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THE RELATIONSHIP BETWEEN PHYSICAL MOBILITY AND FIREFIGHTER OCCUPATIONAL TASK PERFORMANCE

by

SHELBY HARBISON

(Under the Direction of Bridget Melton)

ABSTRACT

BACKGROUND: Firefighters work in a dangerous profession with high injury rates. Mobility dysfunction in firefighters may impact performance and contribute to injury. The Functional Movement Screen (FMS) is commonly used to evaluate individuals for mobility dysfunction and compensatory movements. PURPOSE: Identify if mobility is related to firefighters' occupational task performance. METHODS: This was a retrospective study assessing 29 career firefighters using FMS and occupational performance task scores. Statistical analyses consisted of a multiple linear regression assessing predictors on the occupational task performance and 21 point-biserial correlations ran to assess the relationship between each individual predictor and occupational task performance. RESULTS: Of the 21 point-biserial correlation, four were found to be significant, indicating a relationship between the FMS and occupational task performance. CONCLUSION: Inline Lunge may be a key element in occupational task performance. Future research should evaluate the impact of mobility dysfunction on occupational performance in a larger and more diverse cohort of firefighters.

INDEX WORDS: Firefighter, Mobility, Occupational task, Tactical athlete, Functional movement screen

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CHAPTER 1

PURPOSE OF THE STUDY

This study's intent is to explore the potential relationship between mobility and firefighters' Occupational Performance. Specifically, mobility was measured by the Functional Movement Screen (FMS), and occupational performance was measured by time to complete a series of ground suppression tasks. This study aims to determine the relationship between the FMS and firefighters' occupational performance tasks.

How This Study Is Original

This study is working specifically with active-duty firefighters from a department in rural Southeast Georgia. All participants completed pre-assessment paperwork, including health history and informed consent. Participants were also cleared with a physical assessment consistent with standard practices (National Fire Protection Association (NFPA) 1583 standard) and by the fire department's medical physician to participate. All participants completed an occupational task consistent with NFPA 1584 guidelines created and designed for this department's annual training. All participants also completed the FMS and were evaluated by certified personnel.

CHAPTER 2

INTRODUCTION

Firefighters are known for working in an intense, chaotic, and dangerous profession (Ensari et al., 2017; Smith, 2011). They protect the public while enduring physical tasks, toxic fumes, and encountering fires of all sizes and magnitude (Karter, & Molis, 2010; Smith, 2011). In addition to fighting fires, they are the first responders in rescues and emergency medical calls (Smith, 2011). Approximately 65,000 firefighters are injured on the job annually due to the dangerous conditions they work in and the toll it can take on the body (Campbell, & Evarts, 2021).

Firefighting is physically demanding on the body, relying heavily on their ability to maintain their bodies physically. Common firefighting tasks include stair climbs, forcible entry in buildings and vehicles, body carry, and treating the injured (Smith, 2011; U.S. Bureau of Labor Statistics, 2021). Firefighters work under an urgent timeframe, with limited visibility, and often in dangerous situations like collapsing floors with exposure to flame and smoke (Smith, 2011; U.S. Bureau of Labor Statistics, 2021). Additionally, firefighters' tasks are performed while wearing standard firefighting gear, adding approximately 45lbs. and restricting movement (U.S. Bureau of Labor Statistics, 2021).

Firefighters need various physical skills to perform their jobs safely. Firefighting requires aerobic and anaerobic conditioning to maintain continuous work on the fire scene; muscular endurance and strength to lift and carry tools or victim(s); and mobility for all occupation tasks (Smith, 2011). Mobility is essential for lowering the down to pick up equipment such as chainsaws, maintaining a half-kneeling hose suppression, or crawling on the ground for victim searches. Firefighters have to maintain an appropriate fitness level to complete these occupational tasks safely. Furthermore, when firefighters are exposed to dangerous tasks in less-than-ideal situations, it further challenges their physical and mental fitness, potentially hindering their work (Kesler et al., 2018).

Additionally, firefighters' Personal Protective Equipment (PPE) can impede their mobility; PPE have been shown to decrease firefighters' ability to function and increases their risk of slipping, tripping, and falling (Park et al., 2015; Vu et al., 2017). Although firefighters' train in turnout gear to become accustomed to the lack of mobility and ensure proper task performance, research has found that the self-contained breathing apparatus (SCBA) gear hinders some firefighters' upper trunk and neck movement and boots obstruct ankle mobility (Park et al., 2015).

The FMS is a mobility tool that screens individuals in a dynamic and functional capacity, more specifically in muscular and flexibility imbalances for injury and performance predictability. (Cook et al., 2006; Gribble et al., 2013). There are eight movements that are part of the screen that require stability and mobility movement patterns (Cook et al., 2006; Functional Movement Systems, 2021). These movements allow the tester to evaluate asymmetries, compensation, and overall functional mobility deficits (Gribble et al., 2013). The movement screen is ideally performed prior to competition to decrease the risk of injury (Cook et al., 2006). The FMS has been widely used in varying athletic populations to evaluate the risk of injury. Studies have found that individuals with a total score of ≤ 14 out of 21 possible points are at a greater risk of injury (Dempsey et al., 2013; Gribble et al., 2013; O'connor et al., 2011; Lehr et al., 2013; Kiesel et al., 2007). These studies were implemented in settings such as police, collegiate athletes, and the military investigating FMS and its effect on identifying those predisposed to injury. However, there is limited research investigating the impact of limited mobility on occupational tasks related to fire service.

