Assessing the physical readiness of UK firefighters to return to work following injury: Developing a return-to-work tool.

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Summary of Thesis

In responding to emergencies, firefighters are exposed to physical and psychological stresses. Accordingly, firefighters are required to possess adequate levels of aerobic fitness, muscular strength, and endurance to cope with the physical demands of their job roles which include running, lifting ladders, carrying equipment and evacuating casualties. Due to these demands, the tasks of a firefighter are associated with an increased risk of work-related injury. Whilst national fitness standards have been created for firefighters in the UK, there is no national standard for the use of a return to work (RTW) assessment following an injury.

A systematic review highlighted a substantial shortfall in the understanding of how to assess the readiness of a firefighter to RTW following injury. Accordingly, further research was required to better understand which tasks could be included in such an assessment and how best to implement it within firefighting services.

To this end, a Delphi study was conducted to evaluate a consensus on the tasks that should be included in a RTW assessment. A consensus was gained for the operational firefighter tasks to be included in a RTW assessment. The results from this consensus created the framework for the Fit for Duty screening tool.

Following the Delphi study, the reliability of the Fit for Duty screening tool for firefighters was undertaken. The Fit for Duty screening tool demonstrated good inter-rater reliability (F_K=0.77-0.79) and good-excellent intra-rater reliability (α=0.77-1.00), with 94.3% of participants. The reliability of the Fit for Duty screening tool allows conclusions of a firefighter’s physical readiness to RTW to be made, which can inform a RTW decision for a firefighter. The use of the Fit for Duty screening tool could improve consistency of RTW processes across the UK fire & rescue services.

Published Journal Articles

Noll L, Mallows A, Moran J. Consensus on tasks to be included in a return to work assessment for a UK firefighter following an injury: an online Delphi study. *International Archives of Occupational and Environmental Health*. 2021 Jul;94(5):1085-95.

Noll L, Mallows A, Moran J. Psychosocial barriers and facilitators for a successful return to work following injury within firefighters. *International Archives of Occupational and Environmental Health*. 2022 Mar;95(2):331-9.

Noll L, Mitham K, Moran J, Mallows A. Identifying current uses of return to work screening tests and their effectiveness of reducing the risk of reinjury in athletic occupations–A systematic review. *Physical Therapy in Sport*. 2022 Oct 23.

Noll L, Moran J, Mallows A. Inter-Rater and Intra-Rater Reliability of Return-to-Work Screening Tests for UK Firefighters Following Injury. *Healthcare* 2022 Nov 27 (Vol. 10, No. 12, p. 2381). MDPI.

Conference Presentations

Noll L. How UK firefighters can return to operational duties successfully after injury. Sport & Health Sciences Guest Speaker Conference 2021 – Invited speaker (Appendix 1)

Noll L. Assessing readiness of a firefighters return to work. NFCC FireFit conference 2022 – Invited speaker (Appendix 2)

Noll L. Consensus on tasks to be included in a return to work assessment for a UK firefighter following MSK injury. University of Essex SRES Conference 2023 - Invited speaker.

Competition presentation

Noll L. Assessing readiness of a firefighter’s return to work. Three Minute Thesis Competition 2023, University of Essex – Invited shortlisted finalist.

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Abbreviations

ACL	Anterior Cruciate Ligament
BA	Breathing Apparatus
EPIC	Estimated Preinjury Capacity
GPP	General Physical Preparedness
LPP	Light Portable Pump
LSI	Limb Symmetry Index
MDT	Multi-disciplined team
MSK	Musculoskeletal
PARQ	Physical Activity Readiness Questionnaire
PPE	Personal Protective Clothing
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
RTC	Road Traffic Collision
RTW	Return to work
SPIRIT	Standard Protocol Items: Recommendations for Interventional Trials
UK	United Kingdom

Chapter 1: Setting the Scene

1.1 Introduction

The first British fire service was founded in Edinburgh in 1824 following the ‘Great Fire of Edinburgh’ (1). Currently in the United Kingdom (UK), there are 51 individual fire services with a total of 31,547 individuals employed as firefighters (2, 3). The role of firefighter requires individuals to respond to emergency calls in short timeframes and work in potentially dangerous environments where they are exposed to heat, smoke and toxic fumes (4, 5). Whilst working in these conditions, firefighters are expected to carry out physically demanding tasks, including carrying ladders, fire hoses and specialist cutting equipment (5). To maintain safety when performing these tasks, firefighters are required to wear personal protective clothing (PPE) (5). Over the years, enhancements to the equipment and protective clothing have been made thus enhancing the safety of the role (6-8). However, despite these enhancements, the physical demands placed on firefighters remain high (9, 10).

There are two types of firefighter duty systems within UK fire services: ‘wholetime’ and ‘on-call’. Wholetime firefighters are individuals who are employed full-time for a fire and rescue service and work shift patterns (3). These shift patterns can vary between different fire and rescue services but usually consist of working both day and night shifts (11, 12). On-call firefighters usually have another primary employment and are required to provide 360 hours per month on average, where they are available to respond to emergency calls (13). On-call firefighters are paid an annual retainer fee and receive further payment for each incident they attend (13).

Despite the difference in employment contracts, both wholetime and on-call firefighters are provided with the same level of training and are expected to respond to the same types of emergency incidents (14). Firefighters across the UK attended 620,758 emergency incidents in 2022, a 16% rise compared to the previous year

(15). To increase safety levels and to help reduce the risk of injury, all firefighters on both duty systems are expected to achieve the same level of aerobic fitness and muscular strength (16-18).

According to national guidance, the aerobic fitness level (VO_2 max) all operational firefighters are required to maintain throughout their career is 42.3ml/kg/min, which is based on the results from previous research (19). This VO_2 max level standard was obtained following a metabolic demands analysis involving common simulations of firefighter tasks, including hose running, equipment carry and stair climbing (19). Annually, firefighters are aerobically tested to assess that they are maintaining a VO_2 max level of 42.3ml/kg/min as a minimum (19). The aerobic tests used within UK fire and rescue services include the Chester step test, the Chester treadmill test, and the multistage shuttle run test (20-22).

Additional research has provided national guidance for the entry requirements of firefighters (16). A series of physical tests were created to assess an individual's aerobic fitness and muscular strength to identify those who can meet the initial minimum demands of operational firefighter tasks (16). Once an individual has passed these initial entry physical tests, they progress onto their basic firefighter training course, where more technically advanced firefighting skills are taught and assessed (23, 24). The advanced firefighting skills include breathing apparatus (BA) training, road traffic collision (RTC) training and flashover fire training (25-27).

The national guidance for the entry requirements and the annual aerobic fitness level have been implemented to ensure that individuals are able to meet the physical demands of operational firefighter tasks (16, 17). However, despite these standards being in place, even firefighters with a high level of physical strength and fitness remain at increased risk of musculoskeletal (MSK) injury whilst performing operational duties, due to the hazardous nature of their job role (28, 29).

Between 2021 and 2022, 2,278 injuries were sustained by UK firefighters (30). The total number of injuries sustained was 5% higher in comparison with the previous year (2020-2021) (30). Firefighters often work at high intensities during emergency calls and the lifting and carrying of heavy equipment is a common cause of MSK injuries (28). In addition, firefighters have previously suffered injuries due to slips, trips and falls, caused by working on unstable surfaces very often with reduced vision from darkness or smoke (31).

Time off from work due to an injury can be costly to a firefighter (32). In most cases, they will receive a period of full pay, usually at least six months**,** whilst recovering from their injury. However, once this period ends, this pay will be reduced to statutory pay which could cause increased stress and have financial implications for the firefighter (32). An injury to a firefighter can also have financial implications for their fire and rescue service (28). This is usually due to the need to provide personnel cover for each fire station so that availability levels are sufficient to attend emergency incidents and provide absence pay (28). This can cause firefighters to expedite a return to work (RTW) due to the external pressures and perceived obligations (33). However, if a firefighter returns to work too soon without having regained the required minimum aerobic fitness level or muscular strength to meet the demands of their work tasks, they can put themselves at risk of reinjury and overexertion, potentially compromising the safety of themselves, their colleagues and the general public (5, 17, 34).

Based on the above information, the requirements of a physical assessment to assess the readiness of firefighters to RTW following injury remains unknown. It is currently uncertain which tasks might be included in such a RTW screening tool and how this could be implemented within the UK fire and rescue services.

Without more informed and centralised guidance, UK fire and rescue services are required to make their own independent decisions to determine the process involved for a firefighter’s RTW. This has led to inconsistencies nationally, with some services requiring firefighters to undertake a fitness assessment before being allowed back to work and other services allowing firefighters to RTW once their absence certificate has expired, with no physical assessment undertaken. Insufficient RTW protocols can result in an individual returning to a physically demanding occupational role too soon before a MSK injury has fully recovered, which increases the risk of reinjury (35, 36).

1.2 Aims and Objectives

In the context of further research being required to understand the RTW process of a firefighter, this research aims to develop a screening tool to assess a firefighter’s physical readiness to return to operational duties following injury.

Underpinning this aim are several objectives:

i. To critically review the characterisation of the role of a firefighter and current uses of return to work assessments within physical occupations (Chapter 2).

ii. To systematically review current RTW screening tools conducted for athletic occupations following injury and their effectiveness of reducing reinjury risk (Chapter 3).

iii. To obtain a consensus view on the tasks that should be included in a RTW assessment for operational firefighters following musculoskeletal injury (Chapter 5).

iv. To explore the psychosocial barriers and facilitators during the RTW process following an injury for a firefighter (Chapter 6).

v. To assess the inter-rater and intra-rater reliability of a RTW screening tool to be used on UK firefighters following injury (Chapter 7).

vi. To develop future directions for research and practice in this field (Chapter 8).

Chapter 2: Physical return to work assessments and how they could be used to assess a firefighter's readiness to return to work following an injury in the United Kingdom

2.1 Introduction.

An application to become a firefighter for a fire and rescue service in the UK can be made by an individual providing they meet the initial criteria of being over eighteen years of age, have a full UK driving licence and pass the required medical check (37). No previous experience of firefighting or working in a physically demanding job role is required (37), resulting in applications from individuals of different age ranges with a variety of work experiences. Whilst this process is similar to the recruitment process in other occupations (38), applicants applying to become a firefighter are required to evidence that they possess a standardised level of muscular strength and aerobic fitness, to meet the minimum physical demands of the job (17).

Whilst on duty, firefighters will spend the majority of their time on station carrying out routine checks and maintenance of the equipment on the fire appliance, to ensure that their own personal task book is kept up to date (39). The task book is a document which allows a firefighter to evidence their competencies for firefighter job tasks (39). However, although some of these tasks produce low physical demand on an individual, firefighters are expected to respond to emergency calls in minimal time, sometimes causing a firefighter to go from a sedentary state to high physical exertion within minutes (5, 40). Emergencies can involve conditions that are stressful and unpredictable such as house fires and road traffic collisions (41). Firefighters are required to work in environments of substantial physical and psychological stress that could be considered highly dangerous (5, 41, 42). For example, exposure to high temperatures and toxic smoke whilst wearing PPE and carrying operational equipment can result in reduced visibility and increased risk of injury (41, 43).

Given the physical job task demands involved in firefighting (16) and the unpredictable working environments at emergency incidents (41), it is difficult to compare the role of a firefighter with that of a person employed in a sedentary occupation such as an office worker (44). Therefore, comparisons have been made with other occupations with similar physical demands (45, 46).

Research has identified occupations including paramedics, police, and military personnel when comparing data with similar roles to a firefighter (45, 46). Reasons for this comparison include the similarity of physically demanding tasks, working shift patterns and the workforce age between the different occupations (47-51). Research has compared health surveillance data of paramedics, police and military personnel amongst firefighters. These data included muscular strength and aerobic fitness levels (45, 46). One reason for this comparison is to help identify the effectiveness of occupation-specific health and fitness interventions in relation to an individual's physical performance and safety in their role (17, 52, 53). Current health and fitness interventions implemented within fire, paramedic, police and the military services include assessments of muscular strength and aerobic fitness as part of the recruitment process and yearly physical fitness assessment (19, 53, 54).

Information from the 2022 fire and rescue statistics reported that the number of emergency incidents attended by UK firefighters was 620,758. This was an increase of 16% compared with the previous year (55). Firefighters suffer 3.8 times more injuries when compared with other similarly physical jobs including construction workers and labourers (28). Firefighters are not only at risk of fire-related injuries such as burns (56), but also MSK injuries (57). In the UK there were 2,278 MSK injuries to operational firefighters between the years 2021-2022 (30). This accounted for 7.5% of all firefighters in the UK (30). Of those injuries, 340 injuries caused more than three days off work for those workers who sustained them with 54 of those injuries being classed as ‘major’ in nature (30). Major injuries are classified as requiring medical attention or if the firefighter was required to stay in hospital for more than twenty-four hours (30). Examples of reportable major injuries from the 2022 fire and rescue statistics included, but weren’t limited to, bone fractures, dislocations to the shoulder, hip or knee, limb amputation, chemical or hot metal burn, electric shock and electric burn (30).

After recuperation, a firefighter is expected to return to full operational duties. However, without adequate testing to ensure a safe RTW, the performance of their role could be compromised (58), as the risk factor of reinjury is increased (35). Firefighters who had below adequate fitness levels have been reported to be 2.9 times more likely to sustain another injury (59). Reinjury could suggest that an individual might have returned to their job role too soon and that RTW protocols are not optimal (36).The implications of this issue are serious as reinjury can lead to reduced emergency response availability within a given fire service.

The total number of firefighters in the UK has been reducing since 2011 (30). Reduced government spending (60) has led to a lower recruitment rate; recruitment to the service has decreased by 23% since 2011 (30). As a result of these trends, during this time, the average age of a firefighter in the UK in 2023 is 41 years old (30). The findings from previous research demonstrated a positive correlation between musculoskeletal injuries and age, individuals ≥30 years old have been reported to have a 4-5 fold increased risk of MSK injury when compared with individuals <30 years old. (61-63). Accordingly, it is important to ensure that the risk of reinjury is minimised by optimising RTW assessment for firefighters. This is important as it is clear both injury and reinjury not only affect the individual, but also their colleagues, the public and the overall service (5).

Currently, there is no national guidance for a RTW screening tool following an injury for firefighters. Therefore, the aim of this review is to firstly discuss the characterisation of the role of a firefighter. Secondly, this review will discuss the current uses of RTW screening tools following an injury within other physical occupations. Thirdly, this review will evaluate current physical screening methods used to assess potential injury risk for firefighters. Finally, this review will discuss current physical fitness assessments used within UK fire services to assess an individual's ability and readiness to undertake the physical demands involved in operational firefighter tasks.

2.2 Characterisation of the role of a firefighter

Whilst attending an emergency, a firefighter is required to possess adequate levels of aerobic fitness, muscular strength and endurance (5) to cope with the challenging physical demands (41). These demands include, climbing stairs, running, kneeling, squatting, evacuating casualties, lifting ladders, extending and lowering ladders, carrying equipment and hose running (16, 41). In addition, if the environment contains conditions posing a risk of contact with hazardous chemicals, a firefighter is required to use a breathing apparatus (BA) along with their protective personal equipment (PPE) (64). Firefighters are required to wear PPE to help increase their safety whilst attending an emergency (65). PPE helps to protect a firefighter from physical and chemical harm (66), however, wearing it increases physiological strain and metabolic rate can increase by 14.5% whilst exercising in PPE (66, 67). Coupled with this increased strain is an earlier onset of fatigue (68); this additional equipment weighs twenty-two kilograms (5).

To ensure that those working in a physical occupation are able to meet the physical demands of their role, individuals are often required to possess a foundation of General Physical Preparedness (GPP) (69). Firefighters have a requirement to possess GPP which is assessed in the form of physical selection tests, including aerobic fitness testing, muscular strength testing, and muscular endurance testing (17). Successful completion of the physical selection tests is needed before an individual is able to progress onto further, more advanced, firefighter training (17). Obtaining GPP is also often a prerequisite for employees working in other physical occupations before they can progress onto developing technical and tactical skills of their job role (70, 71).

The development of technical and tactical skills within a physical occupational role allows for an individual to improve their ability to perform effectively within their working environment (72). Following the completion of their physical selection test, firefighters are required to complete an internal training course, within their fire and rescue service, in which they can develop certain specialist skills for operational tasks (73). These specialist skills include, hose running, working whilst using a BA set, water rescue and animal rescue (17, 23, 74).

If an individual is able to increase their ability of these physical skills, they have the potential to develop methods to overcome physical challenges or obstacles to which they would be exposed within their occupation (72, 75). For firefighters, significant correlations were found between higher levels of muscular strength ($p<0.05$) and aerobic fitness ($p<0.1$) and increased firefighting performance ability due to lower levels of physical exertion when conducting operational tasks ($r = -.62$) (76, 77).

The ability to perform occupational-related tasks effectively is especially important in scenarios with increased pressure and intensity (5, 78). For firefighters, some emergency incidents will require casualties to be evacuated from burning buildings or vehicles, often in a time-critical situation, increasing both physical and psychological stress to complete their task as quickly as possible (79).

With such demands, firefighting is a profession that carries an increased risk of work-related injury (16, 28, 80, 81). On their RTW following injury, firefighters are expected to be able to perform the same operational tasks, to the same standard as required from them before they sustained their injury (82). If a firefighter has not regained the required strength following the rehabilitation of their injury they may not be able to effectively perform operational tasks and this could increase the risk of reinjury (83, 84). Currently, there is no national guidance for RTW processes following injury for firefighters.

One method to assess an individual's readiness to RTW in similarly physical occupations is with the use of a screening tool, whereby functional capacity to perform physical tasks relevant to job role is assessed (85-87). Screening tools can be used to make recommendations on time to RTW and can also help in reducing reinjury rates (87).

2.3 Current uses of screening tools in other physical occupations

2.3.1 Functional capacity evaluations

Functional capacity evaluations were created in the late 1970's and continue to be commonly used within workplaces today to help inform decisions of an individual's physical readiness to RTW following injury (88, 89). Prior to the development of functional capacity evaluations, individuals experienced delays in returning to their job role because of the uncertainty from employers to determine when an injured individual was ready to RTW (89). Functional capacity evaluations are standardised tests usually consisting of a series of movements related to an individual's job role and are administered to assess if the individual is able to meet the required physical demands of their job (88, 90, 91). These movements could involve lifting, carrying, trunk flexion and or rotation as well as other activities including running and walking (92).

Time off work due to an injury could result in physical training cessation (93). After training cessation, muscular strength and maximal oxygen uptake decrease gradually at varying rates (94). It has been reported that muscular strength and power performance can decrease by 7% to 14% following 28 days of training cessation (95). Maximal oxygen uptake was reported to reduce by 9.2% ($p<0.05$) following 18 days of training cessation (96). If an individual returned to work following injury with reduced muscular strength and maximal oxygen uptake and was unable to perform at the required physical standards, they could increase their risk of reinjury (93).

To help prevent any further injury, functional capacity evaluations are conducted in a safe and controlled environment (97). A functional capacity evaluation allows the individual to perform specific training, which would be supervised, to help identify any weaknesses in areas including strength, conditioning, and endurance (98). If the individual was unable to complete the assessment in a safe manner then the person conducting the test would stop the evaluation (97). This allows an individual to be tested within their physical limitations and helps prevent a reinjury (99).

Athletes have undergone specific functional capacity evaluations when returning to their sport following an injury (100, 101). The objective of these evaluations is to allow the athlete to return to their sport and perform at their highest functional level (100). This is achieved through the use of tasks which replicate those required during their return to sport during their sport proper (100). For example, in basketball, athletes increase the physical load on their body through jump landings and changing direction quickly whilst playing (102). Therefore, assessments following injury use hops in different directions and jumping exercises to help identify movements which would be completed when they returned to their sport (102).

Specific functional capacity evaluations have also been used in the armed forces (103). Tests used are occupationally relevant as personnel are required to carry backpacks weighing up to 20kg (103). Individuals are required to complete exercises with a backpack on, initially with a reduced mass, gradually increasing to the required mass (103). A similar approach is used by the United States military where a job-specific functional capacity evaluation test for service members returning from injury is used (104). This evaluation consists of a range of operational duty tasks, which is used to assess readiness to RTW (104). Whilst research is limited on functional capacity evaluations following injury for firefighters, screening methods have been used on firefighters to assess the risk of injury occurrence (105, 106). Furthermore, the Functional Movement Screen (FMS) is used with firefighters to assess an individual’s injury risk using a range of movement screening exercises (105).

2.3.2 Functional Movement Screen

FMS uses a range of bodyweight movement patterns such as, a deep squat, a hurdle step, an in-line lunge, a shoulder mobility test, a lying straight leg raise, a trunk stability push up and a rotary stability test which are then scored by how well they are performed (105). A score of three is awarded if the movement is completed as verbally described, without any compensation to the movement and without any pain. A score of two is awarded if the movement is completed without pain but requires some level of compensation. A score of one is given if the movement was not completed. A score of zero is given if the movement caused pain at any point whilst attempting to perform the movement. (105, 107).

The use of the FMS and injury risk has been explored with firefighters (29, 106, 108). Following initial FMS scores, firefighters took part in an individualised 8 week physical training programme (108). The results demonstrated a significant improvement between 55% to 65% in firefighters total FMS scores following the 8 week physical training programme compared to their initial FMS scores ($p = 0.001$)(108). Despite this, it remains uncertain whether a score obtained from the FMS reduces injury risk. Although a score of 14 or less using FMS has been suggested as placing a firefighter 'at risk' of injury (108), research has demonstrated that there is no relationship between FMS score achieved and injury occurrence ($p>0.5$) (109-111). One reason for this could be due to the FMS tests lacking the dynamism required to reflect the demands of firefighting as a profession (112). A firefighter is expected to complete physically demanding tasks with urgency (5). Therefore, a RTW screening tool for a firefighter following injury should include tasks relevant to the physical demands of their job role (90). Firefighters who do not possess sufficient levels of physical fitness should not be allowed to return to operational duties as their ability to perform firefighter-related tasks effectively and safely could be compromised (113). Previous research analysed the aerobic physical demands of specific tasks performed by a firefighter, this lead to a fitness standard being recommended as national guidance (82).

2.4 Fitness assessments currently used within the fire service.

In the UK, national guidance recommendations were created for role-related aerobic fitness standards of operational firefighters (19). One reason for this was due to the cardiovascular demands placed on firefighters during operational tasks (114) which was linked to operational firefighters being five times more likely to suffer acardiac incident when compared with the general public (115, 116). Hose running, casualty evacuation and equipment carrying simulation tasks are used to assess the cardiovascular demands of firefighters during operational duties (19). All tasks were completed wearing PPE to ensure demands closely replicated real scenarios (19). Oxygen uptake was continuously measured whilst completing each task and a minute of peak steady state VO_2 was recorded (19). The mean VO_2 max level of the tasks was taken and the results revealed a VO_2 max level of 42.3ml/kg/min which was recommended as the minimum aerobic fitness standard for an operational firefighter (19). Nationally, firefighter's aerobic fitness levels are usually tested on an annual basis to ensure that operational tasks are carried out safely and effectively (19, 117).

Aerobic fitness tests were created to assess cardiorespiratory levels as well as aerobic capacity prediction (118). Fire services mainly use sub-maximal testing as opposed to maximal testing as it requires less equipment and time (21). The three main tests used are the multistage shuttle run (22), the Chester step (119) and the Chester treadmill (21).

The twenty metre version of the multistage shuttle run test is used to assess aerobic fitness levels for firefighters (22). Individuals are required to run from one marker to another which is placed twenty metres away and to reach it before the sound of the beep to complete a shuttle (120). When the beep sounds, the participant returns to the first marker before repeating the pattern until they can no longer keep up with the beep (120). The speed at the start of the test is 8.5kph and this increases by 0.5km every minute meaning that the beeps occur at more frequent intervals (120). Firefighters are required to reach level eight and complete eight shuttles within this level to achieve the nationally recommended VO_2 max level of 42.3ml/kg/min (121).

The Chester step test is a submaximal test which predicts an individual's VO_2 max level using heart rate recordings (119). The Chester step tests consists of five levels each lasting two minutes in duration (119). The participant steps up and down onto a 30cm box in time with a metronome beat which speeds up incrementally with each level. During level one the metronome beat is 60bpm. During level two the metronome beat is 80bpm. During level three the metronome beat is 100bpm. During level four the metronome beat is 120bpm. During level five the metronome beat is 140bpm (119). The participants heart rate and rating of perceived exertion (RPE) is recorded at the end of each level (119). Once an individual records an RPE of 15 or reaches 80% of their maximum heart rate, the test is stopped and a line of best fit is formed based on regression and an associated formula, VO_2 max (ml/kg/min) = 111.33 - (0.42 × total test time) - (0.03 × heart rate recovery at 1 minute) (119). More recently, a Chester treadmill test was created (122). It is a twelve minute walking test set at a speed of 6.2kph (3.9mph) starting on a flat gradient which increased 3% every two minutes (123). Completion of the twelve minutes equated to a VO_2 max level of 42.3ml/kg/min (21).

In some UK fire services, if a firefighter is unable to reach the required aerobic fitness level but achieves a VO_2 max level between 35.6-42.2 ml/kg/min they have the opportunity to undertake a fire ground assessment (124). This job role-specific test assesses if a firefighter possesses the ability to execute important operational tasks efficiently (124). Tasks include a casualty carry whilst wearing a BA set, hose carrying, hose running, a barbell carry to simulate an equipment carry and shuttle runs (124). A completion time of eleven minutes and eleven seconds or quicker is required to pass the test and enable the firefighter to continue with operational duties (124). The tasks included in the drill ground assessment are similar to the national selection tests used for assessing new firefighter recruits (125).

