated, utilities hidden, clean, ventilated)

23. Does the office layout support reducing sedentary behaviour time? Does the office layout have the following (select all that apply):

- ☐ printers placed in separate area from the desks (i.e., need to walk to printers)
- ☐ office space that can be used for fitness classes
- ☐ sit-stand desks available (e.g., shared desk or individual desk)
- ☐ standing options in meeting rooms
- ☐ a recreation room (e.g., room with table tennis, foosball, stretching area, etc.)

D1: Outdoor Environment

24. The workplace is located in an area that (select all that apply):

- ☐ is safe from crime
- ☐ is safe from automobile traffic and active transportation commuters (e.g., speed, volume, driveways, crosswalks, etc.)
- ☐ has universally accessible sidewalks (i.e., ease of access for people with mobility impairments; sidewalks well paved and cleared of any snow or debris; trails well kept, no obstacles or construction in path, well lit)
- ☐ has enough sidewalk or other pedestrian walkways for a 10-minute walk
- ☐ provides and maintains an outdoor area to be physically active (e.g., playing fields, paths, open spaces)
- ☐ is aesthetically pleasant (e.g., trees, shrubs, interesting architecture, clean, graffiti-free, etc.)
- ☐ is accessible via public transit

D2: Partnership

25. Does the workplace collaborate or have partnership with community-based facilities or services to provide opportunities for *physical activity* / *reducing sedentary behaviour* time (e.g., swimming pool, fitness centre, indoor walking track, community centre, wellness coach, fitness professional, etc.).

Physical
Activity



YES



NO

Sedentary
Behaviour



YES



NO

26. Does the workplace use information from outside sources (e.g., ParticipACTION, MyHealth.Alberta, etc.) for promotion, programing or policies related to *physical activity* / *reducing sedentary behaviour* time.



YES



NO



YES



NO

E1: Programs

27. Does the workplace offer or support participation in the following programs provided within your organization or externally (select all that apply):

- ☐ **Group exercise classes (e.g., cycling, fitness, swimming, dancing, yoga, etc.)**
- ☐ **Organized physical activity clubs, groups, sports team or events (e.g., run club, walking groups, hockey team, bike to work days, etc.)**
- ☐ **Programs supporting physical activity with family members**
- ☐ **Activities, competitions, and/or challenges focusing on physical activity (e.g., inclusive activities such as step challenges, etc.)**
- ☐ **Activities, competitions, and/or challenges focusing on reducing sedentary behaviour time (e.g., “stand when you are on the phone” challenge, stretch breaks, etc.)**
- ☐ **Active living counseling, online programs and/or professional exercise training support by qualified personnel targeting physical activity**
- ☐ **Active living counseling, online programs and/or professional exercise training support by qualified personnel targeting reducing sedentary behaviour time**
- ☐ **Programs that support employees with special needs, different skill levels, different ages and various interests in their participation in physical activity**
- ☐ **Programs that support employees with special needs, different skill levels, different ages and various interests in their participation in reducing sedentary behaviour time**
- ☐ **Tools to track personal physical activity progress and accomplishments (e.g., physical activity monitors, step logs)**
- ☐ **Tools to track personal progress in reducing sedentary behaviour time and achieving accomplishments (e.g., physical activity monitors)**
- ☐ **Prompts and reminders for physical activity (e.g., software to remind users to take an active break)**
- ☐ **Prompts and reminders for reducing sedentary behaviour time (e.g., software to remind users to move, signs by elevators to take the stairs)**

E2: Policies and Practices

28. Does the workplace have the following policies?

- ☐ a) Managers are recognized for supporting physical activity (e.g., staff and team recognition)
- ☐ b) Managers are recognized for supporting reducing sedentary behaviour time (e.g., staff and team recognition)
- ☐ c) Employees are recognized for participating in physical activity (e.g., staff and team recognition)
- ☐ d) Employees are recognized for participating in reducing sedentary behaviour time (e.g., staff recognition)
- ☐ e) Workplace wellness benefits exist that financially support physical activity
- ☐ f) Workplace wellness benefits exist that financially support reducing sedentary behaviour time
- ☐ g) Status reports of physical activity initiatives are reported to top management
- ☐ h) Status reports of reducing sedentary behaviour time initiatives are reported to top management
- ☐ i) Policy statements exist supporting physical activity in the workplace (e.g., dress down, flextime)
- ☐ j) Policy statements exist supporting reducing sedentary behaviour time in the workplace
- ☐ k) The workplace has policies supporting inclusive and accessible physical activity opportunities
- ☐ l) Policies exist supporting inclusive and accessible opportunities to reduce sedentary behaviour time
- ☐ m) Physical activity policies address variations in employee work situations (e.g., shift work, work from home)
- ☐ n) Reducing sedentary behaviour time policies address variations in employee work situations (e.g., shift work, work from home)
- ☐ o) Financial and material resources are allocated for physical activity in the budget
- ☐ p) Financial and material resources are allocated for reducing sedentary behaviour time in the budget
- ☐ q) Sponsorship opportunities for workplace sports teams or events (e.g., walks, running races, or cycling challenges)
- ☐ r) Active transport initiatives (e.g., free or subsidized bus passes or tickets, bike share, etc.)
- ☐ s) Employees can engage in physical activity during paid time

Detailed Active Workplace Audit Tool Scores

	Physical Activity		Sedentary Behaviour	
Overall Score	NEEDS ATTENTION		NEEDS ATTENTION	
 SECTION A Employee Awareness and Education	NEEDS ATTENTION		NEEDS ATTENTION	
	Total Score	0/15	Total Score	0/15
	A1: Messaging	0/6	A1: Messaging	0/6
	A2: Communications	0/4	A2: Communications	0/4
	A3: Education	0/5	A3: Education	0/5
 SECTION B Social Support	NEEDS ATTENTION		NEEDS ATTENTION	
	Total Score	0/7	Total Score	0/7
	B1: Employees	0/2	B1: Employees	0/2
	B2: Management	0/2	B2: Management	0/2
	B3: Top Management	0/3	B3: Top Management	0/3
 SECTION C Organizational Support	NEEDS ATTENTION		NEEDS ATTENTION	
	Total Score	0/28	Total Score	0/20
	C1: Staffing and Committees	0/4	C1: Staffing and Committees	0/4
	C2: Social Climate	0/15	C2: Social Climate	0/7
	C3: Indoor Physical Environment	0/9	C3: Indoor Physical Environment	0/9
 SECTION D Community Assets and Partnerships	NEEDS ATTENTION		NEEDS ATTENTION	
	Total Score	0/9	Total Score	0/2
	D1: Outdoor Environment	0/7		
	D2: Partnership	0/2	D2: Partnership	0/2
 SECTION E Programs and Policies	NEEDS ATTENTION		NEEDS ATTENTION	
	Total Score	0/19	Total Score	0/13
	E1: Programs	0/8	E1: Programs	0/5
	E2: Policies and Practices	0/11	E2: Policies and Practices	0/8

Appendix Table B.1. Kappa and percent agreement by item.