This study aimed to better understand the relationship between firefighters' mobility and how it affects their occupational tasks. Firefighters inevitably perform in dangerous situations and cannot afford to have a hindrance in mobility, whether it be from gear or lack of functional movement. (Park et al., 2015; Vu et al., 2017). There are other professions with similar research that have found positive results between the FMS assessing mobility and occupational tasks such as military and law enforcement (Bock et al., 2016; Dempsey et al., 2013). Currently, there is limited research on how firefighters' mobility affects their occupational performance (Michaelides et al., 2011).

Purpose

The purpose of this study was to investigate the relationship between firefighter mobility as assessed with the FMS and occupational task performance test.

Research Question and Hypothesis

Research Question 1: Does FMS Total score influence time to complete Occupational Task Performance Test?

H.O.: There is no correlation between FMS total Score and performance time.

H1: The higher the FMS score, the better performance on the occupational task performance test.

Research Question 2: Is there a relation between asymmetries in the FMS and the Occupational Task Performance Test?

H.O.: No relation between those without asymmetries and the Occupation Task Performance Test.

H1: The presence of asymmetries in the FMS, the lower the Occupational Task Performance Test.

Research Question 3: Does one of the FMS elements have a stronger relation to the Occupational Task Performance Test?

H.O.: There is no significant correlation between any of the FMS elements and the occupational test.

H1: There is a significant correlation between the FMS elements and the occupational performance

CHAPTER 3
METHODS

Design/Participants-

This study was a retrospective study design with a convenience sample and investigated the relationship between firefighter's movement quality via (functional movement screen) and occupational task performance (e.g., quick dress, forcible entry, high rise pack and tool, carrier, stair climb, hose drag, fire attack, victim search, victim drag, and ladder throw) in full gear (~22.5 kg). This study was part of a larger-scale longitudinal wellness firefighter project.

Twenty-nine career firefighters from rural, Southeast Georgia volunteered to participate in the study. Demographic and anthropometric values of the firefighters can be seen in Table 1. A convenience sample was utilized, and the subjects were contacted with the permission of the deputy chief, and they were informed of the benefits, risks, and purpose of the study. To be considered eligible for participation, individuals had to be a full-time active-duty firefighter in the department and older than the age of 18 years. Exclusion criteria entailed any musculoskeletal injuries that prevented normal job function within the previous six months. Participants were then consented to use their existing data in a de-identified format. All methodologies used in the study were approved by the university's institutional review board, approval number H19098.

Protocol-

For this study, coded data were extracted from existing occupational training and physical testing measures. The data were pulled from the department's March 2020 fitness assessment testing date. Occupational task performance time was pulled from an in-service training session in June 2020. The sample fire department follows the National Fire Protection

Association's guidelines 1583 (NFPA 2015) for annual fitness assessments, with the addition of a supplemental movement screen. Both measures will be explained below. Data were extracted by a participant code, and no identifying information was provided to the researchers.

Measures/Instruments-

Occupational Task Performance Test

As part of the routine fire ground training, the firefighters completed seven tasks that simulated 15 minutes of on-scene fire duties. A team of commanding training officers designed the seven-task course with standard measures and equipment for content validity and reliability (National Fire Protection Association, 2015). On average, firefighters completed this performance test in about 9 minutes. Total time to complete, average heart rate, and highest heart rate were all recorded.

Firefighters were fitted with a Polar H10 Heart Rate Sensor, and heart rate was monitored for the entirety of the task with the Polar Beat smartphone application. Medical professionals were present each day for the simulation—detailed descriptions of the following stations in Figure 1.

Station One, "Quick Dress" Firefighters individually arranged their gear ahead of time with their usual setup. After getting dressed, they then walked 21.3m to the next station while putting on their gloves.

Station Two, "Forcible Entry": Firefighters picked up a (4.8 or 5.4kg*), (76.2 or 91.4cm*) Halligan tool and went to the door simulator. The door was supported by 2 wooden dowels and 4 wooden shims. Once through the door, firefighters put on the air-pack, grabbed their equipment (Halligan tool and high-rise pack), and walked 26m to the next station.

Station Three “Stair Climb”: Firefighters ascended and descended three flights of stairs while carrying their equipment. They then walked 21.3m to a cone where they dropped their equipment then walked another 26m to station four.

Station Four “Fire Attack”: Firefighters had three 4.45cm diameter hose stretches where they completed three different patterned streams: O, T, and Z. Streams were aimed at cones 15.2m away from the hydrant, with 9.1m separating each cone. Following this, firefighters also performed a full, 30.5m hose stretch.

Station Five “Crawl to Body Dummy Carry”: Firefighters started at the end of the fully stretched hose, crawled 15.2m down the hose to a body dummy, they then carried the dummy to the end of the hose 15.2m. They unclipped and set down their regulator following this task.

Station Six “Farmers Carry”: Firefighters carried two kettlebells (24kg) 22.9m to a cone, set the kettlebells down, and then walked 7.6m to the next station.

Station Seven “Ladder Raise”: Firefighters carried a 4.3m ladder 15.2m and raised it against a shipping container. Once the ladder was in place, the occupational task was completed and recorded their time.

Figure 1. Occupational Task

Station	**Occupational Task**	**Description**
0	Simulated Fire Attack	Firefighters were instructed to treat the simulated fire attack as a real fire. Firefighters HR’s were measured during the attack.
1	Quick Dress	Firefighters dressing as quickly as possible in full bunker gear. Dressing included boots, hood, pants, jacket, mask, helmet, a (SCBA) air pack, and gloves.
2	Forcible Entry	Firefighters were instructed to pick up the Halligan tool and force open the secured door. Once the door was opened firefighters were instructed to clip in the SCBA regulator, high rise hose pack, and walk through the door.