The national selection tests were created as a way to assess the potential of how well new recruits could perform key tasks involved in firefighting (126). Firefighter fitness includes an accumulation of aerobic capacity, muscular strength and endurance as well as manual dexterity skills (127). Therefore, the physical assessments selected were those that simulated the physical demands of tasks carried out by UK firefighters (128) to help ensure anyone recruited would be able to effectively carry out their role (128).

The national selection tests consist of six tests designed to simulate operational firefighting tasks; [1] Equipment carry test, [2] casualty evacuation, [3] ladder lift simulator, [4] ladder climb with leg lock, [5] enclosed space crawl and [6] a manual dexterity test (128). A participant must achieve the required criteria for each test, as described by the instructor and complete each test within the designated time frame to be awarded a pass (128). A participant must achieve a pass for all six of the national selection tests before they are progressed through to the next stage of the firefighter recruitment process.

Due to the similarity in the selection tests and required tasks carried out by a firefighter, it was suggested that these tests could be used to also assess current firefighters as part of a standard fitness test (126). Therefore, in a scenario in which a medical advisor, a member of occupational health or a fitness professional required confirmation of a firefighters ability to carry out their role (following a long term of absence or injury for example), the national selection tests could be used as an assessment before returning to operational duties (126). However, certain tasks such as hose running were not included in the national selection tests which have been identified as physically demanding tasks in firefighting (126, 129, 130). In addition, the national selection tests do not include an aerobic capacity test to assess an individual's ability to reach the required aerobic fitness level (21, 124). Therefore, using the national selection tests alone do not represent a comprehensive characterisation of a firefighter's readiness to RTW following injury.

2.5 Limitations of current research

Current RTW approaches within fire services are limited and processes are unclear, which could potentially lead to ambiguity in their application and variation across the country. Current screening tools identified in this chapter are limited and do not provide a comprehensive assessment of a firefighter's ability to sustain the required physical job demands before they can RTW (105, 128). To maximise safety for all the stakeholders (the individual firefighter, their colleagues, and the public) a RTW screening tool assessing a firefighter's physical readiness to undertake the demands of operational tasks following injury is needed. Furthermore, such a screening tool could be used nationally across fire services across the UK to increase the consistency of a firefighter's RTW process.

2.5 Conclusion

This review provides an overview of the current RTW screening tools used within fields other than firefighting, following an injury (91, 100, 101, 103). It also outlines the benefits they present for assessing an individual's readiness to return to their job role (88, 89). The current RTW screening tools detailed in this review use functional capacity evaluations to determine an individual's readiness to RTW (88, 92). Functional capacity evaluations are used across a range of different occupations and the tasks involved are usually relevant to the physical requirements of the role (131, 132).

This review also assesses other methods used to screen injury risk (106). Although screening methods have been created to assess the risk of injury in firefighters (105), this review has highlighted the limitations of current approaches (133). Insufficient muscular strength and aerobic endurance are seen as key determinants of injury risk (134). Whilst current fitness tests used in UK fire services assess the aerobic capacity and muscular strength of firefighters, these tests are designed for individuals who are deemed operationally fit for duty and not those who may be returning to work following an injury.

Further research on the required tests to be included in a RTW screening tool for firefighters following injury is needed. Before a RTW screening tool can be created for firefighters, it would be beneficial to understand current RTW screening tools used within other physical occupations and their effectiveness at assessing readiness to RTW following injury.

Chapter 3: Identifying current uses of return to work screening tools and their effectiveness of reducing the risk of reinjury in athletic occupations – A systematic review

Based upon Noll L, Mitham K, Moran J, Mallows A. Identifying current uses of return to work screening tests and their effectiveness of reducing the risk of reinjury in athletic occupations–A systematic review. Physical therapy in sport. 2022 Oct 23 (Appendix 4).

Abstract

The primary objective of this systematic review was to identify current RTW screening tools conducted for athletic occupations following injury and their effectiveness of reducing reinjury risk. In particular, this review aimed to identify if such studies on RTW screening tools for firefighters existed. A search was conducted of multiple databases (BioMed Central, CINAHL through ebscohost, EMBASE, Google Scholar, PUBMED, Scopus, SPORTDiscus and Web of Science) from their inception to March 2022, using relevant terms to identify articles meeting predefined inclusion/exclusion criteria. The search, data extraction, risk of bias, and evaluation of the certainty of the findings were completed independently by two authors. To understand the effectiveness of screening tools and their impact in reducing in reinjury rates, results were divided into the following three time points: "Short-term" ($\leq$1 year), "Medium-term" (1-2 years) and "Long-term" (>2 years). Five studies met the inclusion criteria. There was a very low level of certainty for the effectiveness of screening tools reducing reinjury risk at short-term, medium-term and long-term follow ups. Only one study recorded a large effect size (1.6) ($p<0.001$) in the reducing reinjury risk. A gap in our understanding currently exists for the effectiveness of RTW screening tools in tactical athletic occupations following injury and further research investigating is required.

3.1 Introduction

Screening tools are used to help identify those at an increased risk of disease or disorder (135). Such tools can be used to identify individuals at high risk of developing a MSK injury (136) and can involve the assessment of performance factors including balance, muscular strength and range of motion (137). Chapter two highlighted the high rates of MSK injuries sustained by firefighters due to the physical demands of their job role and the increased reinjury risk if an individual were to return to that role too soon (35, 36, 58). The results from screening tools can help determine an individual’s readiness to RTW (138).

Research has identified similarities in the physical characteristics of both professional athletes and firefighters (139). Professional athletes, like firefighters are required to maintain physical fitness and undergo fitness assessments to ensure that they are able to meet the physical demands of their job role (140, 141). This similarity between occupations has prompted suggestions that the role of a firefighter could be considered as a tactical athletic occupation and fire services could consider adopting athletic-based approaches when assessing health and physical performance amongst firefighters (139, 142, 143). A tactical athlete has been defined as an individual who works in a physically demanding role which requires a significant level of physical fitness to complete the work task demands such as firefighters, police officers, paramedics and members of the armed forces (142).

A successful RTW following injury in athletic occupations can be defined as when an individual is able to complete all work task demands safely and independently, reaching at least the baseline level of physical fitness required for their role (138).

Screening tools have been created to be user-friendly by being easy to administer, using minimal equipment which is portable (144, 145). This ease of use for screening tools has resulted in a rise in their popularity as a method to reduce injury risk (144, 145). Examples of user-friendly screening tools include the star excursion balance test, functional movement screen, drop jump screening test, Y balance test, tuck jump analysis test and landing error scoring system (144, 145). Results from a RTW screening tool provide data that can help to determine whether or not an individual's present performance is equal to or above their occupational demands (99, 146). Such data are useful to assist in determining suitable recommendations for an individual's RTW protocol, including what tasks are deemed safe to perform and tasks to avoid or perform in a modified manner, which could help in reducing the risk of reinjury (99, 146)

Previously, studies identified that injury risk categorisation is population-specific to the required occupational demands (147, 148). Athletic occupations require muscular strength and aerobic fitness to complete job-related tasks (149, 150). These demands can involve challenging working conditions including lifting heavy loads on a regular basis or continuous repetitive work with lighter loads over a prolonged period of time (149, 151).

Current screening tools used in athletic occupations assess injury risk for individuals who are fit and healthy with no prior injury (152-155). However, there is limited research on screening tools used for a RTW decision following injury in athletic occupations (156, 157). In addition, reinjury following a RTW could cause further economic implications for the workplace including increased sick pay costs and potential increased workload for other members of staff (158). Updated guidance for the use of the best screening tools to reduce reinjury risk is consequently needed.

Therefore, the primary objective of this systematic review was to identify current RTW screening tools conducted for athletic occupations following injury and their effectiveness of reducing reinjury risk. In particular, this review aimed to identify if such studies on RTW screening tools for firefighters existed.

3.2 Methods

This systematic review was guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement (159) (Appendix 3). This study was prospectively registered and published with PROSPERO (ID: CRD42021260947). To structure this systematic review, the PICO search tool (Population, Intervention, Comparison, Outcome) was used.

P: Individuals returning to an athletic occupation (sports athlete) or tactical athletic occupation following MSK injury.

I: The use of a physical screening tool during return to occupation assessment following MSK injury.

C: Results from during physical screening tool.

O: Reinjury rates following return to occupation.

3.2.1 Data sources and search strategy

An electronic search of BioMed Central, CINAHL through ebscohost, EMBASE, Google Scholar, PUBMED, Scopus, SPORTDiscus and Web of Science was undertaken from their inception to March 2022 (Table 1). Two review authors (L.N. and K.M.) independently screened studies based on the eligibility criteria, firstly by inspecting the titles and abstracts, and then by referring to the full text for eligibility.

Disagreements between reviewers were resolved by discussion and if required, by mediation from a third reviewer (A.M. or J.M).

Table 1. Search terms used for database searches.

Search Term
“Firef*” OR “Firefighters” OR “Injured Firefighter” OR “Athlete” OR “Athletes” OR “Tactical Athlete” OR “Tactical Athlete” OR “Injured Tactical Athlete” OR “Injured Athlete” OR “Athletic” OR “Sportsm?n” OR “Sportswom?n” OR “Sportsperson” OR “Individual” OR “Individuals” OR “Injured Individual” OR “Emergency service” OR “Emergency services” OR “Army” OR “Armed Forces” OR “Military”
AND
“Return to duty” OR “Return to play” OR “Return to sport” OR “Return to compe*” OR “Return from injur*” OR “Return to work” OR “Return to physical activity” OR “Suitable return to work” OR “Back to dut*” OR “Back to play” OR “Back to sport” OR “Back to comp*” OR “Back to work” OR “Injury Rehabilitation” OR “Injury Recovery” OR “Musculoskeletal Rehabilitation” OR “Musculoskeletal Recovery” OR “Musculoskeletal Injury” OR “Musculoskeletal disorder” OR “Low back pain” OR “Back pain” OR “Sciatica” OR “Back ache” OR “Back pain” OR “Lumbar Pain OR “Shoulder injury” OR “Shoulder pain” OR “Physi* treatment” OR “Physiotherapy rehabilitation” OR “Physiotherapy recovery” OR “Occupational therapy” OR “Rehabilitation system” OR “Activity limitation” OR “Participation restriction” OR “Expectations” OR “Work capacity” OR “Work exposure” OR “Work related” OR “Job” OR “Employee” OR “Occupation” OR “Reintegration” OR “Work status”

AND
“Climbing stairs” OR “Stair climbing” OR “Climbing ladder” OR “Ladder climbing” OR “Standing” OR “Repetitive movements” OR “Working above shoulder” OR “Working with bend back” OR “Squatting” OR “Kneeling” OR “Lifting” OR “Carrying”.
AND
“Traffic light system” OR “Traffic light criteri*” OR “Decision Making” OR “Decision making system” OR “Decision Criteria” OR “Return to work checklist” OR “Work reuptake criteria” OR “Work ability index” OR “Return to work criteria” OR Return to work OR “Work resumption” OR “Fitness assessment” OR “Fitness Test” OR “Aerobic fitness assessment” OR “Aerobic fitness test” OR “Strength assessment” OR “Strength Test” OR “Physical Assessment” OR “Guidelines for return” OR “Screening” OR “Re-injur*” OR “Reinjur*” OR “Re-injur* Risk” OR “Reinjur* Risk” OR “Functional capacity evaluation” OR “Functional capacity” OR “Functional assessment” OR “Disability evaluation” OR “Follow up stud*” OR “Sick leave” OR “Job re-entry” OR “Sustainable return to work” OR “Performance test” OR “Performance assessment” OR “Performance based test” OR “Performance based assessment” OR “Lifting test” OR “Strength test” OR “Carry test”

3.2.3 Eligibility criteria

3.2.3.1 Population

The review only included participants aged 18 years and over who were returning from a MSK injury to an athletic occupation (sports athlete) or a tactical athletic occupation. We classified a tactical athletic occupation as a firefighter, police officer, paramedics or military personnel (75). Members of both sexes were included. Any studies including participants who were not involved in an athletic occupation or tactical athletic occupation were excluded. There was no restriction on the duration participants had been a sports athlete or tactical athlete, the length of time since participants' injury or surgery and the use of the screening tool and follow up time to assess any reinjury.

3.2.3.2 Outcome Measures

Reinjury rate was the primary outcome variable. Studies not assessing reinjury rates were excluded. Reinjury was defined as an injury of the same type and in the same location on the body (160). Other outcome measures included the nature of the reported injuries, duration away from sport/work, follow-up time and whether participants return to sport participation or full duties.

3.2.3.3 Study Design

Studies were eligible for inclusion if they were; randomised controlled trials (RCTs), quasi-experimental trials, cohort studies, case-control studies, case series studies or case studies investigating the effectiveness of screening tools for reducing reinjury rates. Cross-sectional studies, reviews and editorials were not included.

3.2.3.4 Language

Only studies published in English were included.

3.2.4 Risk of bias assessment

Risk of bias assessment of the included studies was undertaken by two reviewers (LN & KM) using the Cochrane Risk of Bias (RoB) 2.0 tool for randomised control trails and the Risk of Bias in Non-Randomised Studies of Intervention (ROBINS-I) assessment tool for non-randomised control trials (161, 162). The Newcastle Ottawa Scale (NOS) was used to assess the risk of bias for cohort studies (163). The NOS consists of categories including selection, comparability and outcome or exposure depending on the study type (cohort or case-control series). A star system is used, ranging between zero and nine stars (163). Thresholds were set based on overall score; seven to nine stars was considered “low risk of bias”, four to six stars was considered “unclear risk of bias” and three stars or fewer was considered “high risk of bias” (164).

3.2.5 Data Extraction

Two reviewers (LN & KM) extracted the data using a pre-determined extraction form. If there was disagreement between the two researchers, a third reviewer (either AM or JM) was consulted for their assessment on the data extraction. Data to be extracted included aims, research design, sample size, data analysis, findings, conclusions and limitations.

3.2.6 Data Synthesis

To understand the effectiveness of screening tools and their impact in reducing reinjury rates, results were split into the following three time points based on previous literature (165, 166): “Short-term” ($\leq$1 year), “Medium-term” (1-2 years) and “Long-term” (>2 years). Within-group effect sizes were reported for each study and each of the time points of interest. Effect sizes were interpreted as “small” (<0.5), “medium” (0.5-0.7), “large” (0.8-1.2) or “very large” (>1.3) (167).

3.2.7 Assessment of the certainty of the body of evidence of findings

The certainty of the body of evidence of findings was assessed using the Grading of Recommendations, Assessment, Development and Evaluations (GRADE) approach (168). It was used by two reviewers (LN & KM). If there was a disagreement between the two researchers, a third researcher (either AM or JM) was consulted for their assessment of the GRADE approach level. The GRADE approach categorises the certainty of evidence into four levels; “high” (we are very confident that the true effect lies close to that of the estimate of effect), “moderate” (we are moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different), “low” (our confidence in the effect size is limited: the true effect may be substantially different from the estimate of the effect) and “Very Low” (we have very little confidence in the effect estimate) (169).

3.3 Results

3.3.1 Study selection

Figure 1 shows the study identification process. Once duplicates were removed, 2837 studies were identified. After title and abstract screening, 71 studies were considered for full text review with five studies remaining to be included for review.

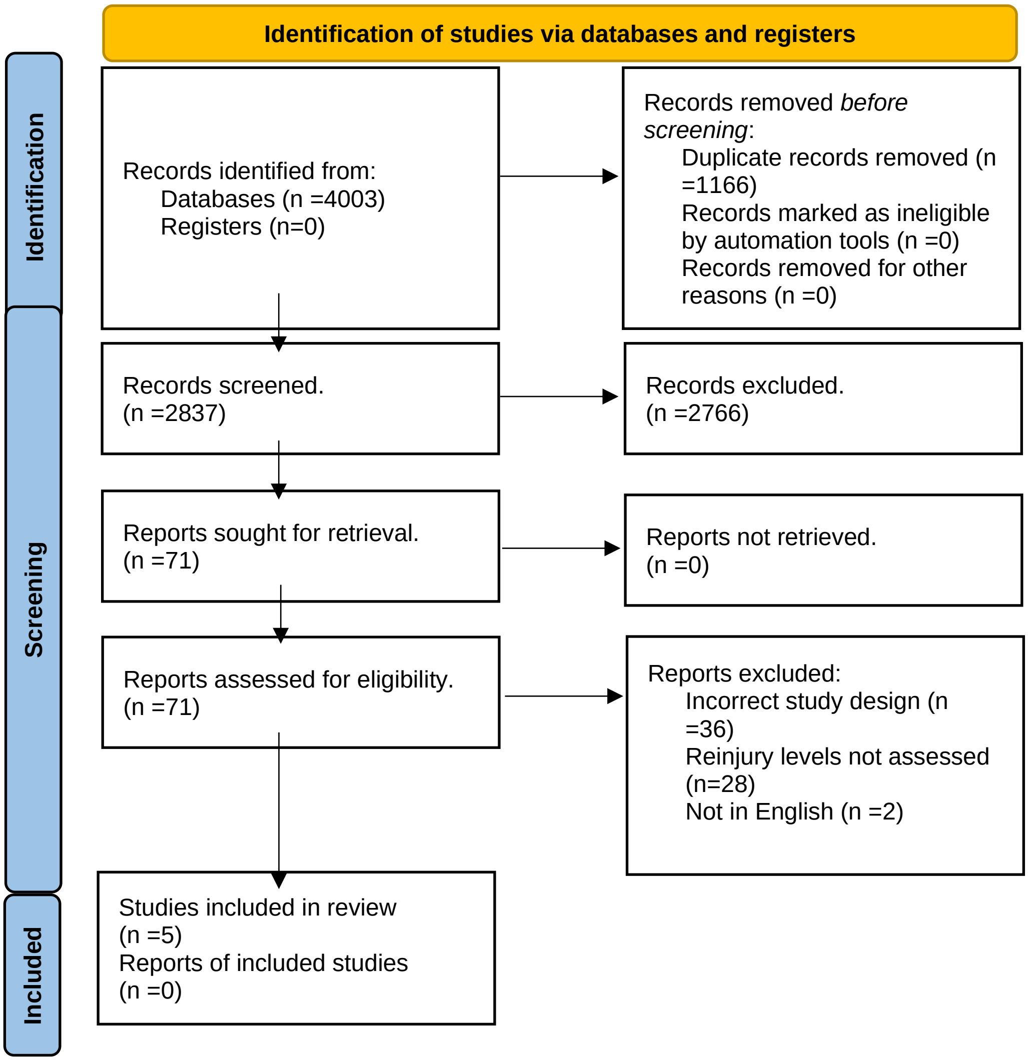

Figure 1. PRISMA 2020 flow diagram for new systematic reviews which included searches of databases and registers only (159).

3.3.2 Study Characteristics

The characteristics of the included studies are described in Table 4. Studies included a total of 507 participants (Male = 309, Female = 198), all of whom were recruited from professional sports (170-174). No studies based on RTW in tactical athlete occupations could be identified. Of the five studies included, all were cohort studies (170-174), four involved people returning to professional sports recovering from an anterior cruciate ligament (ACL) injury (171-174) and one study involved people returning to professional sports recovering from a hamstring injury (170). The mean time between injury or surgery and the use of the return to sport screening tool in the studies ranged between 40 days and 19 months duration (170-174). Three studies each included one follow-up to assess reinjury rates after 24 months (170, 171, 173). Two studies each incorporated two separate follow-ups, at twelve months and 24 months (172) and at nine months and 60 months (174).

3.3.3 Risk of bias assessment

The risk of bias assessment using the Newcastle Ottawa Scale of the included studies is shown in Table 2. Four of the studies were deemed to have a low risk of bias (170, 171, 173, 174) and the remaining study was deemed to have an unclear risk of bias (172).

Table 2. Risk of bias assessment of included studies using the Newcastle Ottawa Scale (NOS)

Author (Year)	Selection	Comparability	Exposure/ Outcome	Total Stars	Risk of Bias
De-Vos et al (2015) (170)	****	**	***	9	Low
Fältström et al (2021) (171)	****	**	***	9	Low
King et al (2021) (172)	****	*	*	5	Unclear
Van-Melick et al (2021) (173)	****	**	**	8	Low
Zore et al (2021) (174)	****	*	**	7	Low

3.3.4 Assessment of the certainty of the body of evidence of findings

The assessment of the certainty of the body of evidence was assessed using the GRADE approach (168). There was a very low level of certainty for the effectiveness of screening tools reducing the risk of reinjury at three separate time points (up to and including one year, greater than one year and up to two years; greater than two years) (Table 3).

Table 3 Assessment of the certainty of the body of evidence findings of reinjury rates following the use of screening tools taken across three time points, with Grading of Recommendations Assessment, Development and Evaluation (GRADE). *Note:* * Downgraded once for risk of bias, ** Downgraded once for inconsistency, *** Downgraded once for imprecision.

Outcome by time point	Studies	No. of studies	Type of studies	No. of participants	Risk of bias	Inconsistency	Indirectness	Imprecision	Publication bias	Level of certainty
≤1 year	De-Vos et al (170)	1 study	1 cohort study	64	-1	-1	No	-1	Undetected	*,***Very Low
>1-2 years	Fältström et al (171) King et al (172) Van-Melick et al (173)	3 studies	3 cohort studies	380	-1	-1	No	-1	Undetected	*,**,***Very Low
>2 years	Zore et al (174)	1 study	1 cohort study	63	No	No	No	-1	Undetected	***Very Low

3.3.4 Return from injury screening tool used.

All studies used a screening tool to help predict if an individual was ready to return to their sport following an injury and or surgery (Table 4) (170-174). The screening tools used in the studies measured physical variables including range of motion, knee extension, knee flexion, jumping and hopping (170-174). One study required the participants to reach a set criterion of a limb symmetry index (LSI) >90% for all movement quantity tests and a single leg hop and hold score of less than six on the Landing Error Scoring System (LESS) before being permitted to return to sport or play (170).

3.3.5 Reinjury rates following the use of a return to sport or play screening tool.

All studies provided reinjury rates in participants following their return to sport assessment. Four studies involved participants who sustained an ACL injury (171-174), reporting reinjury rates of 24% (171), 35% (172), 5% (173) and 19% (174) following a return to sport. One study involved participants who sustained a hamstring injury (170), reporting a reinjury rate of 27% following a return to sport.

Table 4. Study characteristics. SD = Standard Deviation, ACL = Anterior Cruciate Ligament, ACLR = Anterior Cruciate Ligament Reconstruction, ROM = Range of motion, RI = Reinjury group, NRI = No reinjury group, SD = Standard deviation, N = Number of participants, M = Male, F= Female, RTP = Return to play, LSI = Limb Symmetry Index, EPIC = Estimated Preinjury Capacity, EPIC- H = Estimated preinjury capacity of uninvolved limb.

Reference (Year)	Study Design	Area of injury	Sample size	Gender	Mean Age (Year)	Physical Occupation	Outcome measure	Screening tool used	Duration away from sport (Mean + SD)	Follow up time after assessment	Returned to sport participation	Reinjury Rates following RTS/RTP assessment
De Vos R.-J et al (2014) (170)	Cohort Study	Hamstring	N=64	M = 61 F = 3	28 (23-33)	Soccer (N= 45) Futsal (N=1) Field Hockey (N=11) Athletics (N= 4) Tennis (N=1) American football (N= 1) Fitness (N= 1)	Hamstring reinjury rates	Active knee extension test Passive straight leg raise.	40 days (31-55 days)	12-month post initial injury	N=64	N=17 (27%)
Fältström et al (2021) (171)	Cohort Study	ACL	RI = 28 NRI = 89	F = 117	RI = 20+ 3 NRI = 20+ 2	Soccer (N=117)	ACL reinjury rates	Knee extension LSI on single hop for distance(%) LSI on side hop (%) 5-jump test (cm) Tuck jumps	19 (+ 9) months	24-months post ACL reconstruction	N=117	N= 28 (24%)
King E et al (2021) (172)	Cohort Study	ACL	RI = 31 NRI = 57	M = 88	RI = 21.7 (+ 4.9) NRI = 22.9 (+ 4.1)	Gaelic Football RI (N=16) NRI (N=23) Hurling RI (N=6) NRI (N=14) Soccer RI (N=5) NRI (N=11) Rugby RI (N=4) NRI (N=9)	ACL reinjury rates	Quadricep LSI Hamstring LSI Single leg countermovement jump Single leg drop jump Single leg hop for distance Double leg drop jump (knee flexion, centre of mass to ankle vertical distance and ground contact time))	RI = 9.1 (+ 3.1) months NRI = 9.3 (+1.2) months	12-months and 24-months post-surgery	N= 88	N=31 (35%)

Van Melick et al (2021) (173)	Cohort Study	ACL	N = 175	M = 123 F = 52	24± 6	Soccer (N=129) Volleyball (N=9) Handball (N=8) Hockey (N=7) Korfball (N=6) Basketball (N=5) Other pivoting sport (N=11)	ACL reinjury rates	Strength test battery Hop test battery Movement quantity tests combined Hop and hold CMJ with LESS Movement quality tests combined Movement quantity and quality combined	11.8 months (±2.9)	24-months post surgery	N=102	N=7 (5%)
Zore, et al (2021) (174)	Cohort Study	ACL	N = 63	M = 37 F = 26	34.7 (SD= 12.3)	Professional or recreational sports (N=63)	ACL reinjury rates	Knee extension LSI Peak torque (ACLR) Peak torque (uninvolved) EPIC EPIC-H Knee flexion LSI Peak torque (ACLR) Peak torque (uninvolved) EPIC EPIC-H	8.5 months (± 9.03)	Short term (9 months) following ACL reconstruction. Medium term (60 months) following ACL reconstruction.	N=63	N = 12 (19%)

3.3.6 Reinjury rates following the use of a screening tool across different time points.

The extracted data presented in Tables 5-7 provided three time points at which reinjury rates were recorded. Short-term ($\leq$1 year), medium-term (>1-2 years) and long-term (>2 years). If effect size was not reported it was calculated manually using Cohen's *d* and magnitude of effect size (175). The formula used to calculate Cohen's *d* is

$$d = (M_1 – M_2) / SD$$

where M_1 and M_2 represent the two means being compared and SD is a measure of standard deviation (176). Effect sizes were interpreted as "small" (<0.5), "medium" (0.5-0.7), "large" (0.8-1.2) or "very large" (>1.3) (155).