Inter-rater reliability							
Number of fire stations		<i>n</i> =7		<i>n</i> =9		<i>n</i> =8	
Item number	Questions, response options	Cap vs Cap kappa	% agreement	Cap vs FF kappa	% agreement	FF vs FF kappa	% agreement
A1. Messaging	Does the fire department command staff share messages about exercise behavior with firefighter personnel?	0.720	85.7%	0.250	62.5%	-0.250	37.5%
Do exercise-related messages in the fire department include:							
A2. Messaging_1	- A clear and relevant call to action for exercise during the workday (e.g., “fit in a quick workout between calls,” “use downtime for mobility or stretching,” “incorporate movement into daily routines at the station”)?	0.276	57.1%	0.308	66.7%	0.467	75%
A2. Messaging_2	- Appropriate language and literacy level for exercise?	0.222	57.1%	0.052	55.6%	-0.500	25%
A2. Messaging_3	- Appropriate content that is inclusive for firefighters at various fitness and readiness levels to engage in exercise (e.g., new to structured exercise, returning after injury, regularly engaging in high-intensity exercise, or preparing for physically demanding job tasks like a ladder raise)?	0.222	57.1%	0.00	50%	-0.600	0%

Item number	Questions, response options	Cap vs Cap kappa	% agreement	Cap vs FF kappa	% agreement	FF vs FF kappa	% agreement
A2. Messaging_4	- Positive messaging around exercise – avoiding shame, appearance-based goals, or punitive framing (e.g., instead of “you need to get in shape,” using messages like “staying active helps you perform and recover better”)?	0.087	57.1%	0.059	50%	-0.412	25%
A2. Messaging_5	- Information that is relevant, interesting, and relatable to firefighting personnel (e.g., examples tied to job performance, recovery, teamwork)?	0.222	57.1%	-0.521	33.3%	-0.111	37.5%
Does fire department leadership (including command staff and/or company officers) communicate information about exercise or have a campaign that uses the following communication methods and channels?							
A3. Communication_1	- Electronic communications (e.g., emails, union or fire service newsletters, reports, or social media including exercise tips or wellness updates).	0.696	85.7%	0.600	87.5%	0.600	87.5%
A3. Communication_2	- Hard copy communication (e.g., posters in the station(s), internal newsletters bulletin board messages related to movement, training, or fitness).	0.364	71.4%	-0.333	50%	a	75%

Item number	Questions, response options	Cap vs Cap kappa	% agreement	Cap vs FF kappa	% agreement	FF vs FF kappa	% agreement
A3. Communication_3	- In-person opportunities and messaging (e.g., exercise programming at the station, peer coaching, events, classes).	a	71.4%	-0.200	62.50%	-0.200	62.5%
A4. Communication	Does the fire department's command staff have a formal communications plan to promote exercise? (e.g., Department-wide wellness initiatives or campaigns with scheduled communications, coordinated programs or challenges led by command staff)	0.125	42.9%	0.000	50%	-0.200	62.5%
Does the fire department command staff provide personnel with education or personal development to:							
A5. Education_1	- Learn about the short-term and/or long-term benefits of exercise?	0.364	71.4%	a	77.8%	a	87.5%
A5. Education_2	- Develop organizational skills and a behavioral plan related to exercise (e.g., planning and scheduling workouts between calls or during the workday, creating personal fitness goals, or coordinating exercise with crewmates)?	0.222	57.1%	-0.200	55.6%	-0.143	75%
A5. Education_3	- Develop physical skills and practices in exercise (e.g., learning proper	0.364	71.4%	0.357	77.8%	a	75%

exercise techniques, participating in group workouts, using mobility routines during downtime, or incorporating movement strategies during long shifts)?

Item number	Questions, response options	Cap vs Cap kappa	% agreement	Cap vs FF kappa	% agreement	FF vs FF kappa	% agreement
A5. Education_4	- Maintain optimal levels of exercise (e.g., provide various resources, support and programs including workout tracking tools, crew-based challenges, and regular check-ins from officers)?	0.588	60%	-0.174	66.7%	a	50%
A5. Education_5	- Understand the fire department programs and policies that support exercise (e.g., designated exercise time during shifts, use of on- or off-site fitness spaces, wellness initiatives)?	-0.400	42.9%	-0.500	33.3%	-0.067	50%
B1.6. Coworkers	Firefighter personnel are supportive of others' participation in exercise (e.g., invite others to walk or stretch during downtime, support movement or light activity during informal discussions, encourage quick workouts when time allows).	a	100%	a	100%	a	87.5%
B1.7. Coworkers	Firefighter personnel are actively involved in shaping practices, systems, or methods to engage others in exercise (e.g., peer	-0.235	57.1%	-0.143	75%	-0.142	75%

leadership, mentorship, feedback on department policies, scheduling input).

Item number	Questions, response options	Cap vs Cap kappa	% agreement	Cap vs FF kappa	% agreement	FF vs FF kappa	% agreement
B1.8. Coworkers	Firefighter personnel may create social pressure or discourage participation in exercise (e.g., newer members feeling judged for exercising on duty, teasing or negative comments when participating or not participating, subtle exclusion from group activity).	0.364	71.4	0.182	66.7%	a	75%
B1.9. Coworkers	Exercise is culturally normalized among peers (e.g., crews commonly exercise together; on-duty exercise is generally accepted).	a	100%	a	100%	a	87.5%
B2.10. Officers	Officers are a role model for increasing exercise.	-0.167	71.4%	-0.216	44.4%	0.500	75%
B2.11. Officers	Officers acknowledge or recognize firefighter personnel who engage in a exercise.		100%	-0.200	55.6%	a	62.5%
B2.12. Officers	Officers foster a culture where exercise is expected and normalized within the crew.	a	100%	-0.143	75%	0.385	75%

Item number	Questions, response options	Cap vs Cap kappa	% agreement	Cap vs FF kappa	% agreement	FF vs FF kappa	% agreement
B3.13. Command Staff	Command staff communicate their commitment to a culture that supports on-duty exercise.	0.267	57.1%	-0.111	37.5%	-0.429	37.5%
B3.14. Command Staff	Command staff actively create and support a department-wide culture that encourages and normalizes on-duty exercise.	0.087	57.1%	-0.615	22.2%	-0.429	37.5%
B3.15. Command Staff	Command staff are a role model for increasing exercise.	a	85.7%	-0.125	77.8%	a	75%
B3.16. Command Staff	Command staff openly support policies and programs to promote and encourage exercise.	0.417	71.4%	-0.250	37.5%	0.500	75%
C17. Staffing	The fire department has a wellness champion(s) (e.g., fitness liaison, shift-based wellness rep, designated staff member) supporting other personnel's exercise.	1.00	100%	a	75%	-0.200	25%
C18. Staffing	The wellness champion is recognized for their role in exercise (e.g., acknowledgement by fire department leadership, allocating time).	1.00	100%	a	87.5%	a	87.5%
C19. Committees	The department has an established wellness committee that has a mandate to address exercise time.	-0.167	42.9%	0.525	77.80%	0.500	75%