3	Stair Climb	Firefighters ascend 3 flights of stairs to the fourth floor while carrying high rise pack and Halligan tool. After reaching the top they descend the stairs to the bottom floor where they dropped the gear.
4	Fire Attack	Firefighters started at a fire hydrant and did 3 hose stretches with patterns: O, T, and Z. After completing each attack firefighters were instructed to return and touch the starting hydrant. They finished the attack with a full hose carry.
5	Crawl to Body Dummy Carry	Firefighters performed a quadrupled crawl 15.2m and then carried a body dummy(75kg) 15.2m.
6	Farmers Carry	Firefighters carried 2 24kg kettlebells 22.9m to a cone.
7	Ladder Raise	Firefighters carried a ladder 15.2m and then raised it against a shipping container.

** Abbreviations: SCBA- Scott self-contained breathing apparatus,

Functional Movement Screen (FMS)-

During the 2020 annual physical assessments, certified FMS professionals performed the Functional Movement Screen (FMS). Eight fundamental movement patterns make up the FMS: deep squat, hurdle step, in-line lunge, shoulder mobility, active straight leg raise, trunk stability push-up, rotary stability, and ankle mobility; these are further explained in Figure's 1, 2, and 3. These patterns assess basic motor tasks in locomotive, stabilizing, and manipulative movements (Cook, G. et al., 2006). The FMS allows the tester to screen to see if the individual had any impaired movements that may need further medical evaluation or corrective exercises to improve mobility, activation, or motor control as prescribed by a performance specialist (Functional Movement Systems, 2021).

Figure 2. Functional Movement Screen

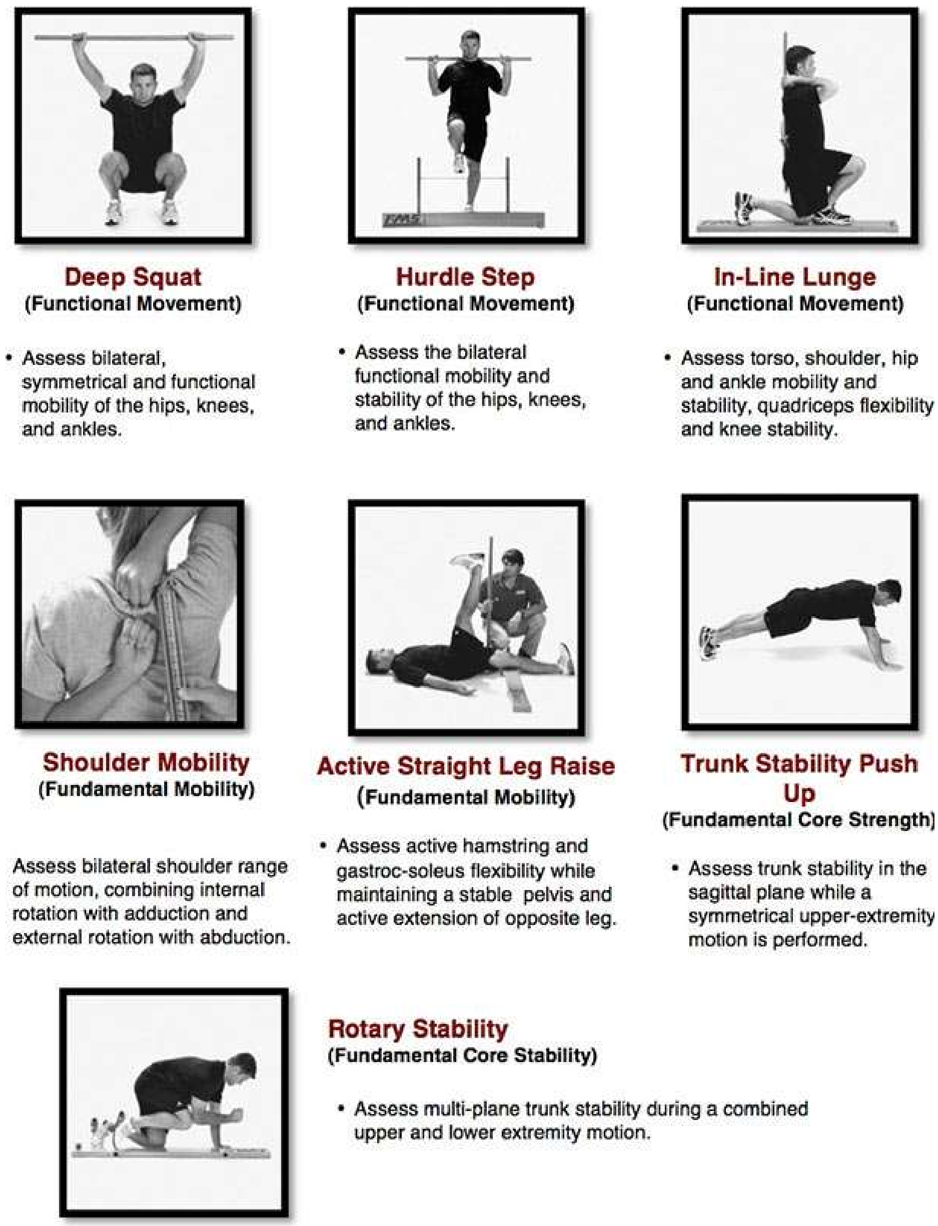

Figure 3. Functional Movement Screen-Ankle

The FMS is scored based on four score outcomes 0-3: 0 indicates pain (individuals are then referred out to the appropriate medical professional; 1 is considered poor (individuals should work with a performance specialist); 2 is good; and 3 is excellent; the highest achievable score is 21. In 2019 ankle mobility was added to FMS and is recorded as green, yellow, and red, with red and yellow indicating the need for improvement (Functional Movement Systems, 2021). The FMS has shown strong results with athletes' injuries and their FMS scores (Kiesel et al., 2007). Previous research has indicated a score below 14, could increase one's risk of injury (Butler et. al., 2013; Chorba et al., 2010). Asymmetries are the difference between the right and left sides of the body and could also increase one's risk of injury (Mokha et al., 2016). Participants are allowed to have up to 3 attempts on each movement pattern; the highest score is recorded.