3.3.7 Short-term ($\leq$1 year)

One cohort study (170) reported a very low certainty of evidence for the effectiveness of screening tools in reducing the risk of reinjury up to and including one year. In the context of this very low certainty of evidence, the effect size was not reported as there were a small number of patients with a subsequent small number of re-injuries. The results from this study demonstrated no significant difference between groups in Knee extension deficit (p=.059) and passive straight leg raise (p=.376) (Table 5).

3.3.8 Medium Term (>1-2 years)

Three cohort studies (171-173) reported very low certainty of evidence for the effectiveness of screening tools to reduce the risk of reinjury between greater than one year and up to two years. In the context of this very low certainty of evidence, two tests demonstrated a small effect in LSI on hopping distance (171, 172) and quadriceps and hamstring strength for reducing the risk of reinjury (171, 172). Two screening tools demonstrated a medium effect for reducing the risk of reinjury, double leg 5-jump test (0.55) and double leg drop jump (0.52-0.64)(171, 172). One study did not report an effect size but did report relative risk for some of the return to sport screening tools (173). Relative risk is the ratio of the probability of an event happening occurring between two groups (177).

Strength test battery screening tools demonstrated a relative risk of 2.95 (0.37-23.51) between the group that did not achieve the test criterion versus the group that did achieve the test criterion (173). Hop and hold screening tool implied a relative risk of 10.17 (1.28-81.10) between the group that did not achieve the screening tool criterion versus the group that did achieve the screening tool criterion (173). Counter movement jump (CMJ) with the landing error scoring system demonstrated a relative risk of 2.16 (0.44-10.62) between the group that did not achieve the test criterion versus the group that did achieve the test criterion (173). Movement quality tests combined identified a relative risk of 3.86 (0.48-30.85) (173).

3.3.9 Long Term (>2 years)

One cohort study (174) reported very low certainty for the effectiveness of screening tools reducing the risk of reinjury greater than two years. In the context of this very low certainty, one return to sport screening tool demonstrated a small effect size in limb symmetry index (LSI) in both knee extension (0.15) and flexion (0.12) for reducing the risk of reinjury. One return to sport screening tool (peak torque) demonstrated a medium effect for reducing reinjury risk during knee extension in both the leg with ACL reconstruction (0.53) and the uninvolved leg (0.54). In addition, peak torque demonstrated a small effect for reducing reinjury risk during knee flexion in both the leg with ACL reconstruction (0.38) and the uninvolved leg (0.54). Another return to sport screening tool, Estimated Preinjury Capacity (EPIC), demonstrated a large effect for reducing the risk of reinjury during knee extension flexion in both the leg with ACL reconstruction (0.84) and the uninvolved leg (1.6). EPIC also demonstrated a medium effect for reducing the risk of reinjury during knee flexion in both the leg with ACL reconstruction (0.52) and the uninvolved leg (0.6) (174).

Table 5. Reinjury rates following the use of screening tools in short term follow-up (<u><</u>1 year).

Study	Area of Injury	Design	Outcome Measure	Follow up	Return to Sport/Play assessment	Effect Size	Magnitude	Between groups *P*-value
De Vos R.-J et al (2014) (170)	Hamstring	Cohort	Hamstring reinjury rates	12 months	Active knee extension deficit Passive straight leg raise	Not reported	Not reported	0.059 0.376

Table 6. Reinjury rates following the use of screening tools in medium term follow-up (>1-2 years). ACL = Anterior Cruciate Ligament, LSI = Limb Symmetry Index, CMJ = Countermovement jump, LESS = Landing Error Scoring System. *Significant Difference (*P*= <u><</u>0.05) **Relative Risk

Study	Area of Injury	Design	Outcome Measure	Follow up	Return to Sport/Play assessment	Effect Size	Magnitude	Between groups *P*-value
Fältström et al (2021) (171)	ACL	Cohort	ACL reinjury rates	24 months	Knee extension	0.39	Small	0.044*
					LSI on single hop for distance(%)	0.12	Small	0.630
					LSI on side hop (%)	0.24	Small	0.237
					5-jump test (cm)	0.55	Medium	0.007*
					Tuck jumps	0	None	0.286
King E et al (2021) (172)	ACL	Cohort	ACL reinjury rates	24 months	Quadricep LSI	0.1	Small	0.652
					Hamstring LSI	0.24	Small	0.275
					Single leg countermovement jump	0.01	Small	0.964
					Single leg drop jump	0.19	Small	0.445
					Single leg hop for distance	0.21	Small	0.388
					Double leg drop jump (knee flexion, centre of mass to ankle vertical distance and ground contact time)	0.52-0.64	Medium	0.21-0.3
Van Melick et al (2021) (173)	ACL	Cohort	ACL reinjury rates	24 months	Strength test battery	2.95 (0.37-23.51)**	Not reported	0.420
					Hop test battery	Not reported	Not reported	0.047*
					Movement quantity tests combined	Not reported	Not reported	0.348
					Hop and hold	10.17 (1.28-81.10)**	Not reported	0.010*
					CMJ with LESS	2.16 (0.44-10.62)**	Not reported	0.445
					Movement quality tests combined	3.86 (0.48-30.85)**	Not reported	0.240
					Movement quantity and quality combined	Not reported	Not reported	0.591

Table 7. Reinjury rates following the use of screening tools in long term follow-up (>2 years). ACL = Anterior Cruciate Ligament, ACLR = Anterior Cruciate Ligament Reconstruction, LSI = Limb Symmetry Index, EPIC = Estimated Preinjury Capacity, EPIC- H = Estimated preinjury capacity of uninvolved limb. *Significant difference (*P*= <u><</u>0.05)

Study	Area of Injury	Design	Outcome Measure	Follow up	Return to Sport/Play assessment	Effect Size	Magnitude	Between groups *P*-value
					Knee extension			
Zore et al (2021) (174)	ACL	Cohort	ACL reinjury rates	5 Years	LSI	0.15	Small	0.663
					Peak torque (ACLR)	0.53	Medium	0.114
					Peak torque (uninvolved)	0.54	Medium	0.096
					EPIC	0.84	Large	0.028*
					EPIC-H	1.6	Large	<0.001*
					Knee flexion			
					LSI	0.12	Small	0.664
					Peak torque (ACLR)	0.38	Small	0.258
					Peak torque (uninvolved)	0.35	Small	0.251
					EPIC	0.52	Medium	0.127
					EPIC-H	0.6	Medium	0.052

3.4 Discussion

The primary objective of this systematic review was to identify current RTW screening tools conducted for athletic occupations following injury and their effectiveness of reducing reinjury risk. In particular, this review aimed to identify if such studies on RTW screening tools for firefighters existed. To the author's knowledge, this is the first review of its kind in that it identified data indicating that screening tools can reduce the risk of reinjury. However, the very low level of certainty of evidence for the effectiveness of the use of screening tools for reducing the risk of reinjury indicates that the findings should be interpreted with caution.

All studies used in this review assessed a population of sports athletes returning to an athletic occupation following an injury (170-174). No studies were found involving firefighters, highlighting a shortfall in our understanding for the use of screening tools on firefighters returning to work following injury. All studies in this review assessed either ACL or hamstring injuries (170-174). People working in athletic occupations are at risk of sustaining other MSK injuries with injuries to the back, ankle, shoulder and hip common in these populations (28, 57). Therefore, further research is needed to assess the effectiveness of screening tools in reducing reinjury risk for a range of MSK injuries.

The screening tools found in this review assessed a range of elements to assess their association with risk of reinjury. These elements were knee extension peak torque (170, 171, 174), knee flexion peak torque (174), LSI (171, 172, 174), hop and jumping tests (171-173) and EPIC (174).

EPIC was the only screening tool where the results demonstrated a large effect size (0.84) in knee extension between the no secondary injury and secondary injury groups (174). This highlights the importance that failure to regain knee function prior to ACL reconstruction may cause an increased risk for a second ACL injury (174). EPIC compares the strength of the previously injured limb of an individual returning to sport with the strength of the non-injured limb immediately after the injury or surgery (174). Individuals who are unable to achieve 90% EPIC levels in their rehabilitating limb are at increased risk of suffering a reinjury (174, 178).

Due to the increased injury risk caused by the physical demands placed on individuals, many athletic occupations require individuals to maintain certain strength standards to enable them to perform their job role safely and effectively (19, 179-181). As discussed in chapter one, national recruitment physical strength and aerobic fitness standards have been developed for firefighters in the UK (16). Previous studies have suggested that failure to retain physical standards and poor performances during physical assessments could increase injury risk (17, 182, 183). The use of a RTW screening tool for firefighters following MSK injury has the potential to assess if the rehabilitated limb can achieve at least the minimum physical demands of operational firefighter tasks before a RTW is permitted (33, 184). The interpretation from this review indicates that screening for reinjury risk should be comprised of multiple tests to reduce the risk of reinjury when compared to using a single test, with an importance placed on muscular strength (173, 174). One study in this review claimed that the use of multiple tests (jump height, jump distance and running change of direction) may offer more accurate information relating to reinjury risk compared to using tests in isolation (172). The subjects in this study were seeking to return to a sport with a high demand placed on multi-directional movements. The results from this study suggested that biomechanical variables during change of direction testing and jump testing specific to the subject's sport may identify those at increased risk of reinjury due to their inability to meet the high demands of their sport (172). Screening tools consisting of tasks specific to occupational demands may provide more relevant information on an individual's physical readiness to RTW than singular strength tests used in isolation (172).

In the absence of any research on the use of RTW screening tools for firefighters following injury and their effectiveness for reducing reinjury risk, further research is urgently required. Currently, multiple tests of aerobic fitness and muscular strength are used in the selection process of tactical athletes such as in military, police and the fire services (17, 179, 185). Previous research in tactical athletes has informed recommendations for entry level aerobic fitness and muscular strength standards to ensure that potential candidates can meet the job task demands before employment (16, 19, 54, 179).

Many tactical athletes are assessed on their aerobic fitness and muscular strength based on generic tasks executed during active duties (including weighted carries, weighted lifts and running) (17, 179). These selection tests were created to assess if an individual could achieve the minimum physical attributes required to meet the task demands of their role (17, 179). The use of generic tasks during the selection tests require no specialised training, making it possible for them to be used in general populations (17, 179). However, once employed as a tactical athlete, individuals are trained in more specific tasks related to their job role, such as firearms, special air service, water rescue, animal rescue and breathing apparatus (BA) training (186-189). Therefore, the use of the generic tasks from current selections process tests may not be suitable for assessing a tactical athlete's physical readiness to RTW following injury. Instead, a RTW screening tool for tactical athletes could involve more specific tasks relating to the individuals physical job task demands.

Previous research has employed physical assessment tests for tactical athletes to predict injury rates (190). Low levels of aerobic fitness and muscular strength were associated with a risk of injury whilst on duty (r =1.06) (190, 191). However, previous research predicting injury risk in tactical athletes included only participants who were physically healthy and with no recent injury (192-194). No research on screening tools aimed at reducing reinjury risk for tactical athletes return to duty following an injury currently exists.

If a screening tool could help to reduce the risk of a reinjury in athletic occupations, it could be advantageous for an employer as it could result in fewer days of employee absence from the workplace and lower associated expenses from sick pay for an organisation (195, 196).

No literature was found to have specifically discussed the requirements for a firefighter’s RTW screening tool and how one could be used to assess readiness to return to operational duties following injury. Accordingly, consensus on the tasks required to determine a firefighter’s safe RTW is needed.

3.4.1 Strengths and limitations

This review is the first of its kind to evaluate the current screening tools used in tactical athletes and their effectiveness in reducing the risk of reinjury. These findings are robust given the adherence to PRISMA 2020 guidelines. This review highlighted several limitations of the evidence found. Firstly, a very low level of certainty of evidence was found at all three identified time points for reinjuries. Secondly, only cohort studies were found during the search and all studies involved individuals returning to sport only. No studies were identified for any tactical athletes returning to duty following an injury. This was surprising to discover and the lack of studies with tactical athletes could have been limited based on the search terms used for the electronic search across research databases. One section of the search terms included very specific occupational movements, including ladder climbing and stair climbing. The requirement for these search terms to be included could have limited the total number of studies found and could have potentially missed studies which may have suitable to include within this systematic review. On reflection it may have been beneficial to remove the section of the search terms which required the inclusion of specific movements and then run the search across the different databases again to discover if the results provided any additional suitable studies which were not included in the original search.

3.5 Conclusion

This review sought to identify current RTW screening tools conducted for all athletic occupations following injury and their effectiveness of reducing reinjury risk. The results demonstrated very low level of certainty of evidence for the effectiveness of RTW screening tools reducing the risk of reinjury. EPIC demonstrated a large effect size and highlighted the importance of regaining muscular strength in the rehabilitating limb before a RTW in professional sport athletes (174). Interpretation from this review indicates that the use of multiple tests specific to the physical job task demands are more beneficial in identifying physical readiness to RTW compared to use of generic strength tests in isolation (172-174). A gap in our understanding currently exists for a RTW screening tool in firefighters. Further research is required to investigate the tasks involved in a RTW screening tool for firefighters returning to work following MSK injury.

Chapter 4: Research Methodology

4.1 Introduction

A lack of knowledge and understanding specific to assessing the readiness of a UK firefighter to return to operational duties following MSK injury was described in the previous chapters (Chapter one & Chapter two), highlighting a need for further research in this area. Overlooking this area of research could lead to not having a sufficient RTW screening tool to assess firefighter's following MSK injury and inconsistencies in RTW processes within fire and rescue services across the UK. For these reasons, this research seeks to address the deficiencies in literature and make an original and important contribution.

The purpose of the current chapter is to describe the research paradigm and the methodology used in this research. Within this research project, pragmatism was adopted as the research paradigm with multi-methods research as its methodology, to help achieve the aim of developing a RTW screening tool to assess a firefighter's readiness to return to operational duties following MSK injury (197-200). This chapter will explain the justification of choosing this research paradigm, the reasons for choosing mixed methods study designs and their suitability to achieve the aims of the research.

4.2 Research Paradigm

The research paradigm is a set of guiding values about a scientific question and can be categorised through, ontology and epistemology (201, 202). Ontology refers to our beliefs about how reality exists and what can be known about it, i.e. is reality interpreted by those in it or is there only one truth (201). Epistemology refers to how knowledge can be found, understood and communicated (203). Epistemology assumptions are made by researchers based on their beliefs (204). Objectivism is the assumption that knowledge exists whether we are conscious of it or not (205). Constructionism is the assumption that we discover and develop knowledge through our interactions (206). Subjectivism is the assumption that everyone has a separate understanding of what is known (207) .

The research paradigm chosen by the researcher aids their beliefs regarding the nature of knowledge and choosing the most suitable methods to help answer their research question (198). Pragmatism research helps to answer questions and provide information that can be useful to stakeholders and used in a practical application (208) . In terms of ontology and epistemology, a pragmatic approach is not committed to any specific ontological or epistemological belief, instead, pragmatists accept that there are multiple realities and incorporate research designs based on what will work best in understanding the answers to the research question of their study so that practical solutions can be developed to help aid in real-world situations (199, 200). The aim of this thesis was to produce meaningful knowledge that could address current limitations in literature and solve practical problems specifically focused on how to assess the readiness of a firefighter returning to work following a MSK injury. Therefore, this research was underpinned by a pragmatic research philosophy, which is based on the assumption that the results should be meaningful to help make a positive difference to the groups and/or individuals (197). To help achieve the aim of this thesis, a multi-methods research design was deemed to be most appropriate.

4.3 Research Design

Multi-method research design is where qualitative and quantitative approaches are used to answer different questions within a single research project (209). The use of a multi-methods research design has been criticised, with some researchers arguing that the combination of the two paradigms, constructivist (qualitative) and positivist (quantitative), is not possible (210). However, multi-methods research has been found to provide balanced evidence to help gain a greater understanding of the research question (211). Due to the limited understanding of assessing a firefighter's readiness to RTW following MSK injury, and seeking to achieve an in-depth understanding, a mixed methods design was chosen as the best suitable approach to answer the research questions and aims of this thesis.

This thesis provides a rationale for each study's method and outlines the explanation of how each method extends on previous research or other studies within this thesis. The methods for each study in this thesis were chosen as best suitable to be able to achieve the research aim of the study (212). As such, separate objectives were provided for the qualitative and quantitative studies, whilst the overarching aim still aligned to discover how to assess UK firefighters' readiness to RTW following MSK injury. Quantitative methods were employed to explore the following aims: the tasks required for RTW screening tool to be used on firefighters (Chapter 5) and the feasibility and reliability of such a RTW screening tool (Chapter 7). Qualitative methods were employed to explore the perceived psychosocial barriers and facilitators experienced by firefighters during their RTW process (Chapter 6).

This chapter provided an overview of the research methodology for this thesis. It also provided an insight into the research design for each individual study in this thesis (Chapters 5-7). This overview was not intended to replace the methods section of the following studies as the methods are fully detailed for each relevant study (Chapter 5-7). The following chapters will now report on each study conducted, including the methods selected and the results. The next chapter details the first study of this thesis. This was a Delphi study looking to gain a consensus of the physical tasks to be included in a RTW screening tool for firefighters following injury.

Chapter 5: Consensus of tasks to be included in a return to work screening tool for a UK firefighter following an injury: an online Delphi study.

Based upon - Noll L, Mallows A, Moran J. Consensus on tasks to be included in a return to work assessment for a UK firefighter following an injury: an online Delphi study. International archives of occupational and environmental health. 2021 Jul;94:1085-95 (Appendix 5)

Abstract

The aim was to provide a consensus of tasks that needed to be included in a return to work screening tool for operational firefighters. A two-stage online Delphi study was conducted with twenty-four participants including firefighters, service fitness advisors and occupational health managers. A consensus was set at 70% agreement. In round one, participants completed an online survey relating to tasks to be included during a return to work screening tool for firefighters following an injury. Round two was an online consensus meeting to discuss the tasks for which consensus was not achieved. A consensus was reached for ten of the thirteen tasks, including the number of repetitions required when lifting a light portable pump and climbing a ladder. A consensus was reached for the total distance equipment should be carried. This included carrying a ladder, a hose and a light portable pump. This study has provided a consensus for tasks to be included when assessing a firefighter for return to work. Further research is needed to understand how to use this screening tool optimally.

5.1 Introduction

The role of a firefighter requires individuals to be ready to respond to emergencies within minutes (42), this means that they can go from a state of rest to high levels of physical exertion very quickly (5). During these emergencies, firefighters can be exposed to conditions that are stressful and unpredictable (41). Such environments can be dangerous for firefighters to work in as they can be exposed to high temperatures and toxic smoke which can reduce visibility (41). In addition, firefighters are expected to respond to emergencies with urgency which can add psychological stress (41).

During these emergencies, firefighters are required to complete tasks requiring certain physical aspects including aerobic fitness, muscular strength and endurance (5), which can cause challenging physical demands on the body (41). Associated tasks include, climbing stairs, evacuating casualties, lifting ladders, extending and lowering ladders, carrying equipment and hose running (16). At other emergencies that require the use of BA, firefighters may need to wear PPE that adds an additional 22kg to their weight (5).

The combination of these tasks, and the unpredictable and varied working conditions that firefighters are faced with, result in a high risk of work-related injuries (28, 81). In the UK there were 2,278 injuries to operational firefighters between the years 2021-2022. Of these injuries, 337 resulted in more than three days' work absence while 49 were classified as 'major'. The major injuries were grouped as fractures or dislocations to the shoulder, hip or knee. Injuries were also classed as 'major' if the firefighter was required to stay in hospital for more than 24 hours (15). Reports show that firefighters suffer over three times more injuries when compared with other similarly physical jobs including construction workers and labourers within the private sector (56). Firefighters are not only at risk of fire-related injuries such as burns (30), but also MSK injuries (57), with muscle strains and sprains, upper and lower extremity injuries and back injuries being the most common (57). Almost half (49%) of all overexertion injuries are caused by lifting movements (28) which is a critical task for a firefighter in their normal job role (16).

On a RTW following an injury, firefighters are expected to return to their normal job role. However, if a firefighter RTW with an injury which hasn't fully recovered, adequate performance in their role as well as the safety of their colleagues and the public is potentially compromised (5, 58). In addition, if a muscle has not fully recovered it may not be fully functional, meaning that the risk factor of reinjury is increased (35). Reinjury rates could imply that individuals may have returned to their job role too soon due to insufficient RTW protocols (36). Therefore, screening tools/functional capacity evaluations have been created to determine the RTW readiness of an individual by measuring their ability to complete work-related activities (57, 213).

Functional capacity evaluations usually consist of a series of movements relating to an individual's job role (214). Examples of these movements can involve lifting, carrying, bending, reaching and climbing (191). These movements can be used in comparison with normative workload requirements from healthy workers (213). If the individual is able to equal or surpass the required workload demands then they would be deemed ready to RTW (213).

All fire services in the UK use standard physical assessment requirements for their entry-level criteria and yearly annual aerobic fitness testing (16). This consistency across the nation is considered important to fire services to ensure that potential candidates are able to meet the minimum physical demands experienced as a firefighter (17, 97).

The results from the systematic review in Chapter 3 highlighted a shortfall in our understanding on the effectiveness of RTW screening tools in tactical athletic occupations. Furthermore, no such consensus exists for a RTW physical screening tool for firefighters following an injury. Therefore, the aim of this study was to provide a consensus view of the tasks needed to be included in a RTW screening tool for operational firefighters.

5.2 Study Design

An online Delphi study was conducted to determine a consensus on relevant tasks which were deemed to be important for firefighters to perform before returning to operational duties following an injury. The Delphi technique is an accepted method used for collecting opinions from experts within a chosen area of research, usually concerning real-world knowledge and can be used to discover information which may result in a consensus from the group of experts (215). A consensus is considered the primary outcome of a Delphi study. This study aimed to gain a consensus from a group of experts working for UK fire and rescue services. Consensus percentage agreement can vary from 50-97% (216), but in line with studies with a similar aim, a 70% consensus was used (217-219). A prior literature review was conducted to ensure tasks included in the decision-making were representative and exhaustive of those tasks currently performed by operational firefighters (see Chapter 2). These tasks included lifting, carrying and climbing a ladder, lifting and carrying a hose, hose running, lifting and carrying a Light Portable Pump (LPP), evacuating a casualty and crawling through enclosed spaces.

5.2.1 Ethical Approval

Ethical approval was sought and granted on 8th April 2020 by The University of Essex research ethics committee. Ethics reference; ETH1920-0832 (Appendix 6)

5.2.2 Data Collection

Stage one – Online Survey

The first stage of this study was completed with the use of an online survey (Appendix 8). The data were collected using Qualtrics survey software (220). Participants were emailed a link to the survey. The start of the survey gave a brief overview of the study and reminded the participants to read the participant information sheet (Appendix 7) should they have required more information before starting the survey. Participants were then asked to give their consent to take part in the survey, these questions were mandatory and progression to the rest of the survey was not allowed unless consent was given. The survey was live for two weeks to allow participants time to take part. A reminder email was sent seven days after the initial invitation to help drive further participation of the target population. Participants were asked to rate each operational task as either ‘important’, ‘not important’, or ‘not sure’. All tasks rated as ‘important’ had a follow-up open question asking specific details about the task in question. This included the mass of the equipment, the distance equipment needed to be carried and the number of repetitions of equipment needed to be lifted. Participants were asked open questions during this part of the survey for the purpose of gaining a quantitative understanding of participants perceived requirements a firefighter needed to achieve before a return to operational duties. The use of open questions provides a participant led study, which encourages participants the freedom to give their opinions on the required tasks to be included in a screening tool to assess a firefighters readiness to RTW and the requirements of these tasks, including the number of repetitions to be completed, the distance to be completed and the mass to be lifted or carried (67, 221). The last section of the online survey required participants to rank the tasks in order of importance to be included in a RTW screening tool following an injury (one= most important, eleven = least important). Participants were asked to provide an email address at the end of the survey. Email addresses were used to invite participants to a consensus meeting for the second stage of the study. After the two week period the results from the survey were collected. For a task to achieve consensus, a minimum of 70% agreement that the task is 'important' was required.

Stage Two – Online consensus meeting

Participants were invited via email to attend an online meeting for the second stage of the study. An online meeting was chosen to increase inclusivity and decrease travel costs to participants. An online Doodle poll was used to identify a suitable date for the online meeting (222). A link to this poll was sent to the participants via email four weeks before the earliest proposed date. The email also contained details about the meeting. Once a majority date had been agreed, a further email was sent inviting participants to the online meeting. This email contained the link to the zoom meeting invitation (223). The aim of this meeting was to gain a consensus for the questions that did not achieve 70% agreement in the first stage online survey. During the online meeting, all questions that did not achieve 70% agreement in the first stage online survey were discussed. Participants were asked individually by LN for their answer to the question. Once all participants had been asked, LN calculated if 70% agreement had been reached. If a consensus agreement could not be met, a discussion between all participants was prompted by LN to see if a 70% agreement could be achieved. The results of the online consensus meeting were reported."