Item number	Questions, response options	Cap vs Cap kappa	% agreement	Cap vs FF kappa	% agreement	FF vs FF kappa	% agreement
C20. Committees	The wellness committee has a budget for exercise (e.g., paid position for wellness coordinator, funding for equipment, local gym membership, training, programs, or wellness events).	0.222	57.1%	0.500	77.8%	0.143	62.5%
C21. Social Climate	The fire department has an organizational plan that addresses exercise time, separate from training, for firefighter personnel.	a	71%	a	66.6%	0.143	62.5%
Does the fire department command staff implement the following in their organizational plans?							
C22._Social Climate_1	- Active commuting to work (formal encouragement or incentives).	1.00	100%	a	100%	a	100%
C22._Social Climate_2	- Availability and/or support for standing workstations in office/administrative areas.	0.364	71.4%	0.400	77.8%	a	87.5%
C22._Social Climate_4	- Standing meetings (officially scheduled).	a	100%	a	100%	a	100%
C22._Social Climate_5	- Use of on-site exercise spaces and equipment.	a	71.4%	a	75%	a	75%
C22._Social Climate_6	- Provide a specific time for exercise while on shift (formal plan).	0.588	85.7%	0.333	75%	0.714	87.5%

Item number	Questions, response options	Cap vs Cap kappa	% agreement	Cap vs FF kappa	% agreement	FF vs FF kappa	% agreement
C22._Social Climate_7	- Allow flexibility in shift schedule for exercise time.	a	85.7%	-0.2	55.6%	0.467	75%
C22._Social Climate_8	- Use of local fitness and recreation centers or facilities (formal access or membership support).	1.00	100%	-0.154	44.4%	-0.429	37.5%
C22._Social Climate_9	- Encourage peer-led fitness initiatives or friendly competitions (e.g., firefighter-led workout groups, shift vs. shift challenges).	a	71.4%	a	77.8%	a	87.5%
C22._Social Climate_10	- Recognition of physical activity and exercise participation or achievements.	a	85.7%	-0.143	75%	a	87.5%
C22.Social Climate_11	- Participation in community physical activity events (e.g., 5Ks, mud runs, firefighter challenges, 9/11 stair climbs).	a	85.7%	a	100%	a	100%
The fire department has a social climate that encourages...Consider what is encouraged or happens in day-to-day department life, regardless of formal policy.							
C23. Social Climate_1	- Active commuting to work (personally supported by peers).	a	100%	a	88.9%	a	87.5%
C23. Social Climate_2	- Regular Use of fitness equipment.	a	85.7%	0.347	77.8%	0.143	62.5%

Item number	Questions, response options	Cap vs Cap kappa	% agreement	Cap vs FF kappa	% agreement	FF vs FF kappa	% agreement
C23. Social Climate_3	- Standing desks in officer/administrative spaces (used in practice).	a	100%	a	87.5%	a	87.5%
C23. Social Climate_4	- Walking meetings when appropriate.	a	100%	a	100%	a	100%
C23. Social Climate_5	- Standing meetings (e.g., briefings, check-ins, informal meetings)	a	100%	a	100%	a	100%
C23. Social Climate_6	- Use of on-site fitness facilities.	a	85.7%	0.182	66.7%	-0.200	62.5%
C23. Social Climate_7	- Exercise during designated times, between calls, or before/after work (actual practice).	0.588	85.7%	0.333	75%	0.333	75%
C23. Social Climate_8	- Use of local fitness and/or recreation facilities.	0.696	85.7%	0.500	75%	0.143	62.5%
C23. Social Climate_9	- Participation in community physical activity events (e.g., 5Ks, mud runs, firefighter challenges, 9/11 stair climb).	0.364	71.4%	a	66.7%	a	100%
C23. Social Climate_10	- Participation in job-related physical tasks or hands-on training as an option when traditional exercise isn't feasible.	0.16	57.1%	0.250	62.5%	0	50%
Does your fire station have the following facilities to support active transportation?							

Item number	Questions, response options	Cap vs Cap kappa	% agreement	Cap vs FF kappa	% agreement	FF vs FF kappa	% agreement
C24. Indoor Enviro_1	- Safe bike lock ups (e.g., bike room, bike racks or rails, bike cages, bike lockers).	0.300	71.4%	0.400	77.8%	a	62.5%
C24. Indoor Enviro_2	- Shelters or covers outside.	a	100%	a	100%	a	62.5%
C24. Indoor Enviro_3	- Shower and change room facilities.	a	71.4%	a	75%	a	100%
C24. Indoor Enviro_4	- Lockers or storage facilities.	-0.235	57.1%	-0.200	62.5%	a	87.5%
Does your fire station have the following exercise supports...							
C25. Indoor Enviro_1	- Fitness equipment	a	100%	a	100%	a	87.5%
C25. Indoor Enviro_11	- Variation in the types of equipment (e.g., various skill or fitness levels, body types, goals, or preferences).	a	85.7%	a	75%	-0.500	25%
C25. Indoor Enviro_2	- Designated space or room for exercise.	-0.235	57.1%	1.00	100%	-0.143	75%
C25. Indoor Enviro_3	- Equitable access to fitness equipment and facilities across all stations.	0.087	57.1%	-0.350	33.30%	0.250	62.5%
C25. Indoor Enviro_4	- Formally or informally allow personnel to access fitness areas outside of designated workout times (e.g., before/after shifts or off-duty).	a	85.7%	-0.231	50%	0.059	50%

Item number	Questions, response options	Cap vs Cap kappa	% agreement	Cap vs FF kappa	% agreement	FF vs FF kappa	% agreement
C25. Indoor Enviro_12	- Flexible spaces for warm-ups, mobility, recovery, and equipment stowage (e.g., portable equipment that can be moved and used in different parts of the station).	0.222	57.1%	a	66.7%	-0.429	37.5%
C25. Indoor Enviro_13	- Shower and change room facilities.	a	100%	a	100%	a	100%
If the fire station has an indoor exercise space, is it:							
C26. Indoor Enviro_1	- Equipped with cardio machines (e.g., treadmills, bikes, ellipticals).	a	100%	a	88.9%	a	87.5%
C26. Indoor Enviro_11	- Equipped with strength training equipment (e.g., free weights, kettlebells, resistance machines).	a	100%	a	100%	a	87.5%
C26. Indoor Enviro_2	- Spacious enough to support multiple personnel working out simultaneously.	0.696	85.7%	0.500	75%	0	50%
C26. Indoor Enviro_3	- Well maintained and clean.	a	57.1%	a	75%	0.333	75%
C26. Indoor Enviro_4	- Temperature controlled and well-ventilated.	-0.167	71.4%	0.182	66.7%	-0.200	62.5%
C26. Indoor Enviro_12	- Appealing to use.	0.300	71.4%	0.143	55.6%	0.059	50%
C26. Indoor Enviro_13	- Used regularly by personnel.	-0.235	57.1%	0.727	88.9%	a	87.5%
C26. Indoor Enviro_14	- Safe and secure (e.g., good lighting, locked when not in use).	a	71.4%	a	62.5%	0.714	87.5%