Additionally, basic demographics were also extracted, including height, weight, age, and years of service.

Data Analysis-

All data were analyzed using SPSS Version 25.0 (IBM Corp., Armonk, NY). Each variable is presented as mean ± *SD* for each condition. Multiple linear regression analysis was utilized to answer research questions one and two. For question one, the independent variables are total FMS score, age, BMI, and max heart rate, categorized as continuous variables. For question two, the independent variables are asymmetries, BMI, and age and are continuous variables. The third research question was analyzed using point-biserial correlation with all the elements being continuous. All the individual FMS elements, including left and right sides, were analyzed individually, and a total combined score for each element will be analyzed. For all three research questions, the dependent variable was continuous and labeled as Occupational Task Time recorded in seconds. All data were analyzed retrospectively.

CHAPTER 4

RESULTS

Characteristics

A total of 29 male rural Southeast Georgia firefighters completed the FMS test and the Occupational Performance Task. Their descriptive statistics are presented in Table 1 by mean and Standard Deviation (S.D.). Not all the firefighters disclosed their years of fire service, with 22 of the 29 reporting. The age ranged from 23 to 50 years old with an average age of 35.1 years and SD of 5.5 years. The average number of years in fire service was 11.11, with a SD of 7.16.

Functional Movement Screen Composite Score

A multiple linear regression model was run to test the effect of age, BMI, max heart rate, and FMS total score on occupational total task time. The overall regression was statistically significant ($F(4, 24) = 3.90$, $R^2adj = .29$, $p=.014$). Age had a statistically significant effect on occupational task time ($\beta = 7.44$, $p=.01$). BMI, max heart rate, and FMS total score did not have a statistically significant effect on occupational task time (p = .13, .07, and .94, respectively). Regression coefficients and their standard errors are displayed in Table 2.

Functional Movement Screen Asymmetries

Another multiple linear regression was run to predict occupational total task time compared to age, body mass index (BMI), and asymmetries. This multiple regression was different than the first regression by removing max heart rate and FMS total score and adding asymmetries to the independent variables. The overall regression was statistically significant ($F(3, 25) = 3.61$, $R^2adj = .22$, $p=.027$). Age had a statistically significant effect on occupational total task time ($\beta = 5.8$, $p=0.02$). BMI and Asymmetries did not have a statistically significant effect ($p = 0.21$ and 0.75, respectively). Asymmetries had a 95% confidence interval with a lower bound of -103.34 and an upper bound of 75.65. Regression coefficients and their standard errors can be found in Table 3.

Functional Movement Screen Elements

A point-biserial correlation was run to determine the correlation between all the FMS individual movements and occupational task time. There are a total of twenty-one point-biserial correlations run which were divided into 8 tests separated by left, right, and combined. For example, “Hurdle Step” is one element that was separated into Hurdle Step Left(L), Hurdle Step Right(R), and Hurdle Step combined. Of the twenty-one correlations, four were found significant with three of them being significant at the < 0.05 level and one at the 0.001 level. Inline Lunge L had a negative correlation with occupational task time and was statistically significant (r_{pb}= -0.46, n = 29, p = 0.012). Inline Lunge Combined had a negative correlation of moderate strength (r_{pb}= -0.523, n = 29, p = 0.004). Shoulder Mobility L had a negative correlation of moderate strength (r_{pb}= -0.445, n = 29, p =0.016). Inline Lunge R had a negative correlation of moderate strength (r_{pb}= -0.583, n = 29, p = 0.001). The remaining 17 correlations were not found to be statistically significant. Table 4 displays the information regarding the correlations between the FMS individual elemental tests and occupational task time.

Table 1. Characteristics of study participants

	n	mean ± S.D.
Height (cm)	29	181.57 ± 5.50
Weight (kgs)	29	98.17 ± 18.50
Age (yrs)	29	35.1 ± 8.77
BMI	29	29.82 ± 5.87
Years Fire Service	22	11.11 ± 7.16

Table 2. Regression Analysis FMS Total Score

Variable	*B*	95% CI for *B*	β	t	P
Age	7.44	[2.44,12.44]	0.56	3.07	0.01
BMI	6.22	[-2.03,14.67]	0.31	1.56	0.13
Max Heart Rate	3.6	[-.32,7.52]	0.35	1.9	0.07
FMS Total Score	-0.57	[-16.71,15.57]	-0.01	-0.07	0.94

Note: *B* = unstandardized regression coefficient; CI = confidence interval; β = standardized regression coefficient; R^2adj = 0.29 (N = 29, p = .014)

Table 3. Regression Analysis FMS Asymmetries

Variable	*B*	95% CI for *B*	β	t	P
Age	5.8	[1.05,10.57]	0.44	2.51	0.02
BMI	4.5	[-2.68,11.67]	0.23	1.29	0.21
Asymmetries	-13.85	[-103.34,75.65]	-0.05	-0.32	0.75

Note: *B* = unstandardized regression coefficient; CI = confidence interval; β = standardized regression coefficient; R^2adj = 0.22 (N = 29, p = 0.027)

Table 4. Point-Biserial Correlation between FMS Elements and occupational task time