5.2.3 Recruitment

A purposive sample of participants, who work in occupational health or fitness departments for fire services in the UK were invited to participate in the study. Operational firefighters in the Essex County Fire and Rescue Service were also invited. The design of the study was very specific to the fire service as the survey required an understanding of the operational tasks expected of a firefighter. Therefore, purposive sampling was used to capture consensus from experts working within the fire service. No minimum number of service years or minimum rank was required to take part in this study. However, participants needed to be either an operational firefighter, part of the national FireFit steering group or the South East fire service fitness advisors regional group.

5.2.4 Sample Size

Thirty-nine participants were invited to participate in the study across three main groups: members from the National Firefit Steering Group (n=18); members from the South East fire service Fitness advisors group (n=6); and operational trainers from Essex county Fire and Rescue Service (n=15). The total number of participants recruited was reflective of the sampled population.

5.2.5 Data Analysis

Descriptive statistics of the results were presented to describe the participant's characteristics and survey responses. Participant characteristics included participants age, participants job role, the number of years participants had worked for their fire service and the UK region of the participants fire service. Descriptive statistics were calculated using Microsoft Excel (224).

5.3 Results

5.3.1 Participants

A total of thirty-nine participants met the inclusion criteria and were invited to take part in this study. Of these, twenty-four (62%) took part in the online survey in the first stage. This sample included a representation of professionals working within fire and rescue services across the UK (Figure 2). There was representation from different fire service departments (n=8), service fitness advisors (40%), operational firefighters (48%) and occupational health managers (12%) (Appendix 9). The mean age of the participants from stage one was 43.4 ($\pm$9.26) years and the mean duration they had worked for the fire service was 16 ($\pm$7.26) years. From the twenty-four participants who completed the online survey, a total of fourteen participants (58% retention rate) attended the online consensus meeting.

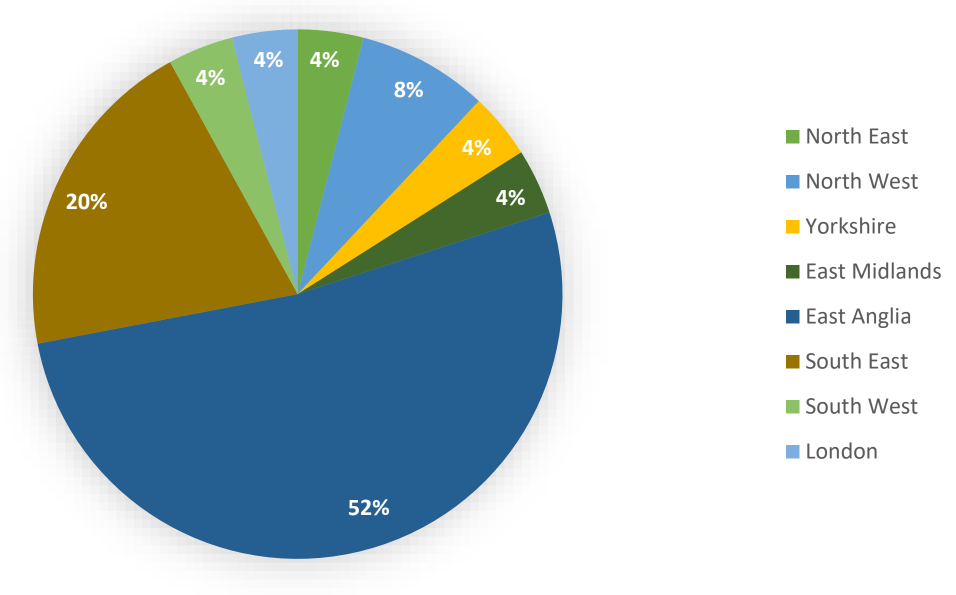

Figure 2: The region representation in the United Kingdom of the participants

5.3.2 Stage one – Online survey

All twelve tasks were classed as ‘important’ (100%), therefore a consensus was agreed on the tasks to be included in a RTW screening tool (Table 8).

Table 8: Results of perceived importance of operational tasks to be included in a return to work screening tool.

Task	Important	Not Important	Unsure
Ladder lift	100%	0%	0%
Ladder carry	100%	0%	0%
Ladder climb & leg lock	100%	0%	0%
Light portable pump lift	100%	0%	0%
Light portable pump carry	100%	0%	0%
Hose carry	100%	0%	0%
Hose run	100%	0%	0%
Casualty evacuation	100%	0%	0%
Putting on & removing breathing apparatus set	100%	0%	0%
Enclosed space crawl	100%	0%	0%
Aerobic fitness test	100%	0%	0%

5.3.3 Aerobic fitness levels, task repetition, distance & mass

A 90% consensus was agreed that firefighters should meet the minimum aerobic fitness level (42.3 ml/kg/min) prior to returning to operational duties (Figure 3).

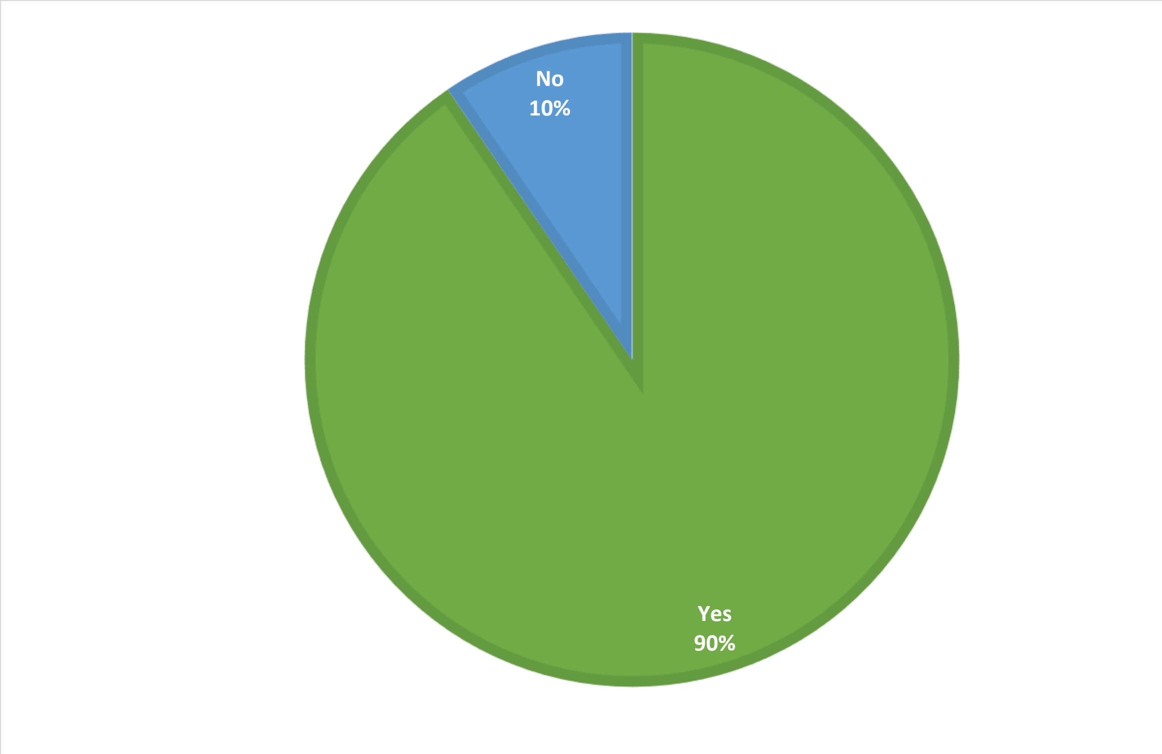

Figure 3: Should a firefighter meet the minimum aerobic fitness level (42.3 ml/kg/min) before returning to operational duties?

Consensus could not be reached for the number of repetitions required for ladder lift, ladder climb with leg lock, lifting an LPP, or putting on and removing a BA set (Figure 4). Consensus could not be reached for the distance required when carrying a ladder, an LPP, a hose, and a simulated casualty (Figure 5). Consensus could not be reached for the distance required to crawl in an enclosed space (Figure 5). Consensus could not be reached for the mass of the simulated casualty (Figure 6).

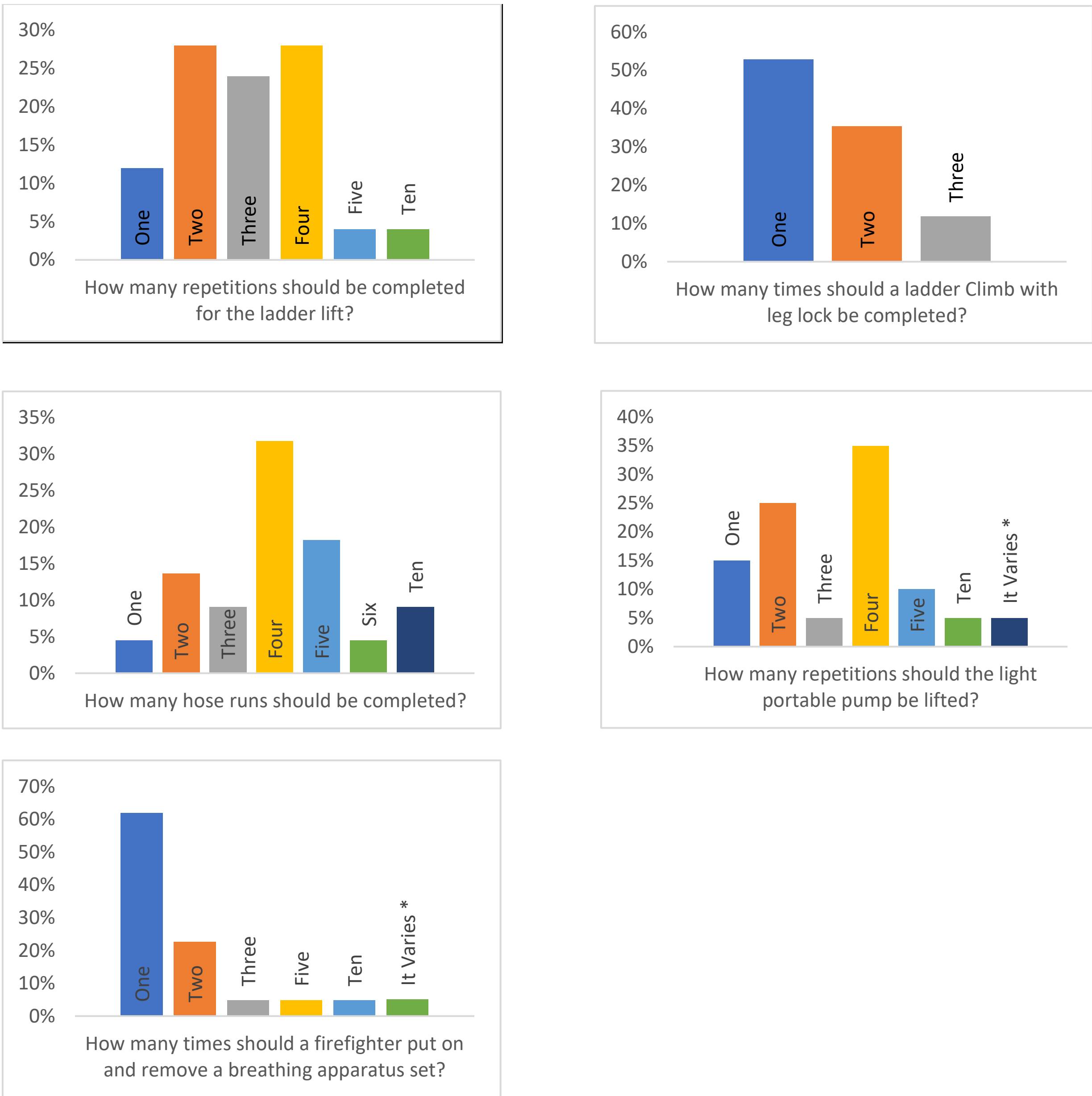

Figure 4: Survey results for the number of repetitions in each operational task to be used in a return to work screening tool following injury. *One participant believed that the number of repetitions varied dependant on the firefighter's injury.

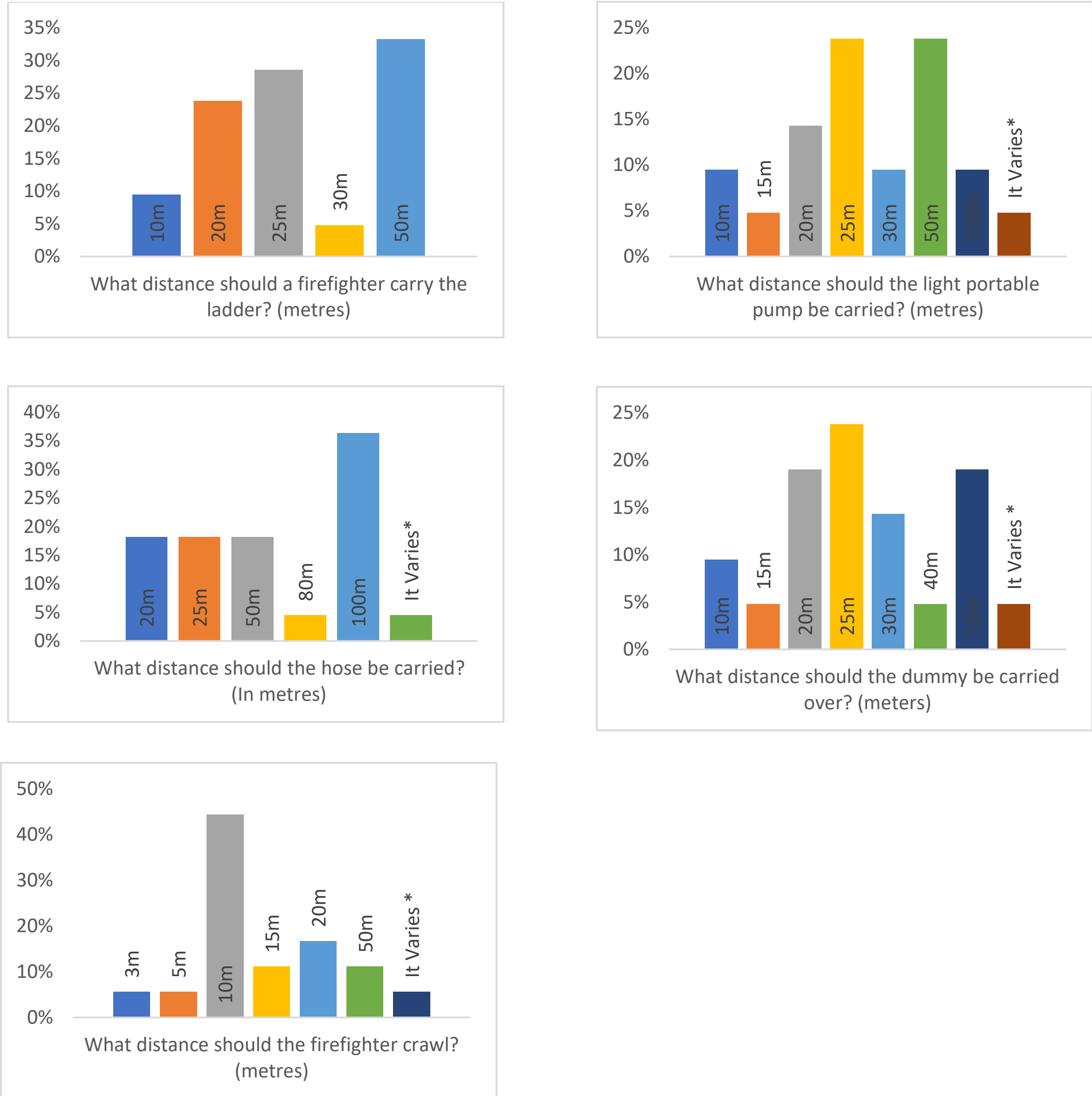

Figure 5: Survey results of the total distance to be completed in each operational task to be used in a return to work screening tool. *One participant believed that the required distance varied dependant on the firefighter's injury.

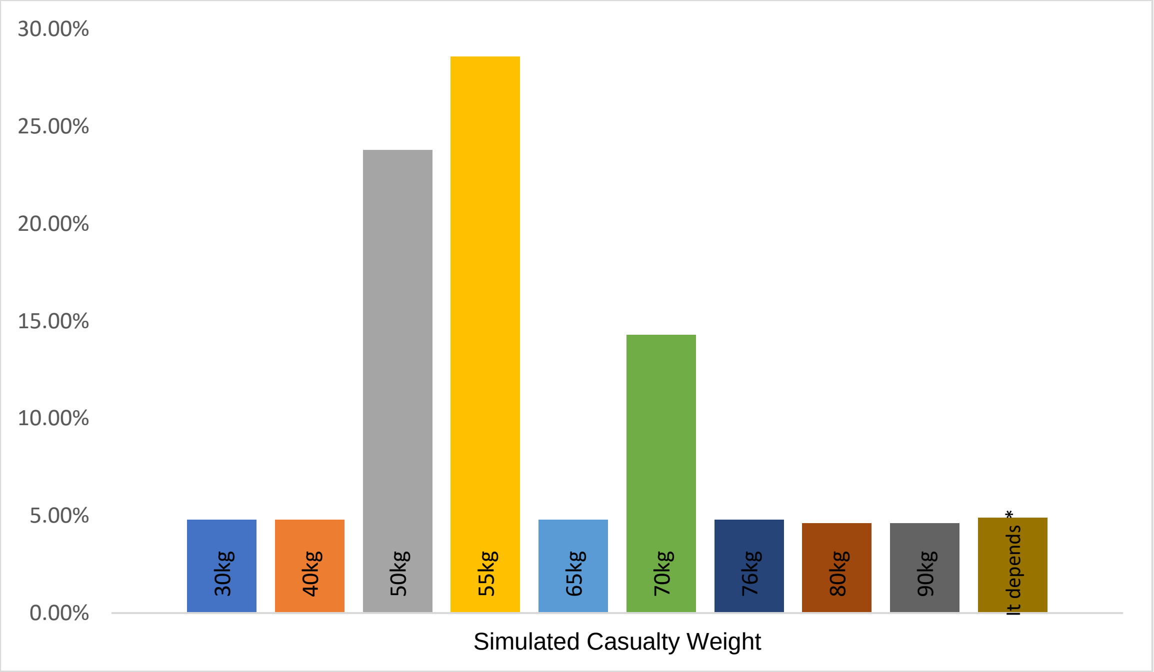

Figure 6: Survey results of the total mass (KG) to be used during a simulated casualty evacuation in a return to work screening tool. *One participant believed that the weight of the casualty was dependant on the firefighter's injury.

5.3.4 Survey results - task order of importance

The results were varied, and a consensus could not be made as no task rank reached more than 70% agreement (Table 9). Therefore, the task-related order of importance was carried forward onto stage two, the online consensus meeting for further discussion.

Table 9: Survey results of the task order of importance for a return to work screening tool following injury (One = most important, Eleven= least important).

Task	1	2	3	4	5	6	7	8	9	10	11
Lifting a ladder	4.55%	18.2%	9.09%	4.6%	9.1%	27.3%	9.1%	4.6%	0.0%	9.1%	4.6%
Climbing a ladder	0.00%	0.0%	0.00%	9.1%	4.6%	9.1%	18.2%	18.2%	27.3%	13.6%	0.0%
Carrying a light portable pump	0.00%	0.0%	0.00%	0.0%	9.1%	4.6%	4.6%	27.3%	18.2%	18.2%	18.2%
Carrying a Hose	0.00%	18.2%	13.64%	22.7%	13.6%	13.6%	4.6%	0.0%	4.6%	4.6%	4.6%
Hose Running	0.00%	4.6%	18.18%	13.6%	22.7%	18.2%	9.1%	4.6%	4.6%	0.0%	4.6%
Carrying a ladder	0.00%	4.6%	9.09%	9.1%	13.6%	9.1%	27.3%	13.6%	4.6%	4.6%	4.6%
Casualty Evacuation	0.00%	0.0%	18.18%	9.1%	13.6%	13.6%	13.6%	13.6%	9.1%	9.1%	0.0%
Putting on/ Taking off a breathing apparatus set	9.09%	22.7%	13.64%	22.7%	9.1%	4.6%	4.6%	9.1%	4.6%	0.0%	0.0%
Climbing into a fire appliance	18.18%	22.7%	9.09%	4.6%	0.0%	0.0%	4.6%	0.0%	9.1%	22.7%	9.1%
Crawling through enclosed spaces	0.00%	4.6%	0.00%	0.0%	4.6%	0.0%	4.6%	4.6%	18.2%	13.6%	50.0%
Aerobic Fitness Test	68.18%	4.6%	9.09%	4.6%	0.0%	0.0%	0.0%	4.6%	0.0%	4.6%	4.6%

5.3.5 Stage two – Online consensus meeting

Fourteen participants (58% retention rate) took part in the online consensus meeting. The duration of the meeting was two hours. Twelve items were brought forward from stage one to be discussed further in this meeting. During the discussion in the online consensus meeting, some options relating to the number of repetitions to be completed, distance to be completed and mass to be lifted or carried, were disregarded by the participants as a method to narrow down the options when seeking to gain a consensus agreement. As a result, some tasks had fewer options to choose from when seeking to gain a consensus. Of these, a consensus ($\geq$70% agreement) was reached on nine items. A consensus could not be reached by the participants for two items. Due to a consensus being reached on 81.8% of the included items, a pragmatic decision was made to end the study after two stages. Previous research has advised that repeated rounds in a Delphi study may lead to fatigue by respondents and decrease participation levels as a result (225). Therefore, if it was assumed that an additional round would not significantly add to the results of the study and it should be stopped (226). In addition, despite three items not achieving a consensus for two items, the results provided a range of repetitions deemed suitable for the tasks.

5.3.6 Online consensus meeting - task repetition, distance & mass

Consensus was reached on three out of the five tasks relating to the total number of times a task had to be performed. Ladder climb and leg lock were agreed to be performed once, an LPP lift was agreed to be performed twice and a hose run was agreed to be performed twice. Consensus was not gained for ladder lift and putting on and removing a BA set (Figure 7). Consensus was reached for all five tasks relating to the total distance to be completed. The distance of the ladder carry, hose carry and the LPP carry had an agreed consensus of 50m. The casualty evacuation distance had a consensus agreement at 25m, and the enclosed space crawl was agreed at 20m (Figure 8). A consensus was agreed that the mass of the casualty to be used in a simulated evacuation should be 55kg (Figure 9).

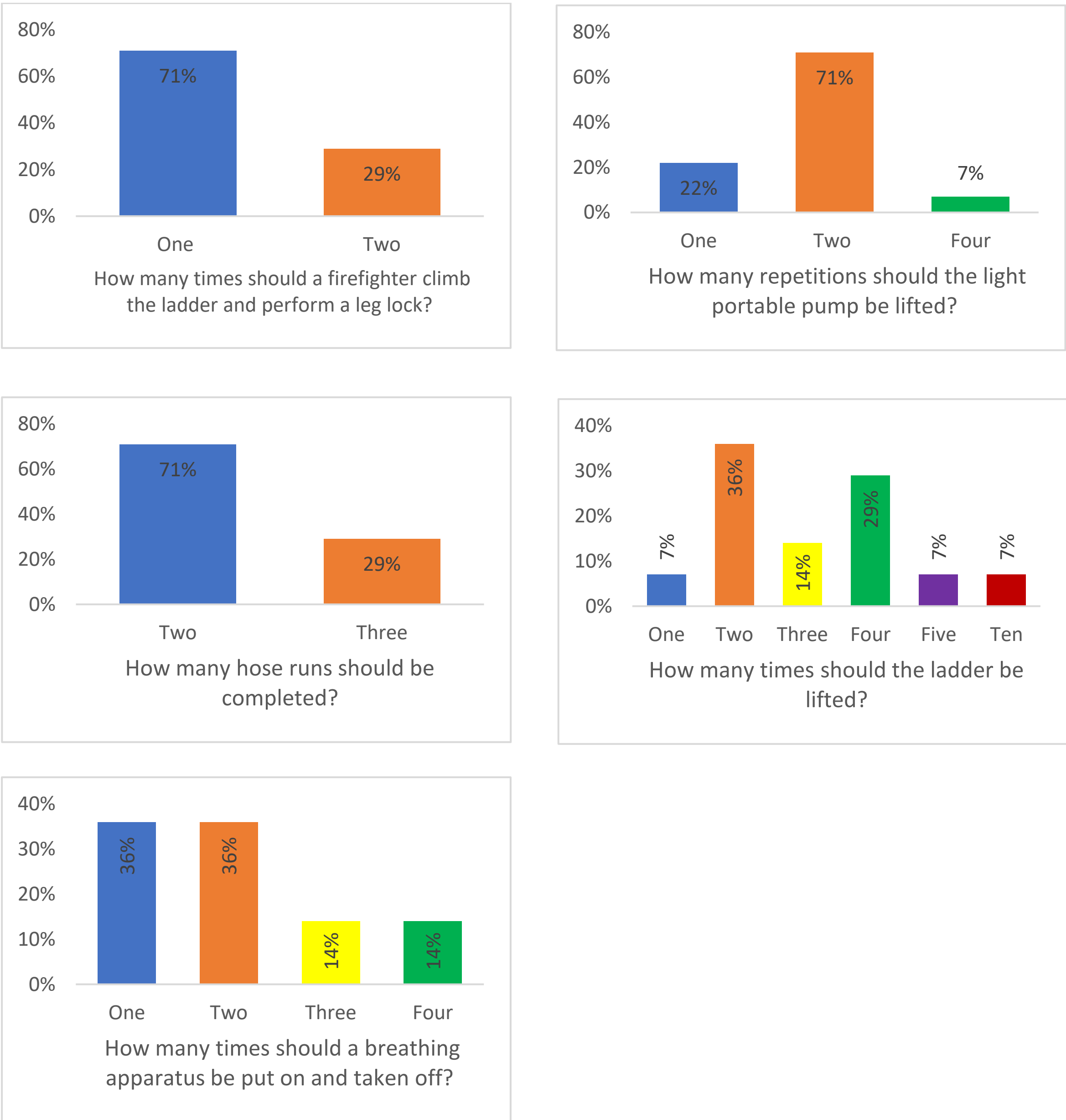

Figure 7: Results from the online consensus meeting for the total number of repetitions for each operational task.