Item number	Questions, response options	Cap vs Cap kappa	% agreement	Cap vs FF kappa	% agreement	FF vs FF kappa	% agreement
C26. Indoor Enviro_15	- Equipped with mats or space for stretching/bodyweight exercises.	-0.273	42.9%	0.182	66.7%	-0.200	62.5%
The fire station is located in an area that... Focus on the outdoor environment surrounding your fire station.							
D27. Outdoor Enviro_1	- Is safe from crime.	0.588	85.7%	0.609	88.9%	0.333	75%
D27. Outdoor Enviro_2	- Is safe from automobile traffic and active transportation commuters (e.g., speed, volume, driveways, crosswalks).	-0.207	28.6%	0.467	75%	0.143	62.5%
D27. Outdoor Enviro_3	- Has universally accessible sidewalks (i.e., well paved, cleared of any snow or debris, free of obstacles or construction in path, well lit).	a	85.7%	0.333	75%	0.600	87.5%
D27. Outdoor Enviro_4	- Has enough sidewalks or other pedestrian walkways for a 10-minute walk.	0.588	85.7%	0.308	66.7%	0.00	50%
D27. Outdoor Enviro_5	- Allows outdoor or informal spaces available for physical activity or exercise (e.g., parking lots or driveways for drills/workouts, open spaces, walking paths, playing fields, or courts).	a	100%	a	66.7%	-0.429	37.5%

Item number	Questions, response options	Cap vs Cap kappa	% agreement	Cap vs FF kappa	% agreement	FF vs FF kappa	% agreement
D27. Outdoor Enviro_6	- Is aesthetically pleasant (e.g., presence of trees, shrubs, clean, graffiti-free).	0.222	57.1%	-0.200	55.6%	0.143	62.5%
D27. Outdoor Enviro_7	- Includes job-relevant facilities for physical training (e.g., training towers, drill yards, outdoor equipment).	0.417	71.4%	0.500	77.9%	1.00	100%
D27. Outdoor Enviro_8	- Relies primarily on off-site resources for exercise (e.g., community recreation or fitness centers, parks or trails).	-0.400	42.9%	-0.154	44.4%	0.385	75%
D28. Partnership	Does the fire department collaborate with or have partnerships with community-based facilities or services to provide opportunities for exercise?	-0.235	57.1%	-0.200	62.5%	0.600	87.5%
D29. Partnership	Does the department use information or resources from outside sources (e.g., International Association of Fire Fighters, Centers for Disease Control, Fire Rescue Fitness) for promotion, programming, or policies related to exercise?	0.696	85.7%	-0.364	44.4%	-0.143	75%
Does the department offer or support firefighter participation in the following programs, either within the department or through external partners?							

Item number	Questions, response options	Cap vs Cap kappa	% agreement	Cap vs FF kappa	% agreement	FF vs FF kappa	% agreement
E30. Programs_1	- Group exercise classes (e.g., CrossFit, cycling, fitness, swimming, yoga).	-0.400	42.9%	-0.174	66.7%	a	87.5%
E30. Programs_2	- Organized clubs, groups, sports teams, or events (e.g., running clubs, walking groups, bike to workdays, department-sponsored recreation leagues).	a	85.7%	a	87.5%	a	100%
E30. Programs_3	- Programs that support exercise with family members.	-0.167	71.4%	a	88.9%	a	100%
E30. Programs_4	- Activities, competitions, and/or challenges that promote exercise and/or physical activity (e.g., inclusive activities such as step challenges, completing workout logs).	a	71.4%	a	77.8%	a	87.5%
E30. Programs_5	- Access to professional support such as active living counseling, online programs, and/or professional fitness coaching.	-0.167	71.4%	a	88.9%	a	87.5%
E30. Programs_6	- Programs that support firefighters with different needs, fitness levels, interests, ages, or injury status in their participation in exercise.	a	85.7%	-0.111	75%	a	87.5%
E30. Programs_7	- Tools to track personal exercise progress and accomplishments (e.g., wearable devices, digital or	a	100%	a	100%	a	87.5%

physical workout logs, goal setting).

Item number	Questions, response options	Cap vs Cap kappa	% agreement	Cap vs FF kappa	% agreement	FF vs FF kappa	% agreement
E30. Programs_8	- Prompts and reminders to exercise and be active (e.g., software notifications, station signage encouraging movement throughout shifts).	0.588	85.7%	a	88.9%	-0.143	75%
Does the fire department have the following policies?							
E31. Policies_1	- Officers are recognized for supporting exercise (e.g., staff and team recognition).	a	100%	a	75%	-0.200	62.5%
E31. Policies_2	- Firefighter personnel are recognized for participating in exercise (e.g., staff and team recognition).	1	100%	a	88.90%	a	75%
E31. Policies_3	- Fire department wellness benefits exist to financially support exercise (e.g., stipend for exercise clothes or shoes, discounted or fully funded gym memberships, or paid fitness coordinator/liaison).	0.364	71.4%	-0.286	55.6%	0.143	62.5%
E31. Policies_4	- Status reports of exercise initiatives are reported to command staff or city administration (feedback from personnel is provided to command staff or upper leadership).	a	85.7%	-0.125	77.8%	a	87.5%

Item number	Questions, response options	Cap vs Cap kappa	% agreement	Cap vs FF kappa	% agreement	FF vs FF kappa	% agreement
E31. Policies_5	- Policy statements exist supporting exercise in the department (e.g., dress down, designated or flexible time).	0.087	57.1%	0.000	50%	0.333	75%
E31. Policies_6	- The department has policies supporting inclusive and accessible exercise opportunities.	0.588	85.7%	-0.412	25%	-0.250	37.5%
E31. Policies_7	- Exercise policies address variations in personnel's operations (e.g., shift work, training, daily tasks).	0.160	57.1%	-0.250	37.5%	0.059	50%
E31. Policies_8	- Financial and material resources are allocated for exercise in the budget (e.g., budget for new equipment, funding for wellness programs or events)	0.417	71.4%	0.357	77.8%	0.00	50%
E31. Policies_9	- Sponsorship opportunities for department sports teams or events (e.g., walks, running races, or cycling challenges).	a	100%	a	100%	a	100%
E31. Policies_10	- Incentive programs or recognition of exercise participation or achievements (e.g., free or subsidized gym memberships, compensatory time off, annual awards for top performers, department-wide challenges).	0.588	85.7%	a	77.8%	a	100%

Item number	Questions, response options	Cap vs Cap kappa	% agreement	Cap vs FF kappa	% agreement	FF vs FF kappa	% agreement
E31. Policies_11	- Active transport initiatives (e.g., free or subsidized bus passes or tickets, bike share).	a	100%	a	100%	a	100%
E31. Policies_12	- Personnel can engage in exercise during duty hours.	a	100%	a	100%	a	100%
E31. Policies_13	- Firefighter personnel can engage in recreational sports during duty hours (e.g., team-based games or activities that the crew can play together, such as basketball, volleyball, or softball, within the station or on department property).	0.087	57.1%	-0.250	37.5%	0.250	62.5%
E31. Policies_14	- Firefighter personnel have annual health assessments.	a	100%	a	87.5%	a	87.5%
E31. Policies_15	- Firefighter personnel have annual fitness assessments that adequately assess occupational tasks, including job-related physical ability tests (e.g., CPAT, annual SCBA drills) and other measures relevant to firefighter duties.	0.696	85.7%	0.750	87.5%	1.00	100%

Notes: Captain = Cap, Firefighter = FF; Paired ratings for Cap vs Cap (n=7), Cap vs FF (n=9), FF vs FF (n=8). Kappa: 0.81–1.00 almost perfect; 0.61–0.80 substantial; 0.41–0.60 moderate; 0.21–0.40 fair; 0.00–0.20 poor. ^aInsufficient item variability across stations to use kappa.