FMS Tests	Pearson Correlation	Sig. (2-tailed)
Deep Squat	-0.019	0.923
Hurdle Step L	-0.13	0.502
Hurdle Step R	-0.141	0.467
Hurdle Step Combined	-0.13	0.502
Inline Lunge L	-0.46	**0.012***
Inline Lunge R	-0.583	**0.001****
Inline Lunge Combined	-0.523	**0.004***
Ankle Mobility L	-0.094	0.626
Ankle Mobility R	-0.176	0.362
Ankle Mobility Combined	-0.066	0.734
Shoulder Mobility L	-0.445	**0.016***
Shoulder Mobility R	-0.113	0.561
Shoulder Mobility Combined	-0.257	0.178
Active Straight Leg Raise L	-0.213	0.268
Active Straight Leg Raise R	-0.361	0.054
Active Straight Leg Raise Combined	-0.283	0.138
Trunk Stability Push-up	-0.094	0.628
Rotary Stability L	-0.089	0.647
Rotary Stability R	0.069	0.721
Rotary Stability Combined	-0.075	0.7

Sig.: **bold**, **bold*** $p < 0.05$, **bold**** $p < 0.001$

CHAPTER 5

DISCUSSION

The study aimed to understand if mobility is related to firefighters' occupational task time. Previous research established that firefighters often have limited mobility and may be subjected to injury (Dempsey et al., 2013 & Gribble et al., 2013). The FMS test was designed to identify predisposing mobility hindrances that could lead to injury (Cook et al., 2006; Gribble et al., 2013).

This study hypothesized that there would be a significant effect of FMS score on the occupational task performance test. This study failed to reject the null hypothesis As FMS composite score was not significantly related to the completion of occupational task time ($p = 0.94$). There was no difference between those with a high FMS score and a low FMS score when completing the task. The overall multiple linear regression was significant ($p = 0.014$). Therefore, changes in the independent variables were correlated with a shift of the dependent variable. Potential reasons we did not find significance in the FMS scores and task time could be attributed to a lack of diversity in FMS scoring. The firefighters in this study were considered averagely mobile, scoring mainly 2's in all FMS tasks. It is also possible these firefighters were influenced by corrective exercises prescribed after their FMS assessment and may have influenced occupational task assessment since that was performed three months later.

Although the overall FMS score was not related to task performance, some of the individual elements were found to be significant in relation to the occupational performance task time including the Inline Lunge L, Inline Lunge combined, Inline Lunge R, and Shoulder Mobility L. This means those that had a higher score on the Inline Lunge task were able to complete their occupational task faster than those with a lower score. Inline lunging typically happens when lowering our center of mass oftentimes during deceleration, directional change, and dynamic squatting (Functional Movement Systems, 2021). During the occupational task, firefighters were required to perform inline lunge movements when picking up tools, transitioning from the ground to standing, pulling the firehoses, or stopping after running to each station. If the firefighters were insufficient at inline lunge movements, they likely relied on compensatory movement patterns, which could explain slower times in the occupational performance task (Cook et al., 2006; Functional Movement Systems, 2021). Similar to the current study Lisman (2013) also found Inline Lunge to be significant when comparing it to the Marines Physical Fitness Test (PFT) (Lisman et al., 2013). This study looked at individual components of the PFT and the FMS and found that Inline Lunge was the only FMS component with a significant correlation similar to the current study. This could be due to similar tactical populations and tasks required. Corrective exercises geared towards the Inline Lunge may potentially decrease occupational task time. These exercises should target static and dynamic motor control patterns such as half-kneeling step up, toe touch progression, split squat, leg lock bridge, etc. (Functional Movement Systems, 2021). Further research is warranted on the effectiveness of target mobility exercises to improve occupational tasks.

Apart from the Inline Lunge, L shoulder mobility was also found to be correlated with the occupational task time. Most of the firefighters in the department reported being right-hand dominant; this could be the reason for only having one shoulder to correlate. The FMS shoulder test assesses the shoulder in dynamic stability and balance and the inability to correctly perform the test has been shown to increase the risk of injury (Sprague et al., 2014). This test also considers asymmetries and their effect on an increase in injury suggesting an underlying impairment. Poor movement could stem from thoracic spine, scapula, or neck limitations as well as just the shoulder joint impairments. The FMS test does not focus solely on the glenohumeral portion of the shoulder, but an integrated look at a reaching pattern (Functional Movement Systems, 2021). Therefore, the FMS should be completed fully, and one portion of the test cannot draw conclusions for lack of mobility and asymmetries cannot be completely determined (Functional Movement Systems, 2021; Sprague et. al, 2014). Firefighters' do perform all fire suppression tasks in turnout gear – limiting thoracic mobility, scapular, and neck movements (Park et al., 2015). Therefore, the hinderance in mobility specifically in one shoulder could potentially be due to a dominant arm having increased range of motion (ROM), carrying gear solely on that side, or wearing excess gear that further limits motion and further research should be conducted to confirm. To improve ROM and mobility firefighters should focus on corrective exercises geared towards both shoulders and not focus on one sided movement patterns. These exercises can consist of breathing techniques, scapular and thoracic rotation, flexion, and extension, and abdominal strengthening (Functional Movement Systems, 2021).

This study also investigated if asymmetries in the FMS lowered the occupational performance task time. We failed to reject this null hypothesis with a significance level of $p = 0.75$. Firefighters with asymmetries had similar times during the occupational performance task as those without asymmetries. Chapman (2014) also evaluated asymmetries, however, they studied athletes over a longitudinal period with corrective exercises prescribed in-between testing (Chapman et al., 2014). They found those that who without asymmetries improved in their performance compared to those that had one or more asymmetries (Chapman et al., 2014). Our study's analysis showed the population had too much variability with a larger than expected confidence interval ranging from -103.34 to 75.65. This created difficulty in establishing conclusions and could explain why there was no significance in asymmetries and task time. To lower the variability and to draw a further conclusion a larger population sample is needed to confirm the hypothesis.