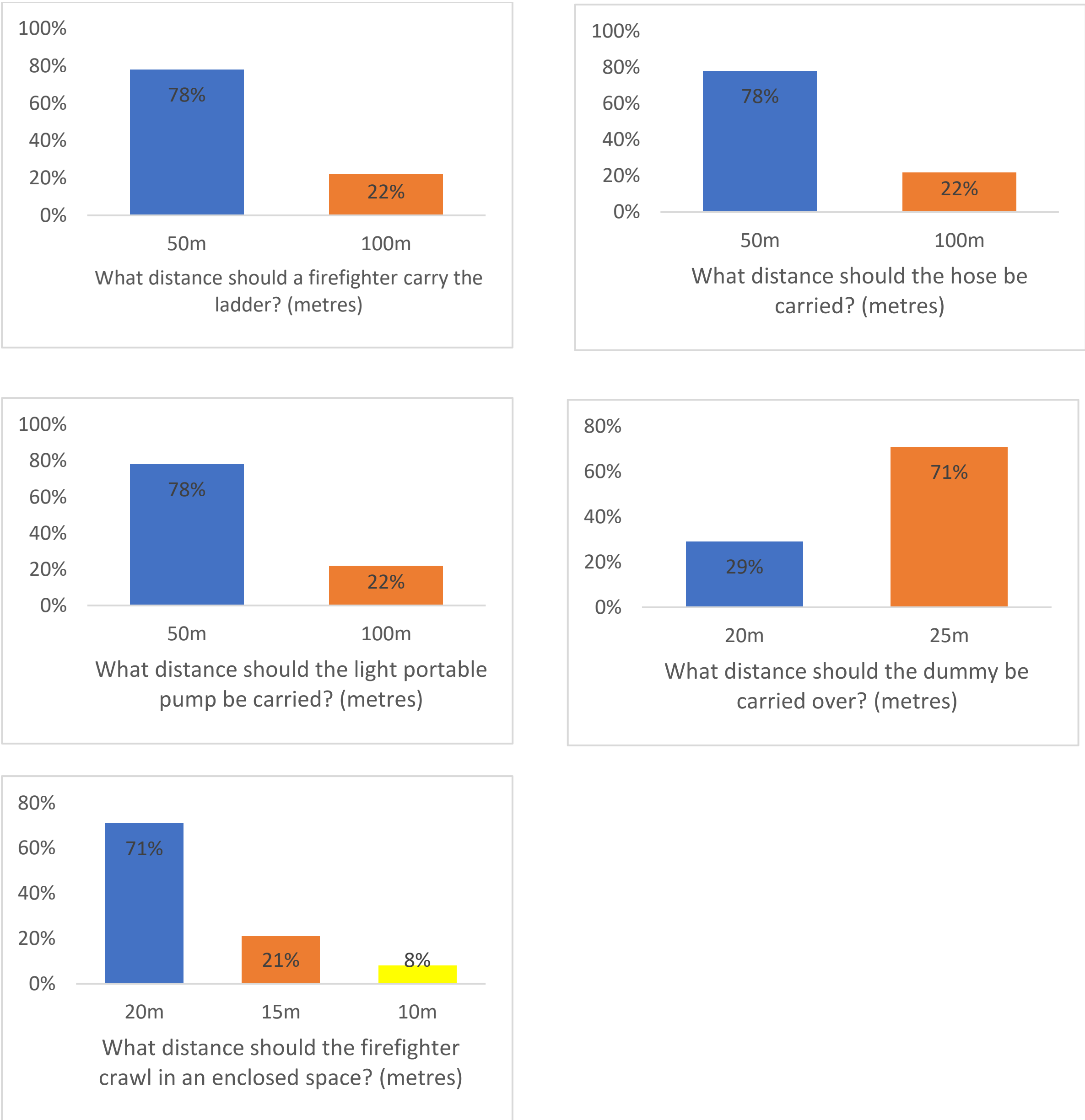

Figure 8: Results from the online consensus meeting for the total distance to be completed for each operational task.

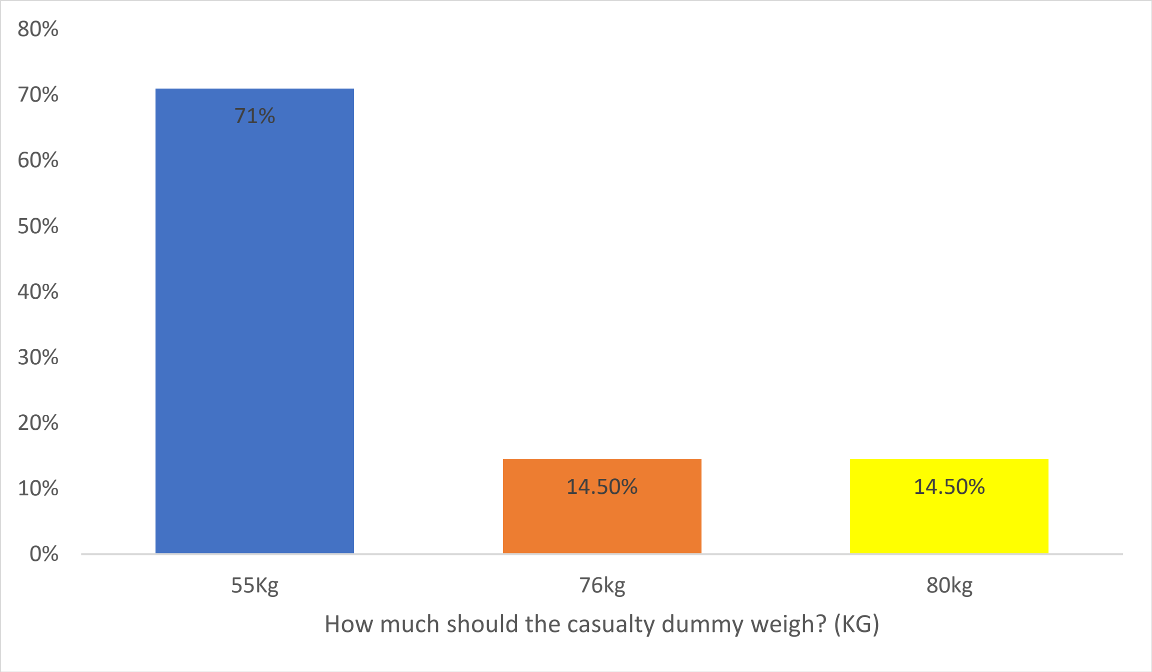

Figure 9: Results from the online consensus meeting of the total mass (KG) to be used during a simulated casualty evacuation.

5.3.7 Online consensus meeting - task order of importance

A consensus could not be reached on the order of importance for the eleven tasks to be completed. An aerobic fitness test was agreed to be the most important task to be tested. However, there was no agreement for the order of the remaining tasks. Instead, a consensus was agreed that the order of the remaining tasks was irrelevant as long as they were all included in a RTW screening tool.

5.4 Discussion

Currently, no nationally agreed screening tool for RTW within the fire services of the United Kingdom exists. Given the importance of firefighters returning safely to work, the purpose of this study was to seek a consensus on the tasks to be included in such a screening tool. To the author’s knowledge, this is the first study that is specifically focused on a RTW screening tool for firefighters following injury.

Discussion largely took place around the included tasks related to the role of a firefighter and expectations during an operational incident. The group dynamic during the discussion in stage two consisted of professionals working for fire and rescue services. Operational trainers and fitness advisors may have had a better understanding of the operational requirements of a firefighter whilst on duty when compared with staff members working within occupational health. Given that the group dynamic of the online meeting consisted of more operational trainers and fitness advisors, this could have led to some members of staff from occupational health changing their mind to agree with the operational trainers and fitness advisors and therefore, this could have impacted the consensus agreement levels. This could have been mitigated through further questioning of participants by LN during the online meeting to provide participants with the opportunity to explain their reasons for their decision in more detail. Alternatively, LN could have implemented an anonymised voting system during the online meeting whereby participants informed only LN of their final decision for each question relating to the consensus agreement.

Consensus was subsequently gained for eleven of the thirteen tasks. Accordingly, these eleven tasks could now be considered as the framework for a fit for duty screening tool. The structure of this screening tool draws similarities with current UK national firefighter recommendations for minimum operational aerobic fitness levels (19) and recruitment selection tests (128). This could have influenced the choices made by the participants for the total number of repetitions, distance to be covered and mass to be used during a RTW screening tool. However, the current recruitment selection tests do not include all key operational tasks required from a firefighter, including hose running and would therefore not be suitable for a RTW screening tool (128).

The interpretation of the fit for duty screening tool results and what order to undertake included tasks remains unknown. One potential solution to address these challenges would be to anchor a traffic light system to each task, similarly used to assess aerobic fitness levels for firefighters in the UK (124).

This was calculated by subtracting the mean standard deviation for hose running, equipment carrying, casualty evacuation and stair climbing from the minimum performance standards for operational firefighter duties. The results from this created a VO_2 max cut-score of 35.6ml/kg/min (42.3-6.7ml/kg/min) for firefighters (18). This system uses colours to indicate an individual's performance level on a particular task (124). For example, if a firefighter's VO_2 max is 42.3ml/kg/min or greater they would be in the 'green' category and ready to RTW. If a firefighter's VO_2 max level is between 35.6-42.2ml/kg/min they would be in the 'amber' category. If a firefighters VO_2 max level is below 35.6ml/kg/min they would be in the 'red' category. Firefighters in the 'amber' and 'red' category are unable to RTW. Firefighters in the 'amber' and 'red' category are required to improve their VO_2 max level to at least the required standard of 42.3ml/kg/min before they can RTW (19). Whenever the firefighter is unable to attain the required aerobic fitness standard, a referral to an occupational health professional is required to assess if a firefighter has any underlying health issues preventing them from achieving the required aerobic fitness standard. Once cleared by an occupational health professional, firefighters are required to undertake remedial training to improve their aerobic fitness. If no improvement in aerobic fitness is made through remedial training, the firefighter's line manager is then able to provide options for extra support or proceed with disciplinary action if necessary.

Alternatively, a pass or fail criteria could be used to interpret the results of the screening tool to determine if a firefighter is permitted to RTW and to resume operational duties. A pass or fail criteria would require individuals to achieve the set number of repetitions or distance where consensus was achieved for all tasks in this RTW screening tool before being allowed to resume operational duties. Pass or fail criteria have been used previously to assess the physical capabilities of firefighters during recruitment and selection tests (227-229). Research focusing on firefighters physical abilities sets a minimum number of repetitions firefighters need to achieve for set tasks for a pass to be awarded (227). Additionally, time threshold scores have been implemented to establish pass criteria results for aerobic fitness levels in firefighters (228).

Although consensus was not reached on the order of importance of each task, it was agreed that an aerobic fitness test should be conducted prior to any other fitness test. Aerobic fitness underpins vital operational duties such as dragging a casualty out of a burning building or hose running (124). Accordingly, it is important that a firefighter possesses both the required aerobic and strength levels to reduce the risk of overexertion and potential injury (17).

Considering the order of the tasks to be undertaken, it may be helpful to divide them into ‘push’, ‘pull’ and ‘carry’ movements where possible (230). This could help reduce unnecessary repetition of task movements and avoid fatigue which could cause an individual to unfairly fail a subsequent task (230). Each movement could be assessed using one’s bodyweight to ensure the correct technique is performed initially. Additional load could then be added until the physical demand of the tasks has been reached (231). The benefits of this progressive approach help to ensure that movement patterns are not compromised by external loads placed on the individual which could reduce injury risk (232).

5.4.1 Strengths and limitations

In this study experts from fire service fitness and occupational health departments, as well as operational firefighters in the UK, were surveyed. These experts were selected from national and regional steering groups, but did not include representation from every fire service in the UK. Nevertheless, those on the national and regional steering groups have previously been involved in creating national firefighting guidance (16, 19). The online survey approach helped to reduce the impact on participants. Those who took part in both the survey and consensus meeting were able to do so without any travel or expenditure required. Whilst this consensus has determined the content of physical tasks to be undertaken in a RTW screening tool, there is no consideration given to a firefighter's psychological readiness to RTW. This can include negative responses of fear of reinjury and stress (233) which can lead to reduced levels of self-esteem and increased anxiety levels (234). The extent these factors play for a firefighter's RTW following injury is not yet understood. Further research exploring potential psychosocial barriers and enablers influencing a firefighter's RTW is warranted.

5.5 Conclusion

This study has provided a consensus for tasks to be considered as a framework for a screening tool when assessing a firefighter's physical readiness to RTW. The key tasks to be included in a RTW involve lifting and carrying equipment including ladders, hoses, casualties and an LPP. Aerobic fitness testing is another vital task required for a firefighter's RTW. Further research is needed to understand how to use this screening tool optimally. This includes how to determine if a task has been ‘passed’ and the order to undertake the tasks. Consideration should be given to utilising a criteria system to rate how successfully the firefighter completed the tasks for readiness to RTW. Additionally, further research is required to exploring potential psychosocial barriers and facilitators experienced during a firefighter’s RTW.

Chapter 6: Psychosocial barriers and facilitators for a successful return to work following injury in firefighters.

Based upon - Noll L, Mallows A, Moran J. Psychosocial barriers and facilitators for a successful return to work following injury within firefighters. International archives of occupational and environmental health. 2022 Mar;95(2):331-9. (Appendix 10)

Abstract

The aim was to explore firefighter's experiences during their recovery from injury. Focused specifically on exploring perceived psychosocial barriers and facilitators firefighters faced during recovery and return to work. Semi-structured interviews were used to provide an in-depth understanding of the firefighter's experiences. The semi-structured interviews were informed by a topic guide. The topic guide focused on five main themes, (1) overall experience of returning to operational duties following an injury, (2) perceived barriers experienced during their return to work, (3) perceived facilitators experienced during their return to work, (4) confidence in participating in physical activity following injury and (5) where they felt areas of improvement could be made with the return to work process. Thematic analysis of the data collected was undertaken using The Framework Method. Two main themes were sought after transcription: barriers and facilitators. From these, nine subthemes were identified (1) communication, (2) confidence in physical activity participation, (3) modified duties, (4) physiotherapy, (5) return to operational duties, (6) support, (7) inconsistency, (8) use of station gyms, (9) detachment from the watch. Consideration should be made for the consistency of procedures followed during an individual's return to work following an injury. Further research is needed to understand if the themes identified in this study are the same for other fire services. Further research is also needed to understand how the findings may be best implemented within the fire service.

6.1 Introduction

Recovery from injury and the subsequent RTW is a complex issue (235). For firefighters, the physical demands of their job and the need for recovery to meet these demands are well documented (5, 16). Government statistics show that 2,278 firefighters in the UK suffered an injury between 2021 and 2022 (236). Return to work for firefighters following common occupation-related injuries, such as MSK strains and sprains and stress fractures (28) can take from three to twelve weeks (237, 238). Reinjury rates for MSK sprains and strains are reported to be between 7% and 34% (239, 240) and stress fractures have been reported at 29% (241). Such high reinjury rates suggest that current processes are suboptimal for assessing a firefighter's physical readiness to RTW and the need to understand factors that influence a successful RTW. In the previous chapter, a consensus study highlighted the need for a physical RTW screening tool for firefighters following a work-related injury, assessing physical parameters including muscular strength and aerobic fitness (see Chapter 5). Physical tasks including hose running, hose carrying, ladder lifting, ladder climbing, and casualty evacuation were agreed to be included in a firefighter's RTW process. Other factors including social support and psychological factors such as fear of reinjury and stress also need to be considered (242, 243).

Negative psychological responses can lead to low levels of self-esteem as well as feelings of anxiety, depression, and increased stress (234). Progression through rehabilitation and recovery can be negatively affected by increased stress levels (233). Negative responses have been shown to peak at two particular points (244); when the injury occurred and when the individual is allowed to return to physical activity in the same capacity before becoming injured (243). Fear of reinjury is an example of a negative response which can be a common factor amongst individuals returning to physical activity (243). Despite pain resolving and function and strength returning, hesitancy to return to physical activity due to a fear of reinjury can remain (245, 246). Reasons for this can include increased anxiety and catastrophic thinking which can decrease motivation to return to physical activity (247). In addition, previous experience of injury has been documented to relate to a feeling of ‘coming to terms’ with the injury and can reduce motivation to meet the demands of returning to pre-injury status (248). This decrease in motivation can then lead to physical inactivity (247).

Physical inactivity decreases aerobic fitness and strength levels (249, 250). Decreased fitness and strength levels negatively impact firefighters’ performance levels and safety when completing job-related tasks (5). These tasks include hose running, hose carrying, ladder lifting, ladder climbing, and casualty evacuation (16). The majority of operational tasks are completed by a firefighter within a group setting with other firefighters on duty alongside them (248). The duty system is also known as a “watch” and firefighters can spend a long time working with the same “watch”, tending to both physically- and psychologically-challenging incidents (251). This contributes to creating strong bonds and friendships between them (251).

A reduction in social contact with colleagues whilst being off work injured can cause feelings of frustration due to the sudden lack of involvement (252). Being away from colleagues due to injury can create a feeling of psychological detachment, which can result in a reduced sense of wellbeing (253). Social support during recovery from an injury can increase motivation and a sense of inclusion, in addition to decreasing symptoms of depression and anxiety when returning to physical activity (254, 255).

There is limited research focused on firefighters' RTW following an injury in the UK. The importance of understanding psychosocial factors for a successful RTW is clear from other active populations such as athletes and military personnel (234, 246-248, 254, 256). However, to date, this has not been investigated in a firefighter population. Accordingly, the aim of this study was to explore firefighters' experiences during RTW following an injury. Specifically, we sought to explore perceived psychosocial barriers and facilitators firefighters faced during injury recovery and RTW.

6.2 Methods

6.2.1 Study Design

This study used semi-structured interviews to provide an in-depth understanding of the perceived barriers and facilitators experienced by firefighters' during their RTW from injury. The study was reported in accordance with the consolidated criteria for reporting qualitative (COREQ) research guidance (257).

6.2.2 Data Collection

Semi-structured interviews were informed by a topic guide (258) (Appendix 11). The topic guide was developed by the chief investigator (LN). Previous research has recommended that topic guides should include open ended questions to enable participants to provide in-depth information relating to the research question (259). The topic guide was used to gain an understanding of the overall experience of a firefighter during their return to operational duties following a MSK injury. To help gain this understanding the topic guide was focused on five themes for a firefighter returning to operational duties following a MSK injury: [1] Overall experience of returning to operational duties following an injury, [2] perceived barriers experienced during their RTW, [3] perceived facilitators experienced during their RTW, [4] confidence in participating in physical activity following injury and [5] areas in which the firefighter felt improvements could be made in the RTW process. Although a topic guide was used, interviews were allowed to be flexible according to each participants experience to help gain an understanding of the perceived barriers and facilitators they experienced during their RTW process.

The interviews were conducted one to one with LN acting as interviewer. LN is a PhD research candidate who has received training in conducting semi-structured interviews. Both LN and the participants in this study were employed by Essex Country Fire and Rescue Service. LN was a member of the support staff team working as a fitness advisor and the participants were operational firefighters. The interviews were held via Zoom and recorded on Zoom (223). Field notes were made during and after the interviews in this study. Two pilot interviews were conducted by LN with work colleagues within the fire service fitness department prior to start of the interviews with the participants. Pilot interviews enabled LN to become familiarised with the questions and assess if any interview questions in the topic guide needed amending following feedback from colleagues. In addition, pilot interviews allowed for testing the run time of each interview and testing of the recording function to test the sound quality of both the researcher and the individual interviewed.

6.2.3 Participants

All current operational firefighters from Essex County Fire and Rescue Service who had previously been injured and returned to work were identified from attendance records and invited to participate (n=20). Records extended to the past 24 months. Twenty participants were emailed an invitation by LN to take part in an interview, along with the participant information sheet. Interested participants had an opportunity to ask questions via email or telephone prior to organising an interview date and time at a mutually convenient time. Prior to commencing the interview, the participant had a further opportunity to ask any questions before providing written consent via email. Consent was also audio recorded. Data saturation was determined when all pre-determined themes had been represented adequately in the data collected (260, 261).

6.2.4 Data Analysis

The recordings were transcribed verbatim and then coded using NVIVO 12 software by LN (262). The coding was checked and verified by AM. Thematic analysis of the data collected was undertaken using The Framework Method. The Framework Method has been developed specifically for applied research in which the objectives of the investigation are set *a* priori (263). The Framework Method allows for a systematic approach to qualitative analysis which provides the ability to compare and contrast data by themes across individual cases (264). The Framework Method consists of seven steps of data analysis (Table 10). LN sent the results framework to all participants to give them an overview of the results for interpretation.

Table 10. Use of The Framework Method during analysis of data.

Step of Analysis	Description
1. Transcription	The recordings of the interviews were transcribed verbatim by the chief investigator (LN)
2. Familiarisation with the interview	All recordings where relistened to and quality checked with the transcripts by LN.
3. Coding	All transcripts were read line by line and codes were applied to the parts of the interviews that were deemed to be relevant by LN. The parts were coded in relation to the pre-existing themes which were informed by the topic guide. Open coding was also used during this process for parts of the interviews which were interesting but didn't fit with the initial coding framework. This was to ensure that potentially important pieces of data were not missed. Coding was reviewed and verified by AM.
4. Developing a working analytical framework	Once all coding was completed, LN analysed the coding to establish that there were no new themes to add relevant to the research aims.
5. Applying the analytical framework	The transcripts were then indexed and codes were used relating to the pre-existing themes by LN. NVIVO 12 software was used to code the transcripts.
6. Charting data into the framework matrix	The coded data from the transcripts was inputted into a final report, and the quotations from the participants were numbered to keep anonymity. LN was assured that data saturation, in relation to the research aims, had been achieved and no new themes had been found from the final interviews.
7. Interpreting the data	LN interpreted the coded data and explored the relationship between the pre-existing themes in relation to the research aims. From these, nine subthemes were identified.

6.3 Results

Twenty firefighters met the inclusion criteria and were invited to participate in the study. Of these, twelve (60%) agreed to participate (Table 11). No response was received from the remaining eight firefighters (40%) invited. Interviews lasted up to thirty minutes. Theoretical saturation has been defined as the point when no new insights are obtained, no new themes are identified and no new issues arise (265). After 12 interviews, no new themes or new insights occurred and theoretical saturation was achieved. As a result, no further interviews were undertaken.

Table 11. Participant Characteristics.

Participant	Gender	Rank	Duty Type
1	Male	Firefighter	On-Call
2	Female	Firefighter	Wholetime
3	Male	Firefighter	On-Call
4	Female	Firefighter	Wholetime
5	Male	Crew Manager	Wholetime
6	Male	Firefighter	Wholetime
7	Male	Firefighter	Wholetime
8	Male	Firefighter	On-Call
9	Male	Firefighter	Wholetime
10	Male	Firefighter	On-Call
11	Male	Firefighter	On-Call
12	Male	Watch Manager	Wholetime

6.3.1 Findings

Two main themes were sought after transcription; perceived barriers and facilitators experienced during the RTW process. From these, nine subthemes were identified;

(1) Communication, (2) Confidence in physical activity participation, (3) Modified duties, (4) Physiotherapy, (5) Return to operational duties, (6) Support, (7) Inconsistency, (8) Use of station gyms, (9) Detachment from the watch.

The nine subthemes have been displayed as a Venn diagram, with overlapping circles of perceived barriers and perceived facilitators (Figure 10). The subthemes participants perceived as barriers only are displayed in the left circle of the Venn diagram and the subthemes participants perceived as facilitators only are displayed in the right circle of the Venn diagram. Any subthemes participants perceived as both barriers and facilitators are displayed in the middle of the overlapping circles of the Venn diagram.