Appendix Table B.2. Percent agreement by fire department.

	FD1	FD2	FD3				Average % Agreement
	% agreement by item	% agreement by item	% agreement by item	At least 1 FD <60% agreement	2 FD <60% agreement	All 3 FD <60% agreement	
A1. _Messaging	83%	60%	83%				76.47%
A2. _Messaging_1	50%	60%	50%		x		52.94%*
A2. _Messaging_2	67%	80%	83%				76.47%
A2. _Messaging_3	50%	60%	83%	x			64.71%
A2. _Messaging_4	50%	40%	50%			x	47.06%*
A2. _Messaging_5	67%	20%	67%	x			52.94%*
A3. _Communication_1	83%	80%	83%				82.35%
A3. _Communication_2	83%	60%	83%				76.47%
A3. _Communication_3	100%	100%	67%				88.24%
A4. _Communication	33%	80%	67%	x			58.82%*
A5. _Education_1	83%	80%	67%				76.47%
A5. _Education_2	83%	60%	67%				70.59%
A5. _Education_3	83%	80%	83%				82.35%
A5. _Education_4	83%	60%	83%				76.47%
A5. _Education_5	67%	40%	50%		x		52.94%*
B1.6. _Coworkers	100%	80%	100%				94.12%
B1.7. _Coworkers	100%	40%	50%		x		64.71%
B1.8. _Coworkers	50%	80%	83%	x			70.59%

B1.9._Coworkers	100%	80%	100%				94.12%
B2.10._Officers	33%	60%	83%	x			58.82%*
B2.11._Officers	67%	40%	83%	x			64.71%
B2.12._Officers	67%	20%	83%	x			58.82%*
B3.13._Command_Staff	50%	40%	33%			x	41.18%*
B3.14._Command_Staff	67%	40%	33%		x		47.06%*
B3.15._Command_Staff	83%	60%	83%				76.47%
B3.16._Command_Staff	50%	40%	33%			x	41.18%*
C17._Staffing	50%	100%	83%	x			76.47%
C18._Staffing	83%	100%	83%				88.24%
C19._Committees	50%	100%	67%	x			70.59%
C20._Committees	50%	80%	67%	x			64.71%
C21._Social_Climate	83%	80%	100%				88.24%
C22._Social_Climate_1	100%	80%	100%				94.12%
C22._Social_Climate_2	67%	80%	83%				76.47%
C22._Social_Climate_4	100%	60%	100%				88.24%
C22._Social_Climate_5	50%	80%	50%		x		58.82%*
C22._Social_Climate_6	100%	100%	83%				94.12%
C22._Social_Climate_7	17%	80%	67%	x			52.94%*
C22._Social_Climate_8	100%	20%	67%	x			64.71%
C22._Social_Climate_9	83%	80%	83%				82.35%
C22._Social_Climate_10	100%	80%	83%				88.24%
C22._Social_Climate_11	100%	60%	67%				76.47%

C23._Social_Climate_1	100%	40%	100%	x		82.35%
C23._Social_Climate_2	67%	80%	33%	x		58.82%*
C23._Social_Climate_3	83%	100%	67%			82.35%
C23._Social_Climate_4	100%	100%	100%			100.00%
C23._Social_Climate_5	100%	80%	100%			94.12%
C23._Social_Climate_6	67%	80%	67%			70.59%
C23._Social_Climate_7	50%	100%	67%	x		70.59%
C23._Social_Climate_8	100%	60%	67%			76.47%
C23._Social_Climate_9	67%	40%	50%		x	52.94%*
C23._Social_Climate_10	50%	80%	17%		x	47.06%*
C24._Indoor_Enviro_1	100%	80%	83%			88.24%
C24._Indoor_Enviro_2	83%	40%	100%	x		76.47%
C24._Indoor_Enviro_3	67%	100%	83%			82.35%
C24._Indoor_Enviro_4	67%	100%	83%			82.35%
C25._Indoor_Enviro_1	100%	100%	83%			94.12%
C25._Indoor_Enviro_11	67%	80%	67%			70.59%
C25._Indoor_Enviro_2	83%	100%	17%	x		64.71%
C25._Indoor_Enviro_3	67%	60%	50%	x		58.82%*
C25._Indoor_Enviro_4	50%	60%	100%	x		70.59%
C25._Indoor_Enviro_12	83%	60%	50%	x		64.71%
C25._Indoor_Enviro_13	100%	100%	100%			100.00%
C26._Indoor_Enviro_1	100%	100%	83%			94.12%
C26._Indoor_Enviro_11	100%	100%	83%			94.12%

C26._Indoor_Enviro_2	67%	40%	50%	x	x	52.94%*
C26._Indoor_Enviro_3	100%	60%	33%	x		64.71%
C26._Indoor_Enviro_4	83%	80%	67%			76.47%
C26._Indoor_Enviro_12	83%	40%	67%	x		64.71%
C26._Indoor_Enviro_13	83%	100%	50%	x		76.47%
C26._Indoor_Enviro_14	83%	60%	67%			70.59%
C26._Indoor_Enviro_15	100%	60%	50%	x		70.59%
D27._Outdoor_Enviro_1	83%	100%	83%			88.24%
D27._Outdoor_Enviro_2	50%	40%	67%		x	52.94%*
D27._Outdoor_Enviro_3	100%	40%	50%		x	64.71%
D27._Outdoor_Enviro_4	83%	80%	83%			82.35%
D27._Outdoor_Enviro_5	67%	60%	67%			64.71%
D27._Outdoor_Enviro_6	17%	80%	17%		x	35.29%*
D27._Outdoor_Enviro_7	83%	60%	67%			70.59%
D27._Outdoor_Enviro_8	50%	80%	33%		x	52.94%*
D28._Partnership	83%	0%	67%	x		52.94%*
D29._Partnership	67%	60%	33%	x		52.94%*
E30._Programs_1_groupeexercise	83%	100%	67%			82.35%
E30._Programs_2_organizedclubs	100%	80%	100%			94.12%
E30._Programs_3_programswithfamily	83%	100%	83%			88.24%
E30._Programs_4_competitionschallenges	67%	100%	100%			88.24%
E30._Programs_5_professionalsupport	50%	60%	100%	x		70.59%
E30._Programs_6_supportdiffneeds	100%	60%	83%			82.35%

E30._Programs_7_self_regulation tools	100%	100%	100%			100.00%
E30._Programs_8_exercisereminders	83%	60%	83%			76.47%
E31._Policies_1	100%	80%	67%			82.35%
E31._Policies_2	100%	60%	83%			82.35%
E31._Policies_3	67%	60%	67%			64.71%
E31._Policies_4	83%	100%	100%			94.12%
E31._Policies_5	67%	80%	50%	x		64.71%
E31._Policies_6	50%	60%	33%		x	47.06%*
E31._Policies_7	50%	20%	67%		x	47.06%*
E31._Policies_8	67%	80%	67%			70.59%
E31._Policies_9	100%	100%	100%			100.00%
E31._Policies_10	83%	80%	100%			88.24%
E31._Policies_11	100%	100%	100%			100.00%
E31._Policies_12	100%	80%	100%			94.12%
E31._Policies_13	67%	80%	67%			70.59%
E31._Policies_14	100%	80%	100%			94.12%
E31._Policies_15	100%	60%	67%			76.47%
TOTAL	76.9%	71%	72.1%	29	14	3

Notes: (*) indicates that average percent agreement across fire departments is below 70%.