Age was found to be significant in both multiple linear regression models. In relationship to the total score, it was found the older the individual had slower occupational task time by .56 seconds. We expected this correlation noting the dissipation firefighting puts on an individual's body. Research has also found this to be significant in terms of body fat. Saupe found as early as 1991 that the older the firefighter, the more their mobility decreased and their body fat increased (Saupe et al., 1991). Another study found age and BMI affected performance in certain firefighting tasks similar to what this current study investigated (Kleinberg et al., 2016). The average age of the firefighters was 35.1, and the average number of years in fire service was 11.11.

To our knowledge, this study is unique and is the first to explore if firefighters' mobility is related to their occupational tasks. Our study is not congruent with previous research. Our study does not have the strength in data to support this in relation to the occupational task, most likely due to the small sample size. The majority of studies thus far have focused on FMS and its relationship of lower scores and injury (Bock et al., 2016; Chorba et al., 2010; Dempsey et al., 2013; Gribble et al., 2013; O'connor et al., 2011; Lehr et al., 2013; Kiesel et al., 2007).

Chobra (2010) found that compensatory movements could increase the risk of injury in female athletes, specifically in soccer, volleyball, and basketball at the Division II level (Chorba et al., 2010). This was identified using the FMS two weeks prior to the athletes starting their seasons. FMS scored ≤ 14 points were considered dysfunctional. This study differs from the current study in application of the FMS test. Our study was designed to be exploratory and utilized individual scores per FMS guidelines, whereas the majority of studies utilized the alternative method interested in injury prevalence (Kiesel et al., 2007; O'connor et al., 2011). Chobra (2010) also followed the participants and tracked injuries throughout the season, whereas the current study did one FMS test and one mobility test without follow-up (Chorba et al., 2010).

More similar to our study on the tactical population and occupational task is Bock (2016). In this study 53 police recruits completed different tasks such as marksmanship, defensive tactics, baton strikes, tactical options, as well as the FMS. Major differences identified were that we measured our occupational task in time, whereas they did individual tasks measured by a score (Bock et al., 2016). They also conducted their FMS scores as pass/fail, whereas we measured by collecting individual scores per FMS guidelines. This study had no significant findings that were congruent to previous research that suggests poor movement patterns predict poor occupational performance tasks.

Limitations

There are multiple limitations which must be considered in the current study. The first is this study was conducted using retrospective data from a convenience sample of rural firefighters. This study also had a small sample size which means that this study may not have been adequately powered to be able to draw conclusions or generalize on the current firefighting population. If a larger sample size had been utilized; this study may have been able to draw further conclusions. Another limiting factor was that the FMS is designed to best assess those with poor movement patterns and was utilized to assess healthy and active firefighters with average movement patterns. This study also assumes that the participants put forth full effort in the FMS and during the occupational task. Future research should sample larger cohorts to strengthen their data and potentially be able to draw conclusions.

CHAPTER 6

CONCLUSION

Firefighting is a dangerous profession, and there is a need to mitigate potential injuries. Research has shown the FMS can easily be utilized for injury prevention and performance predictability by identifying pain and poor movement patterns. Previous FMS research has suggested lack of mobility can lead to the potential for injury and poor performance in athletic populations. It is evident that Inline Lunge may be a key element in the occupational performance task. Correctives focusing on deceleration and dynamic squatting may improve the occupational task. Future research should strive to increase the sample size to draw further supported conclusions.

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APPENDIX A

CRITICALLY APPRAISED TOPIC

Sports Medicine Approach Embedded into the U.S. Military

Abstract:

Clinical Scenario: Research has shown U.S. Soldiers do not report their injuries. Soldiers do not report their injuries because they do not want a profile, the negative perceptions of injury reporting, and the inconvenience of injury reporting. Injury reporting is a common hindrance in the military and a solution is needed to rectify the problem at hand.

Clinical Question: Is the embedded provider approach an effective approach for the Military?

Summary of Key Findings: The most recent and up to date literature was utilized to draw conclusions in this study including one randomized controlled trial, two cross sectional studies, and an observational cohort study. All four studies found the embedded provider approach to be beneficial and all studies met the required inclusion criteria.

Clinical Bottom line: Based on the findings from this appraisal, the embedded provider approach is a beneficial tool for healthcare in the military.

Strength of Recommendation: Level 2 evidence is given to this CAT from the established research with one randomized controlled trial, two cross sectional studies, and an observational cohort study.

Keywords: military, sports medicine, embedded providers, athletic training, musculoskeletal

CLINICAL SCENARIO:

There are 1.6 million injuries in the United States military each year, with the majority of these injuries being musculoskeletal.[1] This number is reported injuries, excluding injuries that go unreported. Musculoskeletal injuries(MSKI) are classified as anything involving muscle, tendon, nerve, ligament, and bone tissue.[2] The U.S. military has an ongoing problem with Servicemembers (SM) not reporting their injuries. Research shows that this is happening for a number of reasons, including the inconvenience of the reporting process, the perceived risk to the SM duty status such having a profile, or the SM doesn't find their injury serious enough to warrant getting it looked at.[3,4] The military cannot properly assess the problem at hand when SM dont report their injuries.

Traditionally in the military SM are expected to report their injuries within a military treatment facility or an outpatient clinic.[2] In these facilities, providers are able to track what kinds of injuries the SM are experiencing and allows providers to address future injuries from occurring. However, current research shows that SM do not want a an injury record (what would lead to a profile) in fear of having a negative impact on their military careers.[3] SM do not want to appear weak or inferior in their units by reporting an injury, especially if they think isn't serious.[4] Research has also shown the inconvenience in injury reporting has taken an extensive amount of time for some SM to receive treatment.[3,4] Apart from the traditional medical providers the military has begun utilizing separate personnel that specializes in MSKI.