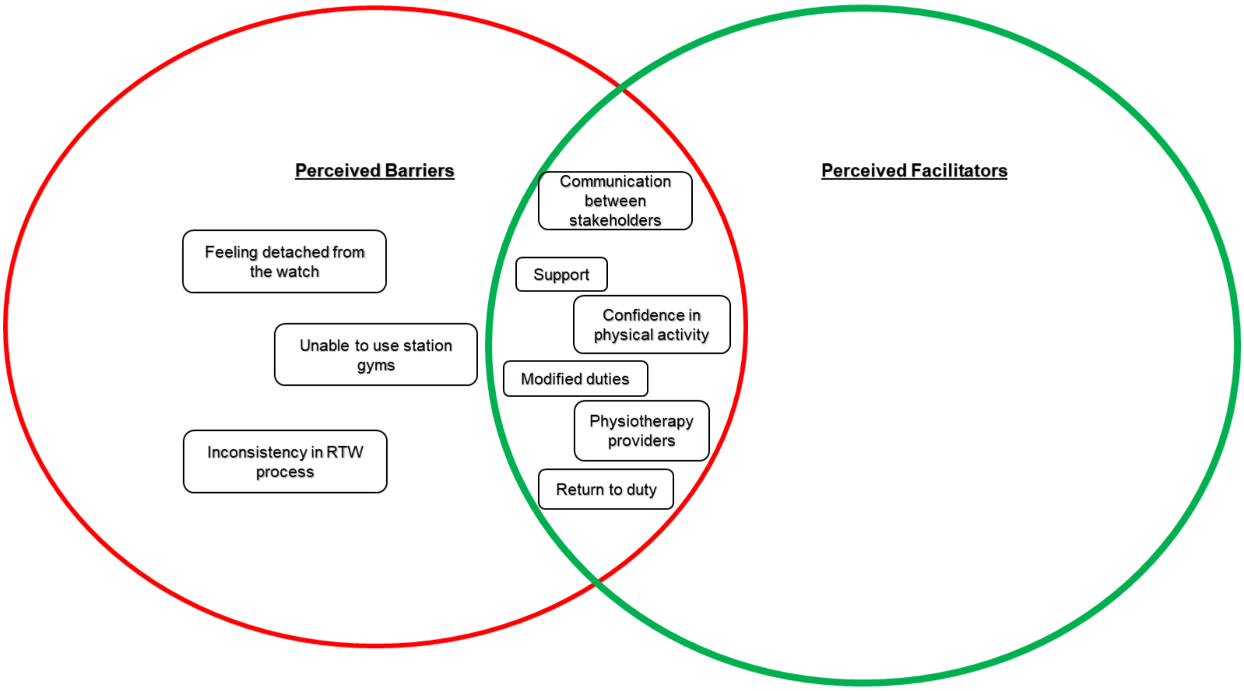

Figure 10: Perceived barriers and facilitators experienced during the RTW process.

6.3.2 Barriers

6.3.2.1 Theme One: Communication

Communication between different departments involved in the RTW process was perceived as being a barrier:

"It could have helped with a quicker return if everyone was in communication with each other. I felt all different departments were separate and the lack of communication dragged the process along". - Participant 3

"I had to keep relaying my progress to each person I met, the fitness team, occupational health, my physio, the firefighter's charity. There seemed to be no communication between everyone" - Participant 12.

6.3.2.2 Theme Two: Confidence in physical activity participation

A common theme reported was confidence to participate in physical activity following an injury was low.

"I started to take myself out for short jogs, but was nervous as hell doing it" – Participant 2

"My confidence was completely shot if I'm honest. I was so worried about doing any damage that I did the bare minimum, which was frustrating because I kept comparing to how I was. Even though I wanted to get back to my original fitness, I just didn't have the confidence to push myself." – Participant 12

6.3.2.3 Theme Three: Modified duties

Whilst recovering from their injury, some firefighters were given the opportunity to work on modified duties. However, other firefighters were not given this opportunity and because of this, they perceived it as a barrier during their RTW experience.

“If you are keen to get back, I think light duties would be beneficial. Rather than a simple on or off the run. I was only allowed back when I was “fully fit”. When I was recovering, I could have gone back to the station to help out with some admin or light training to be involved with the watch. I knew there were things I could do and things I couldn’t do but you shouldn’t be kept off the run just for the things you can’t do.” – Participant 1

“I was just frustrated that I couldn’t return to operational duties until I had completed the tests with you and felt it was just a tick in the box exercise.” – Participant 7

“I would have loved to be able to return to work in a format where I could do some things and not others, that way I could still help out. Instead of this all or nothing approach.” – Participant 11

6.2.3.4 Theme Four: Physiotherapy

All of those interviewed had some form of treatment from a physiotherapist during their rehabilitation. Some found that the expectations from the physiotherapists for recovery was not meeting work demands.

“The physio’s were mainly looking for weight bearing movements and walking but I knew in the back of my mind what I would be required to do when returning to operational duties.” – Participant 5

“They helped and I did benefit from them, however, I knew that the level I needed to reach was beyond their expected level from me” – Participant 6

6.2.3.5 Theme Five: Return to operational duties.

Once they had returned to operational duties, some firefighters felt that the aftercare from human resources could have been better.

“I felt like I was expected to just return to normal as if nothing had happened. I didn’t mind it, but it would have been nice for someone from HR to check in to see how I was doing.” – Participant 6

Three firefighters reported that there needed to be an improvement in the aftercare following a return to work from injury.

“If the service could offer something like a check in every few weeks with a fitness plan that would be good” – Participant 2

“It would be good for the fitness team to create a training package where firefighters could go to and select a workout suitable for the equipment they have or body part they want to train. It could go up on the wall to make it easily accessible.” Participant 3

“I feel that it would be good to have a follow up from the fitness team every few weeks or so just to check in see how my training was going. We have the firefighter’s charity but if that wasn’t there it would be good to have a more in house one. Some people might find it inconvenient, but I think it would be good to offer support. We sometimes package people up send them back on operational duties and that’s it. Maybe an option at the end of the functional assessment to op-in to follow ups.” – Participant 5

6.2.3.6 Theme Six: Support

The support from the fire service varied across the firefighters interviewed. Some firefighters felt mistreated and that the service was putting barriers in their way to return to work.

“It would have been good to know what was expected of me early doors so I could prepare a bit better. It took me another month or so to build up the running and fitness required for the functional assessment, whereas I feel if I knew beforehand, I could have trained specifically and reduced my time off work.” – Participant 6

“My manager was also fully aware that I needed to do a functional assessment so I guess it would have been nice for him to let me know to reduce the delay. If I had known, I would have got it booked in advance for the day my sick certificate ran out. I just wanted to get back and it felt like there were hurdles put in my way for what was in my opinion a simple injury.” – Participant 7

6.2.3.7 Theme Seven: Inconsistency

A common barrier reported was the inconsistency of the process for a firefighter to return to operational duties following an injury.

“I feel that there needs to be consistency in the service for return to work. So that no matter where you are based you are aware of what needs to be achieved to return to work. That way it would stop managers adding in extra assessments here and there because they feel like it.” – Participant 4

“I just don't see how there's one rule for one, and one rule for another. I was happy to do what I was told to do as it helped me get my confidence back. Just feel we should all be singing from the same sheet” – Participant 4

“I was asked to complete training reassessments on almost all elements of my task before I could return to being a firefighter. Other firefighters I know were only asked to complete a functional assessment and then they were able to return to operational duties so when I was asked to do everything it made me feel inadequate and felt like the service were belittling my ability to be a firefighter.” – Participant 11

Other firefighters reported that the RTW process needed to be clearer to increase consistency.

“I think there should be a clear guidance of if you’re off work for an injury you are required to do a return to work assessment with the fitness team. Because it would clear any confusion I experienced and also possibly reduce the amount of time of spent on modified duties.” – Participant 7

“I think there needs to be a clearer policy of what determines a functional assessment. Or at least different levels of a functional assessment suitable for the injury. I get why it’s there and would be great for certain injuries, but I felt like mine wasn’t necessarily an injury that needed a functional assessment” – Participant 10

6.3.2.8 Theme Eight: Use of station gyms

Whilst injured, many firefighters weren’t allowed on station. This meant that they were unable to use the gym facilities during their recovery, which many perceived as a barrier.

“It was annoying as it meant I couldn’t train as much as I wanted for the functional assessment. I went for a few runs around my town to increase my cardio levels, but the weighted side had to be done at the physio and even then, it wasn’t using the full weight used on the functional assessment.” – Participant 8

“I didn’t have any weights at home to help increase my strength in my wrist which was a bit frustrating. It would have been nice to be able to go to the station to use the gym to help with my recovery or have the opportunity to have supervised gym sessions with someone from the fitness team maybe?” – Participant 9

“Being away from the station and not being able to train for my fitness test I would say was a barrier. My manager and you expected me to pass a test, but I wasn’t allowed to train towards it.” – Participant 10

6.2.3.9 Theme Nine: Detachment from the watch

Being away from the station also meant that injured firefighters were unable to meet up with the colleagues on their watch. This was reported as a barrier by many.

“I wasn’t allowed on station. I was considered a visitor and lost contact with the watch, the meals together, the environment, the banter. I feel this time around I feel complete disconnected with the watch. Normally, you are there to see the morning tests and routines but being away I felt separated. We have WhatsApp but it’s not the same as face to face contact.” – Participant 2

“We have a WhatsApp group we all stayed in contact with that. It would have been beneficial to have been slowly integrated back into the watch in small doses rather than being off and then straight back in. Would have been nice to have phased return. Would have been nice to see a few faces at time.” – Participant 3

“Initially during my time off I wasn’t able to go on station and it was hard not seeing the watch. We are a close group of people, so to be away from them was hard. I knew I had to rest up but I’m an active person and found it hard sitting at home watching TV.” – Participant 6

"It was frustrating being off the that long, not being able to see my friends down at the station, I felt a bit like I was being punished for being injured. I felt really detached from the station." – Participant 10

6.3.3 Facilitators

6.3.3.1 Theme One: Communication

Interviews found that communication regarding the RTW process and requirements to pass the functional assessment was good between different stakeholders including line managers and occupational health. This was a facilitator with their RTW process.

"I spoke to occupational health about what I was required to do to return to work and they said it would be a functional assessment, that's when I contacted you and asked what was involved. From there I worked with the physio to build up my fitness levels, specifically in my shoulder." – Participant 8

6.3.3.2 Theme Two: Confidence in physical activity participation

For some firefighters, their confidence was affected but they were comfortable participating in physical activity, building their strength back up gradually.

"My confidence wasn't knocked with training, I just took it very slowly to reintroduce myself to the exercise environment." – Participant 3

"Going back to running I was very cautious, so I started with a light jog and increased the speed slightly each week. Confidence to train on my own was okay, it was just having the confidence to push my knee." – Participant 6

6.3.3.3 Theme Three: Modified Duties

Whilst recovering from their injury, some firefighters were given the opportunity to work on modified duties. This was perceived as a facilitator during their RTW experience.

“The service was good, I moved departments and helped out with the road traffic collision reduction team a day job, which was lower impact.” – Participant 5

“I was allowed back into the training department to do light duties, this involved admin, cleaning equipment, nothing too strenuous but got me back in the rhythm of working again. I also was allowed to work flexible times as my medication made me tired towards the latter part of the afternoon.” – Participant 12

6.3.3.4 Theme Four: Physiotherapy

Some firefighters used private physiotherapy providers who had a contract with the fire service to allow six free treatment sessions for each firefighter per injury. These were perceived as a facilitator for many firefighters.

“For me the physio didn’t just help with the physical side but also the mental side for reassurance my injury was getting better.” – Participant 3

“They were really good because they knew I had been to the firefighter’s charity rehabilitation centre, and they spoke to the physiotherapists there before my visit to get an understanding of my progress. This helped with my progression through my rehabilitation.” – Participant 5

“They were very good in my opinion. They assessed my shoulder and we worked towards strengthening it for the functional assessment.” – Participant 8

6.3.3.5 Theme five: Support

Many firefighters reported that they felt supported throughout their time off being injured and during their RTW process.

“The watch worked and helped where needed for my limitations. For example, on a job the other members of the crew could do some of the other tasks and I could load up the other jobs which were under head height. We worked well as a team.” – Participant 1

“My manager was very supportive, but I was stubborn as I didn’t want to take time off work. But when the pain worsened, and I knew I needed to take time off the service as a whole were very supportive” – Participant 2

“I genuinely felt looked after and the advice was always spot on with no pressure to return to work. My station manager, again, was brilliant with supporting me” – Participant 3

“In terms of getting me back on the run, I was supported from my line manager, the service, the fitness team and the occupational health team. With sufficient time to get back onto the run and come along to do a RTW assessment.” – Participant 5

6.4 Discussion

The aim of this study was to explore the psychosocial barriers and facilitators during the RTW process following injuries to a firefighter. Two main themes were identified from the findings, barriers and facilitators. Nine sub-themes were identified; communication, confidence in physical activity participation, modified duties, physiotherapy, return to operational duties, support, inconsistency in the RTW process, use of station gyms and detachment from the watch.

The findings suggest that providing firefighters with station access to see their colleagues could increase social contact whilst being off sick. The reported feelings of detachment and frustration from being away from the fire station and their firefighter colleagues in this study are similar to those experienced in other active populations including athletes (233, 247). Previous research reported that low levels of social support from colleagues resulted in a strong negative correlation with a rehabilitating firefighters perceived stress levels ($P<0.05$) (266). In addition, support from a firefighter's manager was perceived as significantly more important than support from colleagues in lowering perceived stress levels ($P<0.05$) (266, 267). If a manager provided supportive contact with a firefighter during their injury rehabilitation, to assess the firefighter's injury rehabilitation progression, it could increase the firefighters perceived feeling of support and could have a positive effect on their experience during their injury rehabilitation. Supportive contact through text messages, phone calls or in person meetings have been found to increase an individual's adherence to rehabilitation exercise program (268). Furthermore, providing access to see colleagues could provide social support for firefighters and help to decrease the feelings of detachment from the watch. Examples could include joining meals or attending educational training lectures where no physical activity is required.

Future practice should consider allowing injured firefighters access to gym facilities in their fire stations to aid with their rehabilitation. An individual's muscular strength and aerobic fitness levels can decrease with physical inactivity (242). The majority of fire services in the UK require their firefighters to achieve a maximal aerobic capacity level of 42.3ml/kg/min as a minimum standard to be considered safe to carry out operational duties (19). A strength standard of a 32kg shoulder press and a 60kg rope pull down has also been recommend (17). Findings from this study imply that expectations from physiotherapists for the physical strength of a firefighters during rehabilitation are much lower than the required UK firefighter physical standards. Physiotherapists treating firefighters following MSK injury should consider the basic physical standards that an operational firefighter needs to achieve before returning to operational duties. Restricting access to gym facilities on station could result in physical training cessation (93), which could be a barrier to achieving these standards for returning to operational duties, especially as resistance training has been identified as critical for the recovery of MSK function following injury in athletic populations (269). Following training cessation, it has been reported that muscular strength and power performance can decrease by 7% to 14% following 28 days of training cessation (95). Maximal oxygen uptake was reported to reduce by 9.2% ($p<0.05$) following 18 days of training cessation (96). Given the above observations, providing access to station gym facilities could be further enhanced with an exercise training plan. At present, injured firefighters are not provided a fitness training programme to help with their RTW preparation unless they specifically request one from a qualified professional, in this case a fitness advisor to help increase the effectiveness of the firefighter's injury rehabilitation (270). Previous research has indicated that the provision of an individualised exercise training plan related to increased adherence to exercising and significant improvement in individuals fitness indicators, including weight, BMI, waist/hip ratio, body fat percentage, blood pressure and heart rate ($P=0.05$) (271).

A fitness training programme provides firefighters with a structured routine to follow during their injury rehabilitation (272). A fitness training programme comprised of resistance exercises and cardiovascular exercises have been reported to significantly increase physical fitness and optimise job related performance in tactical athletes (272). Additionally, it has been reported that insufficient support with fitness training reduces exercise adherence in firefighters (273). Previous research with professional athletes has demonstrated a negative correlation between exercise adherence and injury recovery time (268). Time off from work due to an injury can cause financial implications to both a firefighter and their fire service, as discussed in Chapter One (32). The use of a multidisciplinary team (MDT) has been shown to increase exercise adherence for individuals recovering from injury (274). Previous research has also highlighted that the use of a MDT during injury rehabilitation significantly improved function and disease status in patients with MSK conditions ($P<0.05$) (275). An MDT in a fire service, including physiotherapists, the occupational health department, the fitness team and senior management, should keep in regular contact with the firefighter to help support them during their injury rehabilitation. The MDT should monitor firefighters' progression through the fitness training programme and make amendments to the programme if required to help the firefighter stay motivated throughout their physical rehabilitation and increase their adherence to their training plan. Amendments can include exercise selection, the resistance weight used for an exercise, or the number of repetitions performed for an exercise.

To improve the development of an exercise plan for firefighters, good communication between physiotherapists and the fire service occupational health department is needed (270). Communication was a barrier reported in this study, specifically between physiotherapists, occupational health personnel, fitness advisors and senior managers. Findings from previous clinical rehabilitation research found that weekly meetings involving all members of the MDT working with the rehabilitating individual, significantly improved the considerations of the patients' needs and provision of goal setting targets to aid with the patients rehabilitation ($P<0.001$) (276).

Firefighters all had treatment from a physiotherapist before they were referred to the 'in house' occupational health service and fitness team to carry out a functional assessment. Once they were referred, firefighters were responsible to update to occupational health department on their progress. Leaving firefighters to be solely responsible to provide this progress update could result in important information being unknown by key personnel. Instead, if the physiotherapist liaised directly with the occupational health department and the fitness team, a professional update could be provided to ensure all information was handed over. This update could include firefighters' physical progression during their injury rehabilitation.

Physiotherapists could inform the occupational health department and the fitness team of any areas of physical improvement required by the firefighter before a RTW could be recommended. This improved communication could also help improve physiotherapists' awareness of the physical expectations required of a firefighter during their RTW assessment and align rehabilitation goals with strength and aerobic goals.

Previous research has highlighted the importance of an MDT providing clear communication to rehabilitating individuals and that it is essential to facilitate a patient centred approach to the communication (277). A patient centred communication style is integral to increasing positive patient engagement (277). Examples of patient centred communication includes goal setting specific to their MSK rehabilitation and motivational support (277, 278). This could help provide the injured firefighter a sense of control and increased motivation as they could monitor their strength and aerobic fitness levels (269).

Motivation can also come from the support of management providing a positive experience for individuals returning to work following an injury (270). The findings showed an inconsistency in management support across the fire service with some managers in this study being perceived as facilitators for firefighters to RTW while others were perceived as barriers. Inconsistency between managers was evident. Some offered firefighters the opportunity to perform modified duties while others did not. This could be related to the duty system. Whole-time firefighters work full time for the fire service, on-call firefighters work part time on a pager and are employed elsewhere. Providing whole-time firefighters with modified duties could be easier as they do not have alternate employment. Future practice should enable all firefighters where possible, to perform modified duties. This could include carrying out safety checks and station administration tasks regardless of their duty system. This would increase a firefighter’s interaction with their colleagues and manager and prevent feelings of isolation. Previous research has supported this theory where rehabilitating athletes were encouraged to stay involved with colleagues during training by undertaking alternative activities suited to their rehabilitation and as a result, this involvement decreased feeling of isolation from the team (279).

Consistency would be increased by the introduction of a guidance framework for a RTW following injury. For example, the creation of a flow chart staging each process of a return from injury, which specific person is responsible at each given stage and what their role is during that process (280). This would also help communication expectations between physiotherapists, occupational health, fitness advisors, managers and firefighters. This would help ensure all firefighters received the same level of support whilst recovering from an injury.

A consensus was gained for the tasks to be included in a Fit for Duty screening tool to assess the physical readiness of a firefighter to return to operational duties following a MSK injury (see Chapter 5). This screening tool could be adopted by fire and rescue services in the UK and used as part of the RTW process. However, the reliability and feasibility of this screening tool needs to be assessed before it can be implemented within fire and rescue services.

6.4.1 Strengths and limitations

One limitation of this study was that it included current operational firefighters from only one fire and rescue service in the UK. With participants from only one fire and rescue service, it is not known if the perceived barriers and facilitators experienced by firefighters during their injury recovery are representative of those experienced in other fire and rescue services across the UK.

In addition, LN also worked as a fitness advisor for the same fire and rescue service. One limitation could be the power concept of personal identity between LN as the interviewer also being a colleague to the interviewees (281). This power dynamic could have affected the responses given by the firefighters during their interviews. LN's identity during this study was a PhD researcher. Whilst some participants may have perceived LN as a colleague and were more willing to provide details of their RTW experience, providing more genuine findings, other participants may have perceived LN as the fitness advisor who determines if a firefighter possesses the physical fitness requirements to return to operational duties. Therefore, participants might have been concerned about providing an answer that they think the interviewer wanted to hear (281, 282).

Future studies of this nature may benefit from considering using triangulation methodology to help reduce any potential bias in the findings (283). Triangulation methodology can include the use of multiple researchers to collect the data (283). The use of an independent researcher, blinded to the purpose of the study could be used. For each interview completed, the data would be analysed separately, forming two sets of findings. All researchers would then combine their thematic analysis of the data to help reduce any potential bias in the findings (284). Another form of triangulation would be to interview participants from different viewpoints (285). For example, in the fire service this could be achieved by interviewing participants inclusive of all the ranks in the fire service to determine if the perceived barriers and facilitators are consistent across all ranks or if there are any variations in RTW experiences dependent on the rank held.

The fire and rescue service used in this study employs firefighters on two different duty systems. A firefighter in this service could be on a whole-time or on-call duty system. The findings from this study were representative of firefighters from both whole-time and on-call duty systems. Therefore, the findings demonstrated an understanding of the perceived barriers and facilitators firefighters experienced during injury recovery representative to the entire operational workforce of the included fire and rescue service.

All interviews were conducted via video call without the need for travel or expenditure. The use of video calls helped to reduce the burden of the participants as they were able to take part in the interviews whilst on duty at their fire station.

Firefighters taking part in this study were able to do so without impacting their availability to attend emergency calls if required.

All interviews were informed by a topic guide (Appendix 11). The topic guide focused on five pre-determined themes for a firefighter returning to operational duties following an injury: [1] Overall experience of returning to operational duties following an injury, [2] perceived barriers experienced during their RTW, [3] perceived facilitators experienced during their RTW, [4] confidence in participating in physical activity following injury and [5] areas in which the firefighter felt improvements could be made in the RTW process. Although semi-structured interviews provided participants the opportunity to give in-depth answers of their RTW experience, the use of pre-determined themes during the semi-structured interviews could have prevented any other themes, separate from the five pre-determined themes, from emerging from the firefighters RTW experience (258). This could have resulted in other perceived barriers and facilitators experienced during a firefighters' injury recovery being missed and not included during the analysis. Any unidentified perceived barriers during a firefighters RTW experience would remain unknown and could continue to be barriers for future firefighters during their injury recovery.

6.5 Conclusion

This study outlined the perceived barriers and facilitators that firefighters faced during their RTW process following an injury. Modified duties should also be considered to encourage social contact and allow physical training as part of their rehabilitation in preparation for their RTW physical assessment. Further research is needed to understand if the themes identified in this study are the same for other fire services in the UK. Further research is also needed to understand how the findings may be best implemented within the fire service. Physiotherapists working with firefighters could increase their understanding of the physical requirements expected of operational firefighter tasks.

An increased understanding of the physical demands could assist a physiotherapist in providing a discharge summary for occupational health professionals and fitness professionals working with firefighters. The discharge summary could identify areas of physical improvement required by a firefighter to achieve the job-related task demands. Fitness professionals could provide the firefighter with a fitness training programme, using the recommendations from the physiotherapist, to assist with a firefighters' injury recovery. This process could increase the support given to the firefighter throughout their injury recovery.

Consideration should be made for the consistency of procedures followed during an individual's return to work following an injury. In a first step, consistency could be improved by using the Fit for Duty screening tool developed in the previous chapter (see Chapter 5), however assessment of the reliability and feasibility of this screening tool is required before it can be implemented within fire and rescue services.

Chapter 7: Inter-rater and intra-rater reliability of the Fit for Duty screening tool for UK firefighters following injury

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(Appendix 12)

Abstract

The aim of this study was to assess the inter-rater and intra-rater reliability of the Fit for Duty screening tool to be used on UK firefighters following injury. The inter-rater and intra-rater reliability of eight tasks involved in a screening tool was used to assess physical readiness to RTW for UK firefighters following injury. These tasks included the following; (1) putting on and removing a breathing apparatus set (BA), (2) a ladder lift simulation, (3) a ladder carry simulation, (4) a Light Portable Pump (LPP) lift and carry simulation, (5) a hose run, (6) a ladder climb with a leg lock, (7) a casualty evacuation and (8) a confined space crawl simulation.

The overall inter-rater reliability of the Fit for Duty screening tool during both rating sessions was interpreted as Good (F_K=0.77). The inter-rater reliability between each individual screening task included in the Fit for Duty screening tool was interpreted as Very good (F_K=0.89-1.00) for ten (62.5%) of the screening task videos across both rating sessions. Inter-rater reliability was interpreted as Good (F_K=0.68-0.78) for five (31.25%) of the screening task videos across both rating sessions. Inter-rater reliability was interpreted as Moderate (F_K=0.58) for one task, Putting on a BA set (Pass video).

For intra-rater reliability, Cronbach's alpha values (α) for the Fit For Duty screening tool was interpreted as Excellent (α=0.93-1.00) for thirty-one participants (88.6%), Good (α=0.86) for two participants (5.7%) and Acceptable (α=0.77) for two participants (5.7%). Due to the reliability of the Fit for Duty screening tool, conclusions can be made from the results which can inform a RTW decision for a firefighter.

7.1 Introduction

Musculoskeletal injuries can account for one-third of all workplace-related injuries (286). Common causes include overexertion, contact with equipment, slips, trips and falls (286). Many work tasks comprise some risk of injury, however, the extent of these risks differ depending on the type of sector and job role in question (287). The risk of a work-related injury increases for individuals with athletic occupations, including firefighters, military personnel, police officers and paramedics, whose job role requires higher physical demands; for example, heavy lifting or kneeling and crouching (28, 75, 142, 288). Previous research has demonstrated that more than 40% of injuries suffered by firefighters were musculoskeletal-related (142, 289).

Following an MSK injury, assessing an individual's readiness to RTW can be complex. Many factors need to be considered, including physical performance in relation to the work task demands (235, 290). An individual may believe that they are ready to RTW following injury, but if they are unable to meet the minimum work-related physical demands, there is an increased risk of reinjury (83, 84).