Appendix C - Chapter 4 Supplemental Materials

Appendix Table C.1. Exercise logs.

Exercise Log	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
1. <i>What facility or location did you exercise at?</i> (e.g., fire station, community center, local gym, outside, etc.)							
2. Activity Type(s) (strength, cardio, stretching, etc.)							
3. Exercise Description(s): <i>What did you do?</i> Note any equipment you used (e.g., Barbells, dumbbells, sandbags, treadmill, elliptical, etc.)							
4. <i>How hard did this workout feel?</i> Think about how hard you feel you are working overall—your breathing, effort, and fatigue. A 6 feels like resting, while 20 feels like the hardest you could possibly work. <i>*Refer to picture in email or below if needed*</i>	Range from 6 – 20, where 6 = very, very easy, 10 = light effort, & 20 = very, very hard	Range from 6 – 20, where 6 = very, very easy, 10 = light effort, & 20 = very, very hard	Range from 6 – 20, where 6 = very, very easy, 10 = light effort, & 20 = very, very hard	Range from 6 – 20, where 6 = very, very easy, 10 = light effort, & 20 = very, very hard	Range from 6 – 20, where 6 = very, very easy, 10 = light effort, & 20 = very, very hard	Range from 6 – 20, where 6 = very, very easy, 10 = light effort, & 20 = very, very hard	Range from 6 – 20, where 6 = very, very easy, 10 = light effort, & 20 = very, very hard

5. Start & End time of workout (Be as accurate as possible)	Start:	Start:	Start:	Start:	Start:	Start:	Start:
	End:	End:	End:	End:	End:	End:	End:
6. Total time of workout (minutes)	_____ mins	_____ mins	_____ mins	_____ mins	_____ mins	_____ mins	_____ mins
Notes: Use this section to briefly note any relevant context—such as sets/ reps or weight (if applicable), why you worked out (or didn’t), whether it was done independently or with others, and any modifications or barriers (e.g., workout interrupted by a call). Feel free to include any other details you think are important.							

Appendix Table C.2. Frequencies of FD-MES items by department.

Domain		Yes Responses, N (%)		
Subdomain	Items	FD1 (n=20)	FD2 (n=19)	FD3 (n=19)
Awareness & Education				
	Does the fire department command staff share messages about exercise behavior with firefighter personnel?	4 (20%)	7 (36.8%)	5 (26.3%)
	Do exercise-related messages in the fire department include:			
	-A clear and relevant call to action for exercise during the workday (e.g., “fit in a quick workout between calls,” “use downtime for mobility or stretching,” “incorporate movement into daily routines at the station”)	5 (25%)	10 (52.6%)	5 (26.3%)
	-Appropriate language and literacy level for exercise	6 (30%)	7 (36.8%)	6 (31.6%)
Messaging	-Appropriate content that is inclusive for firefighters at various fitness and readiness levels to engage in exercise (e.g., new to structured exercise, returning after injury, regularly engaging in high-intensity exercise, or preparing for physically demanding job tasks like a ladder raise)	7 (35%)	6 (31.6%)	8 (42.1%)
	-Positive messaging around exercise – avoiding shame, appearance-based goals, or punitive framing (e.g., instead of “you need to get in shape,” using messages like “staying active helps you perform and recover better”)	7 (35%)	11 (57.9%)	7 (36.8%)
	-Information that is relevant, interesting, and relatable to firefighting personnel (e.g., examples tied to job performance, recovery, teamwork)	6 (30%)	8 (42.1%)	6 (31.6%)
Communication	Does fire department leadership (including command staff and/or company officers) communicate information about exercise or have a campaign that uses the following communication methods and channels?			

	-Electronic communications (e.g., emails, union or fire service newsletters, reports, or social media including exercise tips or wellness updates).	3 (15%)	8 (42.1%)	2 (10.5%)
	-Hard copy communication (e.g., posters in the station(s), internal newsletters bulletin board for messages related to movement, training, or fitness).	2 (10%)	6 (31.6%)	1 (5.3%)
	-In-person opportunities and messaging (e.g., exercise programming at the station, peer coaching, events, classes).	3 (15%)	5 (26.3%)	2 (10.5%)
	Does the fire department's command staff have a formal communications plan to promote exercise? (e.g., Department-wide wellness initiatives or campaigns with scheduled communications, coordinated programs or challenges led by command staff)?	7 (35%)	1 (5.3%)	3 (15.8%)
	Does the fire department command staff provide personnel with education or personal development to:			
Education	-Learn about the short-term and/or long-term benefits of exercise	3 (15%)	2 (10.5%)	3 (15.8%)
	-Develop organizational skills and a behavioral plan related to exercise (e.g., planning and scheduling workouts between calls or during the workday, creating personal fitness goals, or coordinating exercise with crewmates)	4 (20%)	3 (15.8%)	3 (15.8%)
	-Develop physical skills and practices in exercise (e.g., learning proper exercise technique, participating in group workouts, using mobility routines during downtime, or incorporating movement strategies during long shifts)	3 (15%)	2 (10.5%)	2 (10.5%)

	-Maintain optimal levels of exercise (e.g., provide various resources, support and programs including workout tracking tools, crew-based challenges, and regular check-ins from officers)	3 (15%)	3 (15.8%)	2 (10.5%)
	-Understand the fire department programs and policies that support exercise (e.g., designated exercise time during shifts, use of on- or off-site fitness spaces, wellness initiatives)	14 (70%)	11 (57.9%)	14 (73.7%)
<i>Social Support</i>				
Coworker Support	Firefighter personnel are supportive of others' participation in exercise (e.g., invite others to walk or stretch during downtime, support movement or light activity during informal discussions, encourage quick workouts when time allows).	20 (100%)	18 (94.7%)	18 (94.7%)
	Firefighter personnel are actively involved in shaping practices, systems, or methods to engage others in exercise (e.g., peer leadership, mentorship, feedback on department policies, scheduling input).	19 (95%)	11 (57.9%)	15 (78.9%)
	Firefighter personnel may create social pressure or discourage participation in exercise (e.g., newer members feeling judged for exercising on duty, teasing or negative comments when participating or not participating, subtle exclusion from group activity).	9 (45%)	2 (10.5%)	2 (10.5%)
	Exercise is culturally normalized among peers (e.g., crews commonly	20 (100%)	17 (89.5%)	18 (94.7%)