Embedded providers can bridge the gap between SM and military medical personnel. Research is ongoing for the need of specialized providers in the military. Currently there is limited research conducted on the embedded provider approach. This Critically Appraised Topic(CAT) will assess the research currently addressing embedded providers in the military who specialize in MSKI injuries using the highest level of evidence available.

FOCUSED CLINICAL QUESTION:

Is the embedded provider approach an effective approach for the military?

SUMMARY of Search, 'Best' Evidence' appraised, and Key Findings:

- The research investigated was targeted towards studies that produced real findings with interventions and not solely rationale.
- All 4 studies showed positive data supporting the embedded provider approach
- All 4 studies met the inclusion criteria, including one cluster-randomized trial, two cross-sectional studies, and one observational cohort study.

CLINICAL BOTTOM LINE:

Based on the result of this appraisal, the embedded provider approach is a feasible and effective means to provide injury assessment and education to SM that address the limitations of traditional care including accessibility and time.

Strength of Recommendation:

Across all 4 studies there is consistent level 2 evidence to suggest the embedded provider approach was beneficial to the SM or the embedded provider. All studies analyzed suggested the embedded provider approach helped save time for the SM when having their injuries assessed.

SEARCH STRATEGY:

Terms used to guide Search Strategy:

- **P**atient/Client Group: Sports medicine team in military setting
- **I**ntervention: provide sports medicine sideline coverage to Servicemembers
- **C**omparison: N/A
- **O**utcome(s): Embedding a sports medicine team saves the Military money and provides faster care to Servicemembers

Sources of Evidence Searched (databases)

- Google Scholar
- PubMed
- Hand search
- CINAHL

INCLUSION and EXCLUSION CRITERIA (include search limits)
Inclusion criteria:

- Studies that assessed embedded sports medicine in the military population
- Limited to the English language
- Evidence 2 or higher

Exclusion criteria:

- Studies conducted outside of the United States due to differences in Military
- Studies conducted on a population other than the Military
- Studies that specified the need for embedded providers, but with no intervention

RESULTS OF SEARCH

The search yielded a total of 1510 possible peer-reviewed articles based on title and abstract alone. Three relevant studies that met inclusion criteria were identified and categorized as shown in Table 1 (based on Levels of Evidence, Centre for Evidence-Based Medicine, 2011)

Summary of Study Designs of Articles retrieved

Level of Evidence	Study Design/ Methodology of Articles Retrieved	Number Located	Author (Year)

1	Cluster randomized trial	1	Fisher et al. (2021)
1	Cross-sectional study	1	Radzak et al. (2020)
1	Descriptive cross-sectional survey	1	Rhon et al. (2010)
2b	Observational cohort study	1	Rhon et al. (2017)

BEST EVIDENCE

The following studies were identified as the 'best' evidence and selected for inclusion in the CAT. Reasons for selecting these studies were:

- All 4 studies analyzed the embedded provider approach in the Military setting
- All 4 studies have level 2 evidence or higher
- Studies met inclusion and exclusion criteria

SUMMARY OF BEST EVIDENCE

Characteristics of included studies

	Rhon 2010	**Fisher 2021**	**Radzak 2020**	**Rhon 2017**
Study Design	Descriptive cross-sectional survey	Cluster randomized trial	Cross-sectional study	Observational cohort study

Participants	U.S. Army clinicians deployed in Iraq or Afghanistan in support of Operation Iraqi Freedom (OIF) or Operation Enduring Freedom (OEF) who are part of the medical group in BCTs that PTs were assigned to from May 2006 through August 2007. 107 total participants 52 physicians, 52 non physician medical professionals.	Military recruits randomly assigned to 1 of 3 training squadrons, 2 control and 1 experimental, between January 2016 and December 2018. 20,810 recruits assigned to the intervention squadron at random. 35,590 recruits to the control squadrons at random.	53 athletic trainers who actively work in the Military setting or previously have worked in the military setting as a certified athletic trainer.	National Guard Soldiers from the 116th Cavalry Brigade Combat Team returning from a 1-year tour in Afghanistan that went through an expedited MSK screening process following reverse SRP in August of 2011 284 Soldiers screened.
Intervention Investigated	Survey with 3 topic questions categories completed via mail in.	One unit embedded multiple athletic trainers to diagnose and evaluate injuries establishing a sports medicine care model. The athletic trainers were the primary point of care working under the direction of a sports medicine doctor.	Web based survey with open and close ended questions. Recruited people responded via email and social media.	Survey filled out and placed into a bin away from healthcare providers.
Outcome Measure(s)	Outcomes were classified under:	Main outcome being	3 main outcomes were found: 1-	The 7 question survey was to

	diagnosis and treatment competency (questions 6–9), ancillary support to the healthcare team (questions 1–3 and 5), and impact on medical evacuations (questions 4 and 10).	musculoskeletal attrition. Secondary outcome being were all-cause attrition, other (non-musculoskeletal) medical attrition, mental health attrition, administrative attrition, referral to medical hold and Get Fit, on-time graduation, and change in Air Force Fitness Assessment.	found athletic trainers working in the Military environment who stated it was a rewarding job experience. 2-clinical and personal skills were of high importance when working with the Military. 3-multiple barriers present such as hiring time, lack of recognition, and military culture being a civilian/contracted employee.	assess patient satisfaction with the new SRP process. Patients were screened for MSKI injuries and then transferred to the appropriate medical team member immediately.
Main Findings	Physical therapists had high ratings in mission accomplishment, were considered musculoskeletal experts, and critical members of the ancillary care team. Their presence significantly decreased evacuation within and out of theater.	Recruits that were embedded with the athletic trainers had 25% less musculoskeletal injuries. This embedded unit saved over $10 million in relation to all cause attrition. It was crucial for the care model to work; the plan had to be supported by medical and Military leadership.	Athletic training in the Military is still producing newer positions and aren't always listed under ‘athletic trainer’ for people to find. Many of the athletic trainers stated that they were satisfied with the work they were doing in the Military and listed it as “rewarding”	Patients listed the highest level of care possible in satisfaction (5 on a scale of 1-5). Further information is needed to determine healthcare cost in savings and methods for improving efficiency.
Level of	1	1	1	2