To assess physical performance in relation to work task demands, during recruitment of athletic occupations, a physical screening tool is used to determine if individuals possess the minimum required aerobic fitness and muscular strength standards (52, 53, 79). However, no such test exists to determine if a firefighter can meet the minimum standards after injury. For example, the physical screening tool used for the recruitment of firefighters does not include all tasks involved during operational duties, including hose running and ladder carrying (16). Instead, UK firefighter selection tests are designed to help identify applicants with the potential to be physically suited to roles within UK fire and rescue services and then once employed, individuals are trained in more specific tasks related to their firefighting role (23, 128). If operational tasks cannot be completed effectively in emergency situations, a firefighter could put themselves at risk of danger, their operational colleagues and members of the public (18).

To date, limited research exists on the effectiveness of RTW screening tools to reduce reinjury rates for individuals returning to work in an athletic occupation, for example a professional athlete (170, 173, 174, 291, 292). No research has included athletic populations who are not professional athletes, for example firefighters (170, 173, 174, 291, 292). To address this, a consensus for the inclusion of tasks to be adopted into the Fit for Duty screening tool was sought to be used to assess a firefighter's readiness to RTW following injury (see Chapter 5).

However, before any screening tool can be used to assess readiness for RTW, its reliability must be determined (293). The reliability of a screening tool should be of important consideration especially in settings where decisions on an individual's ability to perform job-related tasks at the required level are based on interpretation of the results (294). A reliable screening tool ensures the same or compatible results across different assessments, regardless of when the test took place, the environment in which the test is conducted, or the professional administering the test (293, 295). Without sufficient inter-rater and intra-rater reliability, any screening tool holds little value in determining if an individual is ready to return to the demands of their job role (296). The aim of this study was to assess the inter-rater and intra-rater reliability of Fit for Duty tool to be used on UK firefighters following injury.

7.2 Methods

7.2.1 Ethical Approval

The University of Essex research ethics committee granted approval for the study. Ethics reference; ETH2122-1516.

7.2.2 Study Design

A reliability study of eight tasks involved in the Fit for Duty screening tool was used to assess the inter-rater and intra-rater reliability of the Fit for Duty screening tool. The eight tasks in the screening tool were gained by consensus during a recent Delphi study within this thesis (see Chapter 5) and include the following; 1) putting on and removing a BA set BA, 2) a ladder lift simulation, 3) a ladder carry simulation, 4) a Light Portable Pump (LPP) lift and carry simulation, 5) a hose run, 6) a ladder climb with leg lock, 7) a casualty evacuation and 8) a confined space crawl simulation.

7.2.3 Participant Criteria

A purposive sample, of occupational health, fitness professionals or operational firefighters working within fire services in the United Kingdom (UK) was recruited to be participants. Purposive sampling aimed to capture experts within the fire service. All participants were currently involved in health and fitness assessments of operational firefighters. There was no limit on the number of years a participant had worked within their role.

7.2.4 Recruitment

Participants were recruited from the National Fire Chiefs Council Fitness Advisers and Occupational Health online groups. The researcher (LN) emailed fitness advisors, occupational health managers, occupational health nurses, occupational health advisors and operational firefighter trainers who currently work for UK Fire and Rescue Services, inviting them to participate in the study. The email included a hyperlink to the study website page and a participant information sheet. All participants were asked to give their consent by answering the pre-study questions before progressing further in the study.

7.2.5 Sample Size

A priori power analysis was conducted to estimate the sample size required using G* Power software (version 3.1.9.4) (297). The results estimated that a sample size of thirty-five would be required to establish inter-rater and intra-rater reliability ($H0 = 0.00$, $H1 = 0.70$, $\alpha = 0.05$, single tail, power = 0.95) (298). To allow for attrition, we increased this estimated sample size by 10% and rounded it up to the nearest whole number (299, 300), leaving a sample size of thirty-nine.

7.2.6 Data Collection/Testing Procedure

Participants were provided access to a website, created using the E-learning tool Moodle (301). The website hosted videos of the screening tests which were recorded in 1080p HD video at 60 frames per second using an iPhone 12 and were edited in iMovie (22). The iPhone 12 was set up on a tripod at approximately two meters (23) from the individual being recorded, from a front view. Each screening test was recorded two times with predetermined outcomes, (1. Pass, 2. Fail).

A screening criteria form (SCF) (Appendix 13) provided details on the requirements for a pass to be awarded. A pass video showed a firefighter completing the screening test and demonstrating all points required on the SCF. A fail video showed a firefighter completing the screening test but not demonstrating the correct technique required on the SCF. An example would be during the casualty evacuation the SCF states that the firefighter must grasp the casualty with both hands. In this example during the pass video (Image 1) the firefighter is grasping the casualty with two hands and in the fail video (Image 2) the firefighter is grasping the casualty with one hand.

Image 1 – Example of firefighter completing the pass video

Image 2 – Example of firefighter completing the fail video.

All participants were unaware of the predetermined outcome for each video. The scoring criteria were based on the current national firefighter guidance for the correct technique required for the tests (128).

All participants were required to watch an online training video detailing the online screening criteria form (SCF) before completing any rating as part of this study. The online training video was created by one of the researchers (LN) by screen recording a mock screening test rating using Microsoft Teams (302). The mock screening test was different from the included screening tests to avoid any influence on participants' ratings. After viewing the online training video, all participants were required to complete a multiple-choice questionnaire based on the training video with 100% pass mark required to pass the training. If any participants had difficulties with the online training, they were able to contact one of the researchers (LN) via email for assistance. To ensure audio and video quality, a pilot test was undertaken by one of the researchers (LN).

Participants visually assessed the technique used in the video for each screening test using a scoring criterion of “Pass” or “Fail”. Scores were based on a participant’s judgment regarding technique throughout the task using the scoring criteria provided for each task as a reference (Appendix 13).

For each participant, two rating sessions were performed with two weeks separating each session as used in previous reliability studies (25, 26). The measures obtained from both rating sessions were used to estimate inter-rater reliability. The initial and follow up testing measures from participants were used to estimate intra-rater reliability. All participants were blinded to other participants scores by viewing the videos of the screening test online individually. All participants were encouraged to complete each rating session alone and to prevent any communication about the screening videos and/or ratings between each other. All videos were required to be rated in one sitting.

7.2.7 Statistical Analysis

Descriptive data were used to characterise the participants using means and standard deviations (SD) where applicable using a Microsoft Excel spreadsheet. Scores from the participants were initially stored in a Microsoft Excel spreadsheet.

Inter-rater reliability was measured using a Fleiss Kappa (F_K) statistic (303). This method is used when results are recorded for more than two raters for either binary or ordinal data (303) This study used an ordinal scoring criteria of either “Pass” or “Fail”. The strength of agreement for the Kappa values was based on the following criterion: Very good (0.81-1.00), Good (0.61-0.80), Moderate (0.41-0.60), Fair (0.21-0.40) and Poor (<0.20) (304). For intra-rater reliability of the “Pass” or “Fail” scoring criterion was calculated using a Cronbach’s alpha (304). The measure of internal consistency was interpreted based on the following criterion: Excellent (≥0.9), Good (0.81-0.9), Acceptable (0.71-0.8), Questionable (0.61-0.7), Poor (0.5-0.6) and Unacceptable (<0.5) (305). All statistical analysis were conducted using Statistical Package for the Social Services (SPSS) version 27 for Windows (276).

7.3 Results

7.3.1 Participants

Forty-two participants volunteered to participate in this study. Participants’ job roles within their service included fitness advisors (n=14) (40%), occupational health doctor (n=1) (2.8%), occupational health manager (n=1) (2.8%), occupational health nurse (n=1) (2.8%), occupational health advisor (n=7) (20%) and operational firefighter trainer (n=11) (31.4%) (Figure 11). From these, a total of thirty-five participants completed both online rating screening sessions (83.3% retention rate). There was representation from different fire and rescue services across the UK (n=8) (Figure 12). Overall, the demographic of the participants was proportionally representative of the original invitation list. The mean age of the participants in this study was 40.34 (± 9.02) years and the mean duration they had worked for their fire service was 12.40 (± 8.11) years.

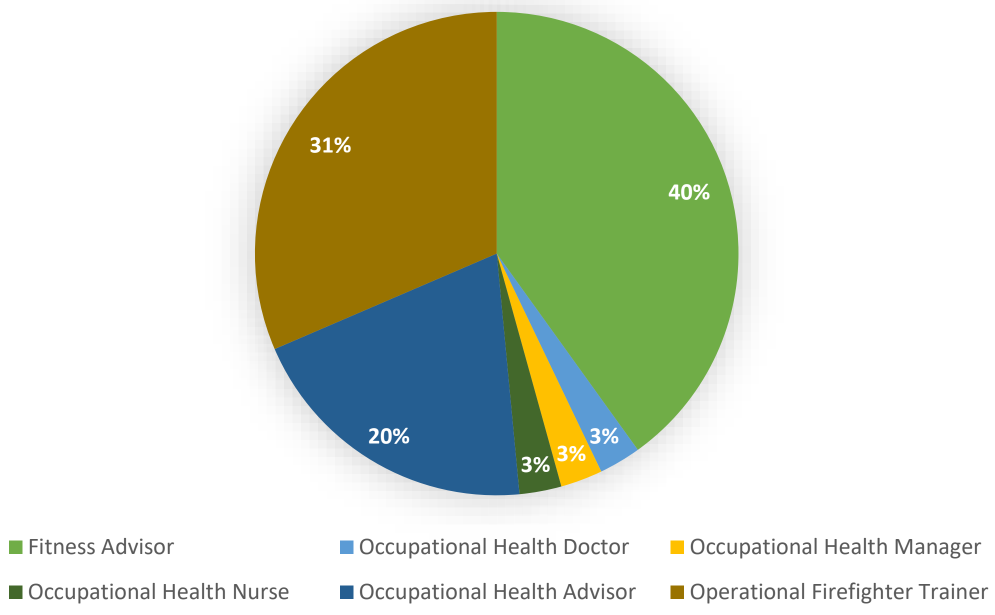

Figure 11: Job role of the participants.

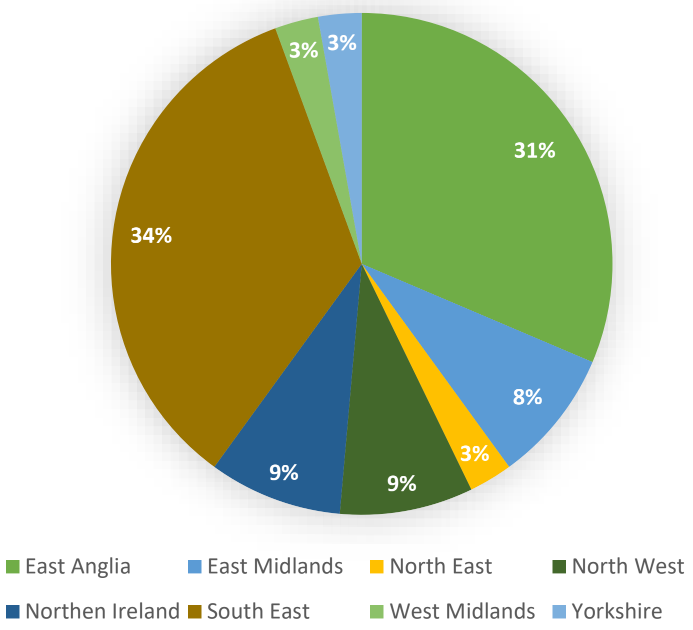

Figure 12: Region representation in the United Kingdom of the participants.

7.3.2 Inter-rater reliability of the Fit for Duty screening tool.

The inter-rater reliability of the Fit for Duty screening tool during rating session 1 was interpreted as Good (F_K=0.77). The inter-rater reliability of the Fit for Duty screening tool during rating session 2 was interpreted as Good (F_K=0.79) (Table 12). For participants with 0-9 years of service, the inter-rater reliability of the Fit for Duty screening tool during both rating sessions was interpreted as Good (F_K=0.75) (Table 13). For participants with more than nine years of service, the inter-reliability of the Fit for Duty screening tool was interpreted as Very good (FK=0.83) (Table 13).

Table 12: Overall inter-rater reliability of all Fit for Duty screening tool for both rating sessions. CI = Confidence interval.

	Inter-rater reliability			
	Rating Session	**Fleiss Kappa value**	**95% CI**	**Interpretation**
Fit For Duty screening tool tasks	1	0.77	0.75-0.78	Good
	2	0.79	0.77-0.80	Good

Table 13: Inter-rater reliability of al Fit for Duty screening tool for both rating sessions based on years worked with the fire service. CI = Confidence interval.

	Inter-rater reliability			
	Rating Session	**Fleiss Kappa value**	**95% CI**	**Interpretation**
0-9 years of service	1	0.75	0.71–0.78	Good
	2	0.75	0.71–0.78	Good
9+ years of service	1	0.83	0.80-0.85	Very good
	2	0.83	0.80-0.85	Very good

7.3.3 Inter-rater reliability between each individual screening task included in the Fit for Duty screening tool.

The inter-rater reliability between each individual screening task included in the Fit for Duty screening tool was interpreted as Very good (F_K=0.89-1.00) for ten (62.5%) of the screening task videos across both rating sessions. These tasks included, Ladder lift (Pass Video), Putting on a BA set (Fail Video), Ladder carry (Pass & Fail video), LPP lift and carry (Pass & Fail video), Hose run (Fail video), Casualty evacuation (Pass & Fail video) and Confined Space (Fail video) (Table 13). Inter-rater reliability was interpreted as Good (F_K=0.68-0.78) for five (31.25%) of the screening task videos across both rating sessions. These tasks included, Ladder lift (Fail video), Putting on a BA Set (Pass video), Ladder climb & leg lock (Pass & Fail video), Confined space (Pass video). Inter-rater reliability was interpreted as Moderate (F_K=0.58) for one task, Putting on a BA set (Pass video) (Table 14).

Table 14: Inter-rater reliability of each individual screening test video over two rating sessions. CI = Confidence interval.

		Inter-rater reliability		
	Rating Session	**Fleiss Kappa value**	**95% CI**	**Interpretation**
Ladder Lift	1	1.00	1.00-1.00	Very good
(Pass)	2	1.00	1.00-1.00	Very good
Ladder Lift (Fail)	1	0.78	0.72-0.84	Good
	2	0.78	0.72-0.84	Good
Putting on a BA set	1	0.58	0.53-0.64	Moderate
(Pass)	2	0.58	0.53-0.64	Moderate
Putting on a BA set	1	0.89	0.83-0.94	Very good
(Fail)	2	0.89	0.83-0.94	Very good
Ladder Carry (Pass)	1	0.89	0.83-0.94	Very good
	2	0.89	0.83-0.94	Very good
Ladder Carry (Fail)	1	0.89	0.83-0.94	Very good
	2	0.89	0.83-0.94	Very good
LPP lift & carry	1	1.00	1.00-1.00	Very good
(Pass)	2	1.00	1.00-1.00	Very good
LPP lift & carry (Fail)	1	1.00	1.00-1.00	Very good
	2	1.00	1.00-1.00	Very good
Hose Run (Pass)	1	0.89	0.83-0.94	Very good
	2	1.00	1.00-1.00	Very good
Hose run (Fail)	1	0.78	0.72-0.84	Good
	2	0.89	0.83-0.94	Very good
Ladder climb & leg	1	0.78	0.72-0.84	Good
lock (Pass)	2	0.68	0.72-0.84	Good
Ladder climb & leg	1	0.78	0.72-0.84	Good
lock (Fail)	2	0.68	0.72-0.84	Good
Casualty Evacuation	1	0.89	0.83-0.94	Very good
(Pass)	2	0.89	0.83-0.94	Very good
Casualty Evacuation	1	0.89	0.83-0.94	Very good
(Fail)	2	0.89	0.83-0.94	Very good
Confined Space	1	0.68	0.62-0.73	Good
(Pass)	2	0.68	0.62-0.73	Good
Confined space	1	1.00	1.00-1.00	Very good
(Fail)	2	1.00	1.00-1.00	Very good

7.3.4 Repeatability of the Fit for Duty screening tool between rating sessions.

The repeatability of the Fit for Duty screening tool over time between rating session 1 and rating session 2 was interpreted as Very good (F_K=0.94-1.00) for all tasks (Table 15).

Table 15: Repeatability of the Fit for Duty screening tool between the two rating sessions.

	Inter-rater reliability				
	Correct/Incorrect rating session 1	**Correct/Incorrect rating session 2**	**Fleiss Kappa value**	**95% CI**	**Interpretation**
Ladder Lift (Pass)	100/0%	100/0%	1.00	1.00-1.00	Very good
Ladder Lift (Fail)	94.3/5.7%	94.3/5.7%	1.00	1.00-1.00	Very good
Putting on a BA set (Pass)	88.6/11.4%	88.6/11.4%	1.00	1.00-1.00	Very good
Putting on a BA set (Fail)	97.1/2.9%	97.1/2.9%	1.00	1.00-1.00	Very good
Ladder Carry (Pass)	97.1/2.9%	97.1/2.9%	1.00	1.00-1.00	Very good
Ladder Carry (Fail)	97.1/2.9%	97.1/2.9%	1.00	1.00-1.00	Very good
LPP lift & carry (Pass)	100/0%	100/0%	1.00	1.00-1.00	Very good
LPP lift & carry (Fail)	100/0%	100/0%	1.00	1.00-1.00	Very good
Hose Run (Pass)	97.1/2.9%	100/0%	0.94	0.87-1.00	Very good
Hose run (Fail)	94.3/5.7%	97.1/2.9%	0.94	0.87-1.00	Very good
Ladder climb & leg lock (Pass)	94.3/5.7%	91.4/8.6%	0.94	0.87-1.00	Very good
Ladder climb & leg lock (Fail)	94.3/5.7%	91.4/8.6%	0.94	0.87-1.00	Very good
Casualty Evacuation (Pass)	97.1/2.9%	97.1/2.9%	1.00	1.00-1.00	Very good
Casualty Evacuation (Fail)	97.1/2.9%	97.1/2.9%	1.00	1.00-1.00	Very good
Confined Space (Pass)	91.4/8.6%	91.4/8.6%	1.00	1.00-1.00	Very good
Confined space (Fail)	100/0%	100/0%	1.00	1.00-1.00	Very good

7.3.5 Intra-rater reliability

For intra-rater reliability, Cronbach's alpha values (α) for the Fit For Duty screening tool was interpreted as Excellent (α=0.93-1.00) for thirty-one participants (88.6%), Good (α=0.86) for two participants (5.7%) and Acceptable (α=0.77) for two participants (5.7%) (Appendix 14).

7.4 Discussion

Currently, no nationally agreed RTW screening tool exists in the UK fire services. To develop a nationally agreed test, previous consensus was gained to identify the tasks to be included. However, the reliability was yet to be determined (see Chapter 5). This study aimed to assess the inter-rater and intra-rater reliability of the Fit for Duty screening tool to be used for the assessment of UK firefighters' fitness to RTW following injury. Results showed that the overall inter-rater reliability between all screening tasks was interpreted as Good (F_K=0.77-0.79) for both rating sessions (Table 12) and repeatability over time between both rating sessions was interpreted as Very good (F_K=0.94-1.00) for all tasks (Table 15). The intra-rater reliability was interpreted between acceptable-excellent (α=0.77-1.00), with 94.3% of participants reliability being interpreted between good-excellent (α=0.86-1.00) (Appendix 14).

Employers often rely upon screening tools assessing functional capacity to assist in determining an individual's work capacity relevant to their specific job role (90). The results from these screening tests can aid with the decision to allow an individual to return to their job role or help provide further rehabilitation interventions following injury (90). In addition, screening tools can provide a consistent method of assessment of an individual's physical capability to meet the job task demands used within a workforce (90, 306).

Similar studies assessing functional capacity set an Kappa value of >0.60 for screening tools to be classed as “reliable” (307, 308). The inter-rater results from this study (F_K=0.77-0.79) suggest that the Fit for Duty screening tool is a reliable tool to assess firefighters’ physical readiness to RTW. These findings are important, as it is essential to have reliable screening methods when assessing a firefighter’s ability to complete operational tasks with the correct technique to determine their physical readiness to return to operational duties (309). A reliable RTW screening tool can improve the safety of a firefighter, their colleagues and the public on their RTW (310). Previous research concluded that reliability studies should focus on multiple raters of varying backgrounds and with varying levels and types of experience (311, 312). This was achieved as thirty-five participants from eight fire and rescue service regions across the UK completed both of the required screening sessions. The results obtained were provided from professionals working across a range of occupational health, fitness and operational training departments, with an average of 12.40 ($\pm$ 8.11) years’ experience.

Intra-rater reliability is important when using a screening tool because it determines the accuracy of an assessment when a single rater may make multiple assessments over time (313, 314). This study showed that for intra-rater reliability, Cronbach’s alpha values ranged from 0.77-1.00 with 100% of participants achieving an intra-rater reliability interpretation above the Cronbach’s alpha value criterion of >0.75 to be classified as reliable as shown in previous research (315). This suggests that the RTW screening tool for firefighters following MSK injury used in this current study is suitable for repeated measures in assessing a firefighter’s readiness to RTW.

Reliability for repeated measures is especially important in assessing the consistency of Fit for Duty screening tool. This study showed that repeatability between rating sessions was interpreted as Very good (F_K=0.94-1.00) for all tasks (Table 15). A lack of consistency for RTW assessments following injury was perceived as a barrier amongst firefighters experienced during their RTW process (see Chapter 6). Therefore, if the Fit for Duty screening tool was used as good practice within UK fire & rescue services, it could potentially remove this barrier by underpinning firefighters' and rehabilitation professionals' trust in the RTW process, helping to increase the consistency of the RTW assessment.

The online design of the Fit for Duty screening tool used in this study increased the ease of access for participants, as they were able to complete the rating sessions for the Fit for Duty screening tool on desktop or portable devices, including laptops, smartphones, and tablets. As a result, future practice could allow for the Fit for Duty screening tool to be used in various locations across different UK fire and rescue services provided they possess the required equipment to conduct the screening tool. Fire and rescue services will require the following equipment to conduct the Fit for Duty screening tool; (A) One fire hose, (B) 10.5 meter or 13.5 meter ladder, (C) Ladder lift simulator, (D) Confined space cage, (E) BA set, (F) 55kg casualty dummy, (G) Two 12.5kg dumbbells, (H) 25kg dumbbell, (I) 30kg barbell. Further research is needed to assess the feasibility of the use of this Fit for Duty screening tool to help reduce firefighter reinjury rates in UK fire and rescue services.

7.4.1 Strengths & Limitations

This study included experts from fire service fitness and occupational health departments as well as operational firefighters in the UK. Experts from fire and rescue services across the UK were invited to participate but this study participation did not include representation from every fire and rescue service in the UK. Nevertheless, those who did take part provided representation from a large range of

UK fire and rescue services. The online format helped reduce the impact on the participants current work commitments as they could complete the rating sessions at a time convenient to them. This study was focused on participants working for UK fire and rescue services. The online approach allows for representation from fire and rescue services internationally in future studies.

A training video and a clear SCF helped to provide the participants with the information of what was required from them during the rating sessions. The screening test videos filmed for the rating sessions, provided clear visual information for participants to decide if the video should be awarded a pass or a fail. Another strength of this study was that the design of the website allowed the SCF, and the screening test videos to be on the same webpage. This allowed participants to use one screen or device and the rating session could be completed on a computer desktop, tablet or mobile device.

7.5 Conclusion

The Fit for Duty screening tool used in this study provided evidence that it has good inter-rater reliability for all tasks (F_K=0.77-0.79) and repeatability over time between both rating sessions was interpreted as Very good (F_K=0.94-1.00) for all tasks. Intra-rater reliability was interpreted as good-excellent (α=0.86-1.00) for 94.3% of participants and acceptable intra-rater reliability (α=0.63) for 5.7% of participants. Due to the reliability of the Fit for Duty screening tool, it allows conclusions to be made from the results which can inform a RTW decision for a firefighter. The Fit for Duty screening tool provides a method for fitness and occupational health experts as well as operational trainers working for UK fire and rescue services to refer to when assessing the readiness of a firefighter to return to operational duties. If used, this screening tool could increase the consistency of RTW process within UK fire and rescue services and add trustworthiness to the decisions made.

Chapter 8: Implementation of the Fit for Duty screening tool for firefighters following injury within fire and rescue services in the United Kingdom – Study protocol for a single arm feasibility trial.

Abstract

A novel RTW screening tool, the Fit for Duty screening tool, was developed and reported good inter-rater reliability (F_K=0.77-0.79) and good-excellent intra-rater reliability (α= 0.75-1.00). To date, the effectiveness of the Fit for Duty screening tool in reducing reinjury rates amongst firefighters remains untested. This study will evaluate the feasibility of conducting a single arm feasibility trial to compare the effectiveness of the Fit for Duty screening tool versus current UK fire and rescue services RTW procedures in reducing reinjury risk in firefighters following injury.

This study will be designed in the form of a single-arm trial, with repeated measures and a follow-up at four separate time points (3 months, 6 months, 9 months,12 months). During these follow ups, firefighters' reinjury rates following their RTW will be assessed. The feasibility of conducting a full-scale multi-centre single arm feasibility trial will be determined by the process outcomes (recruitment rates, retention rates during the trial and follow-ups and RTW screening tool adherence), resource outcomes (centre and equipment requirements, impact on current workflow) and the acceptability of the online training.

This study could provide the first steps in developing an understanding of RTW screening tools for firefighters and their effectiveness in reducing reinjury rates.