	exercise together; on-duty exercise is generally accepted).			
Officer Support	Officers are role models for increasing exercise.	14 (70%)	13 (68.4%)	18 (94.7%)
	Officers acknowledge or recognize firefighter personnel who engage in exercise.	16 (80%)	10 (52.6%)	18 (94.7%)
	Officers foster a culture where exercise is expected and normalized within the crew.	18 (90%)	11 (57.9%)	18 (94.7%)
Command Staff Support	Command staff communicate their commitment to a culture that supports on-duty exercise.	8 (40%)	6 (31.6%)	8 (42.1%)
	Command staff actively create and support a department-wide culture that encourages and normalizes on-duty exercise.	7 (35%)	7 (36.8%)	5 (26.3%)
	Command staff are a role model for increasing exercise.	2 (10%)	3 (15.8%)	1 (5.3%)
	Command staff openly support policies and programs to promote and encourage exercise.	9 (45%)	9 (47.4%)	8 (42.1%)
<i>Organizational Support</i>				
Staffing & Committee	The fire department has a wellness champion(s) (e.g., fitness liaison, shift-based wellness rep, designated staff member) supporting other personnel's exercise.	4 (20%)	0 (0%)	3 (15.8%)
	The wellness champion is recognized for their role in exercise (e.g., acknowledgement by fire department leadership, allocating time).	2 (10%)	0 (0%)	1 (5.3%)
	The department has an established wellness committee that has a mandate to address exercise time.	14 (70%)	0 (0%)	5 (26.3%)

Social Climate (Organizational plans)	The wellness committee has a budget for exercise (e.g., paid position for wellness coordinator, funding for equipment, local gym membership, training, programs, or wellness events).	8 (40%)	2 (10.5%)	3 (15.8%)
	The fire department has an organizational plan that addresses exercise time, separate from training, for firefighter personnel.	16 (80%)	18 (94.7%)	15 (78.9%)
	Does the fire department command staff implement the following in their organizational plans?			
	- Active commuting to work (formal encouragement or incentives).	1 (5%)	1 (5.3%)	0 (0%)
	- Availability and/or support for standing workstations in office/administrative areas.	4 (20%)	1 (5.3%)	1 (5.3%)
	- Standing meetings (officially scheduled).	0 (0%)	2 (10.5%)	0 (0%)
	- Use of on-site exercise spaces and equipment.	15 (75%)	16 (84.2%)	16 (84.2%)
	- Provide a specific time for exercise while on shift (formal plan).	20 (100%)	16 (84.2%)	4 (21.1%)
	- Allow flexibility in shift schedule for exercise time.	10 (50%)	16 (84.2%)	15 (78.9%)
	- Use of local fitness and recreation centers or facilities (formal access or membership support).	0 (0%)	5 (26.3%)	14 (73.7%)
	- Encourage peer-led fitness initiatives or friendly competitions (e.g., firefighter-led workout groups, shift vs. shift challenges).	2 (10%)	4 (21.1%)	1 (5.3%)
	- Recognition of physical activity and exercise participation or achievements.	1 (5%)	3 (15.8%)	1 (5.3%)
	- Participation in community physical activity events (e.g., 5Ks, mud runs, firefighter challenges, 9/11 stair climbs).	0 (0%)	2 (10.5%)	2 (10.5%)

The fire department has a social climate that encourages...Consider what is encouraged or happens in day-to-day department life, regardless of formal policy.				
Social Climate (Department culture)	-Active commuting to work (personally supported by peers).	0 (0%)	3 (15.8%)	1 (5.3%)
	-Regular use of fitness equipment.	18 (90%)	14 (73.7%)	11 (57.9%)
	-Standing desks in officer/administrative spaces (used in practice).	1 (5%)	0 (0%)	2 (10.5%)
	-Walking meetings when appropriate.	0 (0%)	0 (0%)	0 (0%)
	-Standing meetings (e.g., briefings, check-ins, informal meetings)	0 (0%)	1 (5.3%)	0 (0%)
	-Use of on-site fitness facilities.	17 (85%)	16 (84.2%)	14 (73.7%)
	-Exercise during designated time, between calls, or before/after work (actual practice).	15 (75%)	17 (89.5%)	11 (57.9%)
	-Use of local fitness and/or recreation facilities.	1 (5%)	3 (15.8%)	5 (26.3%)
	-Participation in community physical activity events (e.g., 5Ks, mud runs, firefighter challenges, 9/11 stair climb).	1 (5%)	6 (31.6%)	5 (26.3%)
	-Participation in job-related physical tasks or hands-on training as an option when traditional exercise isn't feasible.	4 (20%)	11 (57.9%)	11 (57.9%)
Does your fire station have the following facilities to support active transportation?				
Indoor Environment	-Safe bike lock ups (e.g., bike room, bike racks or rails, bike cages, bike lockers).	5 (25%)	1 (5.3%)	1 (5.3%)
	-Shelters or covers if outside.	2 (10%)	3 (15.8%)	0 (0%)
	-Shower and change room facilities.	18 (90%)	19 (100%)	18 (94.7%)
	Lockers or storage facility.	15 (75%)	18 (94.7%)	18 (94.7%)
Does your fire station have the following exercise supports...				
	-Fitness equipment	20 (100%)	19 (100%)	18 (94.7%)
	-Variation in the types of equipment (e.g., various skill or	17 (85%)	14 (73.7%)	16 (84.2%)

	fitness levels, body types, goals, or preferences).			
	-Designated space or room for exercise.	19 (95%)	19 (100%)	11 (57.9%)
	-Equitable access to fitness equipment and facilities across all stations.	15 (75%)	17 (89.5%)	8 (42.11%)
	-Formally or informally allow personnel to access fitness areas outside of designated workout times (e.g., before/after shifts or off duty).	16 (80%)	15 (78.9%)	9 (47.4%)
	-Flexible spaces for warm-ups, mobility, recovery, and equipment stowage (e.g., portable equipment that can be moved and used in different parts of the station).	14 (70%)	12 (63.2%)	14 (73.7%)
	-Shower and change room facilities.	20 (100%)	18 (94.7%)	18 (94.7%)
	If the fire station has an indoor exercise space, is it (select all that apply):			
	-Equipped with cardio machines (e.g., treadmills, bikes, ellipticals).	20 (100%)	19 (100%)	18 (94.7%)
	-Equipped with strength training equipment (e.g., free weights, kettlebells, resistance machines).	20 (100%)	19 (100%)	18 (94.7%)
	-Spacious enough to support multiple personnel working out simultaneously.	11 (55%)	15 (78.9%)	10 (52.6%)
	-Well-maintained and clean.	18 (90%)	17 (89.5%)	12 (63.2%)
	-Temperature controlled, well-ventilated.	19 (95%)	18 (94.7%)	12 (63.2%)
	-Appealing to use.	8 (40%)	9 (47.4%)	7 (36.8%)
	-Used regularly by personnel.	19 (95%)	19 (100%)	14 (73.7%)
	-Safe and secure (e.g., good lighting, locked when not in use).	17 (85%)	17 (89.5%)	12 (63.2%)
	-Equipped with mats or space for stretching/bodyweight exercises.	18 (90%)	16 (84.2%)	9 (47.4%)
Community Assets & Partnerships				
Outdoor Environment	The fire station is located in an area that... Focus on the outdoor environment surrounding your fire station.			