Evidence				
Validity Score (if applicable)				
Conclusion	Providers with a long-standing history of combat medical management at level I and level II appear to esteem the value of a PT serving at this level of medical care. PT and medical providers at level I and II agree that collaboration between the two parties benefits the Soldiers quality and access to care.	The MSKI program care plan utilizing the embedded provider approach performed better than the original care given. This plan was so successful for this specific population because of the specialized people they included in the sports medicine model(i.e athletic trainers). Future research should tailor their team to the specific needs of their population.	Participants stated that each position was unique and required their own set of skills. Being a contractor or civilian in the military one of the many challenges is learning the chain of command and the way things are completed.	Patient satisfaction median score was the highest possible with exemplamotory. However, they didn't have a comparison group to make further conclusions.

IMPLICATIONS FOR PRACTICE, EDUCATION and FUTURE RESEARCH

Overall all four studies analyzed the embedded provider approach either from the Soldiers perspective or the medical professionals perspective. Additionally all four studies found the embedded provider approach to be beneficial and a positive experience. Fisher and Rhon 2017 looked at the Soldier specifically going through an intervention with embedded providers.[5,8] These studies created an alternative plan for care and reporting of injuries for the Soldiers. Soldiers had faster turn around in reporting their injuries and receiving care.[5,8] They also found an decrease in Soldiers lost duty days.[5]

Rhon 2010 and Radzak looked at the embedded providers specifically and how they affect the military.[6,7] They found that having the medical professionals available enhanced Soldiers' treatment and the embedded providers felt successful in the mission at hand.[6,7] They also found Soldiers felt completely satisfied in the care they were given from the embedded providers as well as the embedded provider feeling they were making a difference for the Soldiers.[6,7]

Limitations were present in these studies. First, there was bias in the recruitment process for participants in multiple studies. Second, these studies analyzed opinions on overall success of the embedded providers. Some had limited data in numbers to confirm this statement. Third, some studies did not have a direct comparison and could not provide data for SM who went through traditional military treatment. Finally, all studies indicated that there should be further research done on the long term effects of the embedded providers.

The results of the CAT suggested that the embedded provider approach was beneficial to the SM. Considering the limitations and when these studies were published further research should be conducted.

This CAT should be reviewed in 2 years to determine whether additional best-research evidence has been published that could aid in answering the focused clinical question.

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APPENDIX B

IRB APPROVAL

GEORGIA SOUTHERN UNIVERSITY
RESEARCH INTEGRITY

Institutional Review Board (IRB)
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To:	Melton, Bridget; Ryan, Greg; Klibert, Jeff
From:	Eleanor Haynes, Director, Research Integrity
Date:	4/9/2021
Current Expiration Date:	2/28/2022
Original Approval Date:	3/12/2019
Subject:	Status of Modification (#_4_) & Extension Request for Approval to Utilize Human Subjects in Research – Originally Approved by **Full Board Review**

After a review of your Extension & Modification Request for research project numbered **H19098**, and titled **"Physiological Profile of First Responders in Southeast Georgia,"** it appears that (1) the research subjects are at minimal risk, (2) appropriate safeguards are planned, and (3) the research activities involve only procedures which are allowable. You are authorized to enroll up to a maximum of _758_ subjects.

Therefore, as authorized in the Federal Policy for the Protection of Human Subjects, I am pleased to notify you that the Institutional Review Board has approved your extension and modification.

Modification description:

- **Addition of Jeff Klibert and Haresh Roshani as Co-Is. Addition of Thomas Nagel as a Research Assistant. Additionally, the updated COVID protocols and the expansion to regional recruitment has been approved.**

Please provide the IRB with any information concerning any significant adverse event, **whether or not it is believed to be related to the study**, within five working days of the event. In addition, if a change or modification of the approved methodology becomes necessary, you must notify the IRB Coordinator **prior** to initiating any such changes or modifications. At that time, an amended application for IRB approval may be submitted. Upon completion of your data collection, you are required to complete a *Research Study Termination* form to notify the IRB Coordinator, so your file may be closed.

APPENDIX C

SUPPORTING TABLE

DATA ANALYSIS TABLE FOR METHODS

Research Question	Null Hypotheses	Alternative Hypotheses	Independent Variable/s	Dependent Variable/s	Data Analysis
Demographics					Descriptive / Frequency
Does FMS Total score influence time to complete Occupational Task Performance Test?	There is no significant difference between...	There is a significant difference between …	Total FMS Score	Occupational Task Time	Multiple Linear Regression
Is there a relation between asymmetries in the FMS and the Occupational Task Performance Test?	There is no difference	There is a difference	Asymmetries	Occupational Task Time	Multiple Linear Regression
Does one of the FMS elements have a stronger relation to the Occupational Task Performance Test?	There is a stronger relation	There is no relation	FMS elements	Occupational Task Time	Point Bi-serial Correlation