	-Is safe from crime.	17 (85%)	19 (100%)	14 (73.7%)
	-Is safe from automobile traffic and active transportation commuters (e.g., speed, volume, driveways, crosswalks).	16 (80%)	13 (68.4%)	5 (26.3%)
	-Has universally accessible sidewalks (i.e., well paved, cleared of any snow or debris, free of obstacles or construction in path, well lit).	20 (100%)	13 (68.4%)	10 (52.6%)
	-Has enough sidewalks or other pedestrian walkways for a 10-minute walk.	18 (90%)	11 (57.9%)	6 (31.6%)
	-Allow outdoor or informal spaces available for physical activity or exercise (e.g., parking lots or driveways for drills/workouts, open spaces, walking paths, playing fields, or courts).	18 (90%)	16 (84.2%)	14 (73.7%)
	-Is aesthetically pleasant (e.g., presence of trees, shrubs, clean, graffiti-free).	15 (75%)	16 (84.2%)	12 (63.2%)
	-Includes job-relevant facilities for physical training (e.g., training towers, drill yards, outdoor equipment).	13 (65%)	3 (15.8%)	7 (36.8%)
	-Relies primarily on off-site resources for exercise (e.g., community recreation or fitness centers, parks or trails).	4 (20%)	1 (5.3%)	7 (36.8%)
Partnerships	Does the fire department collaborate with or have partnerships with community-based facilities or services to provide opportunities for exercise?	1 (5%)	8 (42.1%)	3 (15.8%)
	Does the department use information or resources from outside sources (e.g., International Association of Fire Fighters, Centers for Disease Control, Fire Rescue Fitness) for promotion, programming, or policies related to exercise?	2 (10%)	5 (26.3%)	8 (42.1%)
<i>Programs & Policies</i>				

Does the department offer or support firefighter participation in the following programs, either within the department or through external partners?				
Programs	-Group exercise classes (e.g., CrossFit, cycling, fitness, swimming, yoga).	2 (10%)	3 (15.8%)	2 (10.5%)
	-Organized clubs, groups, sports teams, or events (e.g., running clubs, walking groups, bike-to-work days, department-sponsored recreation leagues).	0 (0%)	3 (15.8%)	0 (0%)
	-Programs that support exercise with family members.	1 (5%)	2 (10.5%)	1 (5.3%)
	-Activities, competitions, and/or challenges that promote exercise and/or physical activity (e.g., inclusive activities such as step challenges, completing workout logs).	4 (20%)	3 (15.8%)	0 (0%)
	-Access to professional support such as active living counseling, online programs, and/or professional fitness coaching.	4 (20%)	2 (10.5%)	0 (0%)
	-Programs that support firefighters with different needs, fitness levels, interests, ages, or injury status in their participation in exercise.	1 (5%)	3 (15.8%)	1 (5.3%)
	-Tools to track personal exercise progress and accomplishments (e.g., wearable devices, digital or physical workout logs, goal setting).	1 (5%)	0 (0%)	0 (0%)
	-Prompts and reminders to exercise and be active (e.g., software notifications, station signage encouraging movement throughout shifts).	2 (10%)	3 (15.8%)	3 (15.8%)
Does your fire department have the following policies?				
Policies	-Officers are recognized for supporting exercise (e.g., staff and team recognition).	1 (5%)	1 (5.3%)	3 (15.8%)
	-Firefighter personnel are recognized for participating in exercise (e.g., staff and team recognition).	1 (5%)	2 (10.5%)	2 (10.5%)

-Fire department wellness benefits exist to financially support exercise (e.g., stipend for exercise clothes or shoes, discounted or fully funded gym memberships, or paid fitness coordinator/liaison).	4 (20%)	6 (31.6%)	4 (21.1%)
-Status reports of exercise initiatives are reported to command staff or city administration (feedback from personnel is provided to command staff or upper leadership).	1 (5%)	2 (10.5%)	1 (5.3%)
-Policy statements exist supporting exercise in the department (e.g., dress down, designated or flexible time).	15 (75%)	12 (63.2%)	14 (73.7%)
-The department has policies supporting inclusive and accessible exercise opportunities.	12 (60%)	11 (57.9%)	10 (52.6%)
-Exercise policies address variations in personnel's operations (e.g., shift work, training, daily tasks).	12 (60%)	11 (57.9%)	9 (47.4%)
-Financial and material resources are allocated for exercise in the budget (e.g., budget for new equipment, funding for wellness programs or events)	12 (60%)	1 (5.3%)	5 (26.3%)
-Sponsorship opportunities for department sports teams or events (e.g., walks, running races, or cycling challenges).	0 (0%)	0 (0%)	0 (0%)
-Incentive programs or recognition of exercise participation or achievements (e.g., free or subsidized gym memberships, compensatory time off, annual awards for top performers, department-wide challenges)	1 (5%)	1 (5.3%)	3 (15.8%)
-Active transport initiatives (e.g., free or subsidized bus passes or tickets, bike share).	0 (0%)	0 (0%)	0 (0%)
-Personnel can engage in exercise during duty hours.	19 (95%)	18 (94.7%)	19 (100%)

-Firefighter personnel can engage in recreational sports during duty hours (e.g., team-based games or activities that the crew can play together, such as basketball, volleyball, or softball, within the station or on department property).	11 (55%)	14 (73.7%)	3 (15.8%)
-Firefighter personnel have annual health assessments.	20 (100%)	16 (84.2%)	19 (100%)
-Firefighter personnel have annual fitness assessments that adequately assess occupational tasks, including job-related physical ability tests (e.g., CPAT, annual SCBA drills) and other measures relevant to firefighter duties.	20 (100%)	3 (15.8%)	11 (57.9%)

Appendix Table C.3. Spearman's correlations (*r*) of FD-MES subdomains & physical activity.

Domain	Awareness & Education			Social Support			Organizational Support			Community Assets & Partnerships		Programs & Policies	
Sub-domain	Messaging	Communi- cation	Education	Coworker	Officer	Command Staff	Staff & Committees	Social Climate	Indoor Environ- ment	Outdoor Environ- ment	Partner- ships	Programs	Policies
SED	-.332*	-.131	-.136	-.260	-.129	-.110	-.213	-.202	-.225	-.295	-.061	-.131	-.329*
LPA	-.216	.017	-.170	.001	-.095	-.157	.048	-.275	.180	-.041	-.100	-.092	-.160
MPA	-.070	-.188	-.227	.258	.079	-.080	.286	-.095	-.158	.000	-.010	-.203	.009
VPA	-.031	-.057	-.106	.246	.074	.006	.048	.121	-.140	.090	-.047	-.184	.036
MVPA	-.059	-.135	-.182	.239	.041	-.020	.198	.028	-.180	.039	.023	-.170	.019

Note: * $p < .05$