8.1 Background

When called to an emergency, firefighters are exposed to physically demanding tasks and can work in unpredictable environments (17). These working conditions can lead to firefighters being at high risk of sustaining a MSK injury (28, 316).The physical movements of lifting, pulling and carrying performed during these tasks increase the risk of sustaining MSK injuries, which commonly occur to the shoulder, lower back, knee and ankle (113, 228, 317). In the UK, there were 2,278 MSK injuries sustained by firefighters between 2021-2022, 5% more than reported for the previous year (236). Whilst injured, a firefighter is unable to perform operational duties and they are placed on modified duties (318). Their job role is restricted by reducing demands and tasks to be carried out, work location and working hours (319, 320).

Injuries to firefighters can have a negative impact upon both the individual and the fire service they are employed by (28). Absenteeism in a fire service can result in reduced availability to respond to emergency calls (321). To combat this, fire services are required to increase staff financial expenses by offering overtime or additional shifts to prevent a reduction in emergency response availability (321). For a firefighter, being on modified duties can be personally frustrating and can entrench negative attitudes towards their job role (320). In addition, research has demonstrated that whilst off work due to injury, firefighters feel external pressure to RTW as quickly as possible, a trend caused by financial burdens as well as an innate sense of duty to their peers and employers (33).

If a firefighter returns to work before they have fully recovered physically from their injury, they may not be able to carry out the minimum physical demands of their operational role (83). Returning to work prematurely, unaware of the associated risks due to inappropriate RTW processes being in place, can increase the chances of reinjury (33, 35, 36). To reduce the chance of reinjury, functional capacity evaluations have been used in other roles to assess an individual's physical readiness to RTW following injury (146, 322, 323).

Functional capacity evaluations have been used within workplaces as a screening tool to assess if an individual possesses the required strength, muscular endurance and aerobic endurance to perform their job tasks successfully. Popular job task screening movements usually involve lifting, carrying, bending, reaching and climbing (146). Research has suggested that because of the multidimensional needs of physical job roles, RTW screening tools for physical occupations should be comprised of multiple tests to help reduce the risk of reinjury instead of singular tests alone, with a particular focus on muscular strength (173, 174).

Currently, no national guidance exists for RTW protocols for firefighters. This has resulted in an inconsistency in RTW procedures within fire and rescue services across the UK. In chapter six it was reported that the inconsistency of RTW procedures was seen as a barrier to a successful RTW experience amongst firefighters.

The aim of this research project was to develop a novel screening tool to assess the physical readiness of a firefighter to return to operational duties following MSK injury. In chapter five a novel RTW screening tool, the Fit for Duty screening tool, was developed and in chapter seven the inter-rater and intra-rater reliability of this RTW screening tool was tested. The Fit for Duty screening tool reported good inter-rater reliability (F_K= 0.77-0.79) and good-excellent intra-rater reliability (α=0.76-1.00).

Chapter 3 highlighted a shortfall in our understanding of the effectiveness of a RTW screening tool in reducing reinjury rates for firefighters and to date, the effectiveness of the Fit for Duty screening tool in reducing reinjury rates amongst firefighters remains untested. Future directions of this research project aim to conduct a single arm trial to assess the effectiveness of the Fit for Duty screening tool in reducing reinjury rates for firefighters compared with current RTW procedures used within UK fire and rescue services.

However, conducting trials to compare injury rehabilitation screening tools and their effectiveness in reducing reinjury risk can be challenging and resource intensive (324). Feasibility studies are often used to determine if future trials are achievable (324, 325). Feasibility studies can inform process (assessing the feasibility of recruitment and retention rates) and resource (assessing time, costs and equipment) requirements (324). The findings from such a feasibility study can be used to identify if a future main single arm trial can be conducted (324).

This study protocol highlights the future directions of this research project and will aim to evaluate the feasibility of conducting a single arm trial to compare the effectiveness of the Fit for Duty screening tool versus current UK fire and rescue services RTW procedures in reducing reinjury risk in firefighters following injury. This feasibility study has the following aims:

i. To assess process outcomes (recruitment rates, retention rates during the trial and follow-ups, group allocation acceptance and RTW screening tool adherence).
ii. To assess resource outcomes (centre and equipment requirements, impact on current workflow).

iii. To assess the acceptability of the online training.

8.2 Methods

8.2.1 Study Design

This study will be designed in the form of a single-arm trial, with repeated measures and a follow-up at four separate time points (3 months, 6 months, 9 months,12 months). During these follow ups, firefighters' reinjury rates following their RTW will be assessed. Data will be collected from three fire and rescue services in the United Kingdom (UK); [1] Essex Fire and Rescue Service, [2] Kent Fire and Rescue Service, [3] Northern Ireland Fire and Rescue Service. Letters of cooperation have been received from all four fire and rescue services (Appendix 15). An overview of the study design flow is shown in Figure 13. This study has been developed using the Standard Protocol Items: Recommendations for Interventional Trials (SPIRIT) guidelines (326) (Appendix 16).

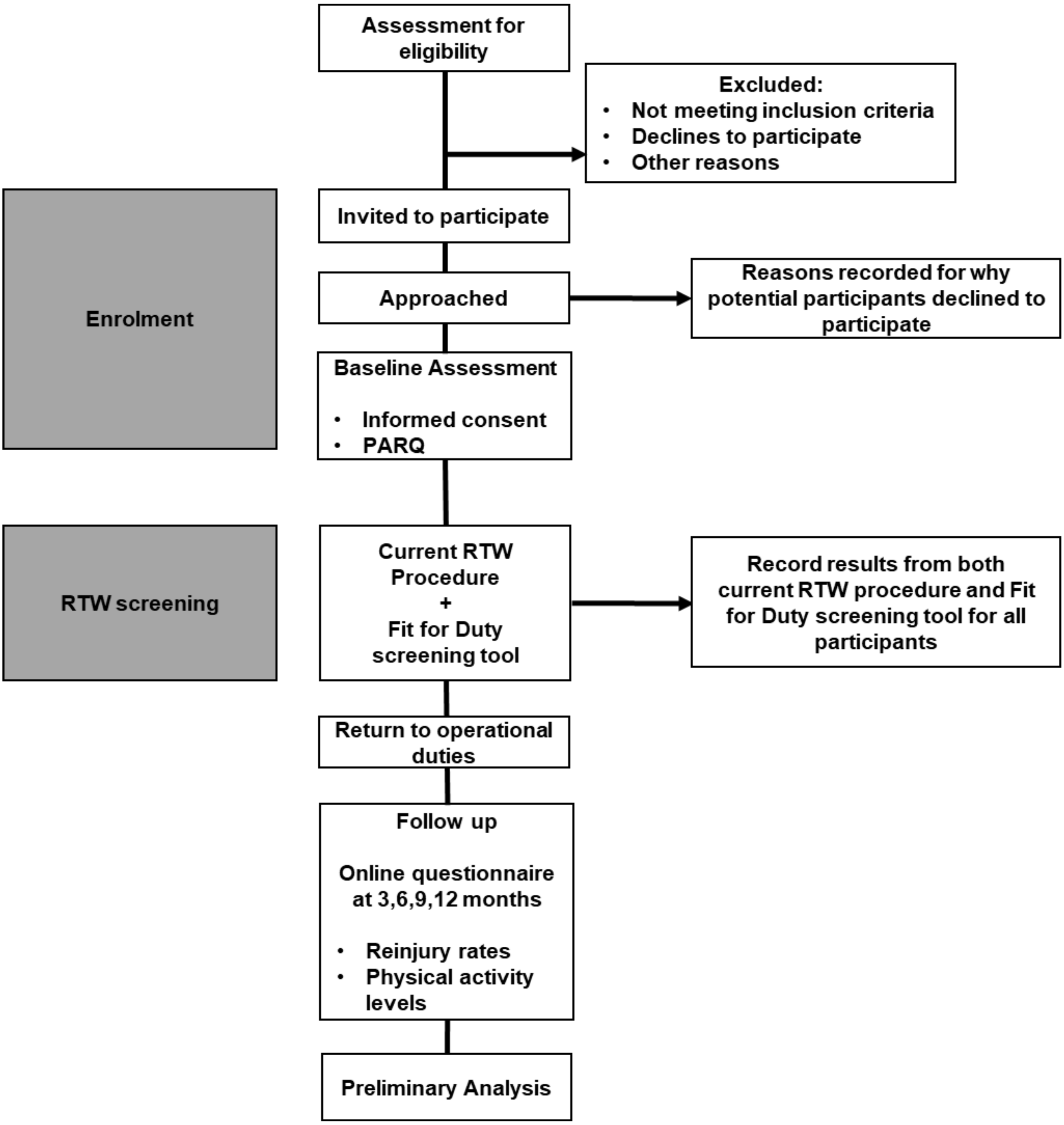

Figure 13. Overview of study design flow. PARQ = Physical Activity Readiness Questionnaire, RTW = Return to work.

8.2.2 Eligibility Criteria

A purposive sample of firefighters working withing fire and rescue services in the UK will be recruited to be participants. Firefighters who are returning to work following a MSK injury will be eligible if they meet the inclusion criteria displayed in Table 16.

Table 16: Eligibility Criteria for participation

Inclusion Criteria	Exclusion Criteria
• Age 18+ years • Currently employed as an operational firefighter for a UK fire and rescue service. • Returning to work following a MSK injury, for example, muscle strain, muscle sprain or stress fractures (327).	• Still undergoing physiotherapy treatment. • Returning to a non-operational role within their fire and rescue service.

MSK injuries included will be work-related and non-work related. In addition, eligible participants will be required to complete a Physical Activity Readiness Questionnaire (PARQ) (Appendix 16). Participants will be required to answer ‘No’ to all questions before the Fit for Duty screening tool can be administered. Answering ‘No’ to all questions in the PARQ reduces the risk of causing any discomfort or pain to the participant during each task included within the Fit for Duty screening tool (328, 329). Participants will be excluded from the study if at the time of screening they answer ‘Yes’ to any of the questions on the PARQ. There will be no restriction on the number of years a participant has worked as an operational firefighter.

Eligible Participants will be invited to provide informed consent that they accept randomisation to either the Fit for Duty screening tool or usual RTW procedures in determining their physical readiness to return to operational duties. Participants will provide informed consent by completing an online consent form (Appendix 17). A link to the online consent form will be sent from the site administrator to the participant via email.

Eligible sites will be fire service stations or fire service training centres across the UK. Eligible sites will require an area that is 25m in length and 5m in width, with one metre clearance on all sides so that the task movements can be performed reliably. The following equipment is to conduct the RTW screening tool; (A) One fire hose, (B) 10.5 meter or 13.5 meter ladder, (C) Ladder lift simulator, (D) Confined space cage, (E) BA set currently used in the participating fire service, (F) 55kg casualty dummy, (G) Two 12.5kg dumbbells, (H) 25kg dumbbell, (I) 30kg Barbell.

Eligible individuals who will administer the RTW screening tool will work for a UK fire and rescue service as one of the following; (A) fitness advisor, (B) occupational health manager, (C) occupational health nurse, (D) operational firefighter instructor. There will be no requisite on the number of years a RTW screening tool administrator has worked for a fire and rescue service.

8.2.3 Sample size

As this is a feasibility study, a formal power sample calculation will not be undertaken. Previous research has recommended that a minimum of twenty-four participants be recruited (330, 331). To allow for attrition we will increase this sample size by 10% and round up to the nearest even number, leaving a sample size of twenty-eight participants (n=14 in each group). Achieving this sample size will require an average of 2.3 participants per month, across all centres, over a twelve-month recruitment period.

8.2.4 Recruitment

Participants will be recruited from fire and rescue services within the UK. Participants returning from an MSK injury will be identified by fire service staff members working for occupational health or fitness departments as they will have access to information to firefighters currently absent from operational duties. Details of eligible participants will be transferred to one of the following members of staff from their fire and rescue services; fitness advisor, occupational health manager, occupational health nurse who will act as the site administrator. Participants will be invited via email by the site administrator. The email will include a participant information sheet.

The recruitment process will start with the screening of participants applying the inclusion/exclusion criteria (Table 16). Screening of eligible participants will be performed by the site administrator. Eligible participants will be required to give their consent by completing an online questionnaire, answering pre-study questions, before progressing further in the study (Appendix 17). A link to the survey will be sent to eligible participants via email by the site administrator.

8.2.5 Site administrator training

Site administrators will be provided with online training on how to administer the Fit for Duty screening tool. A link to this online training video will be sent to the assessors via email before the recruitment process starts. After viewing the online training video, all participants will be required to complete a multiple-choice questionnaire based on the training video with 100% pass mark required to pass the training. If any participants have difficulties with the online training, they will be able to contact one of the researchers (LN) via email for assistance.

The main researcher (LN) will provide the site administrators with email templates to use when contacting participants at different timepoints throughout this study to increase the consistency of the procedures used between centres and to reduce the burden on the site administrators (332, 333).

8.2.6 Experimental procedure

This study will have a single arm. All eligible participants will undertake both the current RTW practices used within their participant fire and rescue service and the Fit for Duty screening tool. Due to the study design, participants and site administrators cannot be blinded.

8.2.7 Fit for Duty screening tool.

The Fit for Duty screening tool consists of eight tasks; [1] Putting on and removing a BA set, [2] a ladder lift simulation, [3] a ladder carry simulation, [4] a light portable pump (LPP) lift and carry simulation, [5] a hose run, [6] a ladder climb with leg lock, [7] a casualty evacuation and [8] a confined space crawl simulation. Eligible participants will be instructed to complete the required repetitions or distances for each task one after another in a fixed order. The layout of the Fit for Duty screening tool is displayed in Figure 14. The Fit for Duty screening tool used within this trial has good inter-rater reliability (F_K=0.77-0.79) and acceptable-excellent intra-rater reliability (α=0.77-1.00) (see Chapter 7).

Site administrators will use a screening criteria form (SCF) (Appendix 13) during the administration of the RTW screening tool to determine if a participant has passed each task. Eligible participants will be required to achieve all criteria for all tasks to pass the Fit for Duty screening tool. The total number of repetitions or distances to be completed and the mass to be lifted or carried is displayed in Table 17.

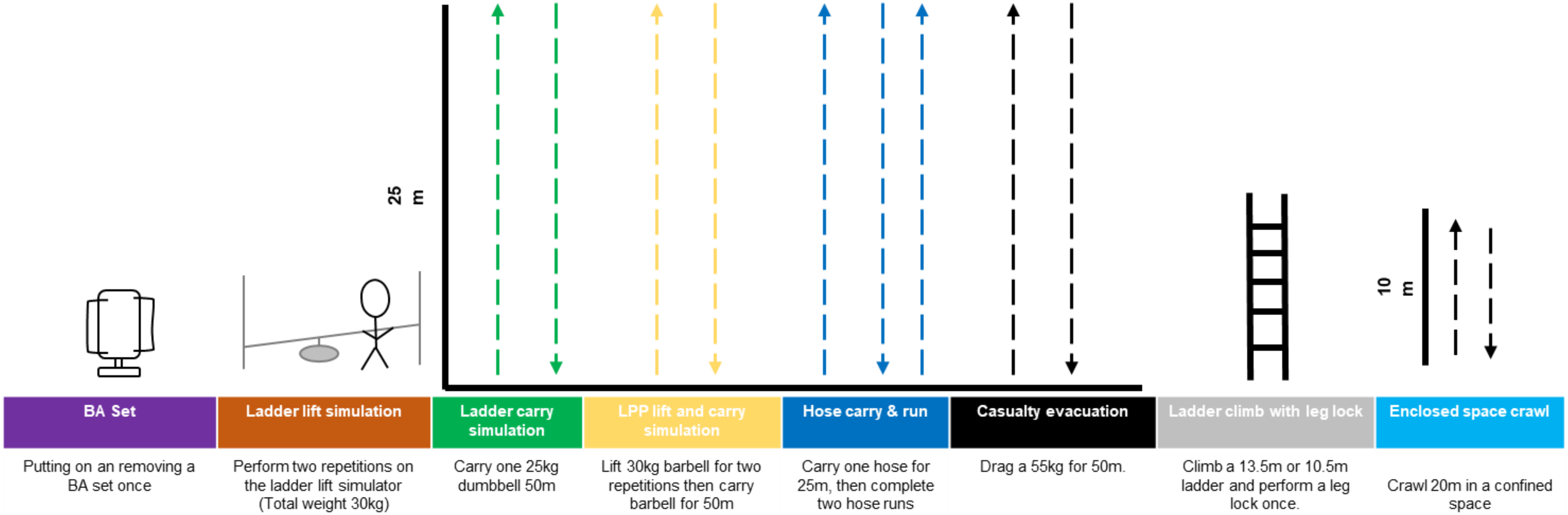

Figure 14: Fit for Duty screening tool protocol. BA = Breathing apparatus, LPP = Light Portable Pump.

Table 17: Required mass, repetitions, distances of tasks to pass Fit for Duty screening tool. BA = Breathing Apparatus, LPP = Light Portable Pump.

Task	Requirements
Aerobic fitness test	Achieve a minimum VO_2 max level of 42.3ml/kg/min
Putting on and removing a BA set	Put on and remove a BA set once.
Ladder lift simulation	Perform two repetitions on the ladder lift simulator (Total mass 30kg)
Ladder carry simulation	Carry one 25kg dumbbell for 50 metres
LPP lift and carry simulation	Deadlift a 30kg barbell for two repetitions and then carry for 50 meters
Hose carry and run	Carry a hose for 25m and then complete two hose runs.
Ladder climb with leg lock	Climb a 10.5m or 13.5m ladder and perform a leg lock once.
Casualty evacuation	Drag a 55kg casualty dummy for 50 metres
Confined space crawl	Crawl 20m in a confined space.

8.2.8 Data Collection

After completing the screening process, eligible participants will be referred to the participant information sheet, via email from the site administrator, which will detail the aim of the study and the justification for undertaking both current RTW procedures and the Fit for Duty screening tool.

All eligible and consenting participants will be invited via email, by the site administrator, to an appointment to undertake their RTW assessment at their fire and rescue service testing site. Both the current RTW procedure and the Fit for Duty screening tool will be undertaken during the same appointment. Confirmation of this appointment will be sent to the participants via email by the site administrator. A calendar request with a reminder notification twenty-four hours before their appointment will also be sent to the participant via email by the site administrator to help with attendance rates. Included in the email will be a link to an online questionnaire which will collect demographic data including, date of birth, gender, number of years working for their fire service and an email address (Appendix 18).

Participants will undertake their fire and rescue service's current RTW procedure followed by the Fit for Duty screening tool. Participants will be given time to recover between each RTW assessment if required. The site administrator will record the results from the current RTW procedure and the Fit for Duty screening tool for all participants. For the Fit for Duty screening tool, the site administrator will record details of which included tasks were passed or failed by participants.

Once a participant returns to operational duties, the site administrator will send an online follow up questionnaire (Appendix 19) via email asking if the participant has experienced any recurring pain of if they have suffered a reinjury in their previously injured limb. The follow up questionnaires will be sent to the participant at four separate time points (3 months, 6 months, 9 months, and 12 months) starting from when the participant has returned to operational duties.

8.3 Feasibility outcomes

The feasibility of conducting a full-scale multi-centre single arm trial will be determined by the process outcomes (recruitment rates, retention rates during the trial and follow-ups and RTW screening tool adherence), resource outcomes (centre and equipment requirements, impact on current workflow) and the acceptability of the online training.

8.3.1 Process outcomes

Site administrators will be sent a uniform database template using Microsoft Excel for entering data related to the process outcomes by the main researcher (LN) (224). This data will include the following;

1 The total number of participants who consented to take part in the study and undertake both current RTW procedures and the Fit for Duty screening tool.

2 The retention rates of the participants from agreeing to participant in the study to attending the RTW assessment. Participation retention will also be recorded during the follow up stages and will be measured by the number of follow-up questionnaire responses.

3 The total number of participants who completed all tasks included in the Fit for duty screening tool and the relationship with re-injury rates for firefighters.

8.3.2 Resource outcomes

Centre & equipment requirements

All centres in this trial will be required to have sufficient space and specific equipment to administer the Fit for Duty screening tool in order to participate in this trial. Full details of the centre and equipment requirements are provided in Table 18. Centres availability to meet these requirements will be recorded in a database.

Table 18. Centre and equipment requirements. BA = Breathing Apparatus.

	Requirements
Centre	• A tower to enable a fire ladder to be pitched against for the ladder climb and leg lock drill. • A flat surface of at least 25 metres for the carrying tasks.
Equipment	• 1 x BA set • 1 x Ladder lift simulator • 2 x 25kg dumbbells • 1 x 30kg barbell • 2 x Fire hoses • 1 x 105 metre or 135 metre ladder • 1 x 55kg casualty dummy • 1 x confined space simulator

Impact on current workflow

Impact on current workflow will be measured using an online survey asking site administrators to provide feedback of their experience during the study. The online survey will ask site administrators to rate how the administration of the Fit for Duty screening tool impacted their current workflow in comparison with the RTW processes currently used in their fire service (Appendix 1). A link to the online survey will be sent to the site administrator via email by the main researcher (LN) at the end of the data collection.

8.3.3 Management outcomes

Acceptability of the online training will be measured using an online survey asking site administrators to provide feedback on their experience of the online training provided during the study. The online survey will ask site administrators to rate how easy the online training video was to access and to rate if the online training provided them with sufficient information to enable them to administer the Fit for Duty screening tool (Appendix 20). The online survey will be sent to the site administrator via email by the main researcher (LN).

8.4 Progression criteria

In order to assess the feasibility of future progression for this single arm trial, a traffic light system will be used to guide progression to a main single arm trial (334). The traffic light system will be based on previous research, with varying levels of acceptability being used for quantitative feasibility outcomes (334-337). The traffic light system will consist of three categories, ‘Green’, ‘Amber’ and ‘Red’ (334). ‘Green’ will indicate that the protocol is feasible with current methods, ‘Amber’ will indicate that modifications will be required to one or more components of the methods before the protocol can be progressed and ‘Red’ will indicate that a main single arm trial would not be feasible (335). If ‘Red’ is awarded significant changes to the study design will be required before attempting a main single arm trial (338). Full details of the traffic light categories for progression criteria to a main single arm trial are displayed in Table 19.

8.5 Data analysis

Descriptive and inferential statistics will be used to analyse the data and report the data. All data will be anonymised at source, personal details will not be included in the study. Descriptive data will be used to characterise the participants and data collected in the follow up online questionnaires and online surveys. Descriptive data will be reported as mean (standard deviation), median (range) or count (percentage) as appropriate using a Microsoft Excel spreadsheet (224). For the inferential statistics, a paired *t*-test will be used to compare reinjury rates following return to operational duties between current RTW procedures and the Fit for Duty screening tool across the follow up time points if data are normalised. If data are not normally distributed, a non-parametric Wilcoxon Signed-rank test will be used to compare the data (339). The confidence interval will be set at 95% and the statistical significance will be set at $P<0.05$ (340, 341). All statistical analysis will be completed using SPSS version 27 for windows (342).

8.6 Ethical approval and protocol registration.

Ethical approval will be sough from the University of Essex research ethics committee. The authors intend to submit this study protocol to the ISRCTN registry. The University of Essex research ethics committee and the ISRCTN registry will be informed of any important protocol modifications (e.g. changes to eligibility criteria, outcomes and analysis.

Table 19. Progression criteria for future single arm trial

Criteria	Green	Amber	Red
Recruitment	At least 28 eligible participants are identified and agree to take part over 12 months	Between 18-27 eligible participants are identified and agree to take part over 12 months	Fewer than 18 eligible participants are identified and agree to take part over 12 months
Retention	At least 80% of the participants complete the RTW screening tool and all follow up surveys	Between 50-79% of the participants complete the RTW screening tool and all follow up surveys	Fewer than 50% of the participants complete the RTW screening tool and all follow up surveys
Group allocation acceptance	At least 80% of the participants accept their group allocation.	Between 50-79% of the participants accept their group allocation.	Fewer than 50% of the participants accept their group allocation
Centre requirements	At least 80% of the centres meet the requirements to conduct the RTW screening tool	Between 50-79% of the centres meet the requirements to conduct the RTW screening tool	Fewer than 50-79% of the centres meet the requirements to conduct the RTW screening tool
Impact on current workflow	At least 80% of the assessors do not perceive that the RTW screening tool negatively impacts their current workflow.	Between 50-79% of the assessors do not perceive that the RTW screening tool negatively impacts their current workflow.	Fewer than 50% of the assessors do not perceive that the RTW screening tool negatively impacts their current workflow.

8.6 Discussion

The aim of this study is to evaluate the feasibility of a future larger randomised controlled trial investigating the effectiveness of the Fit for Duty screening tool in reducing reinjury rates among firefighters on RTW following MSK injury.

The feasibility criteria including recruitment rate, retention, group allocation acceptance, centre requirements and impact on current workflow collected in this study will be used to estimate if a main single arm trial can be conducted. Furthermore, the feedback provided from site administrators and participants of their experience during the study will allow for improvements of the study protocol to increase the success of a future study to test the effectiveness of the Fit for Duty screening tool in reducing reinjury rates for firefighters.

Previous research in this thesis has highlighted a shortfall in our understanding of RTW screening tools for tactical athletes and their effectiveness in reducing reinjury rates (see Chapter 3). Therefore, this study could provide the first steps in developing this understanding in a tactical athletic population of firefighters (343).

One strength of this trial would be the inclusion of fire and rescue services across the UK. As a national feasibility trial, this study protocol will allow for a comparison between RTW procedures currently used in UK fire and rescue services and the Fit for Duty screening tool in reducing reinjury rates and a range of different current practices.

Chapter 9 – Conclusion and summary

9.1 Aim of this thesis

This research project aimed to develop a novel RTW screening tool to assess the physical readiness of UK firefighters following MSK injury. Currently, there is no national guidance for a RTW screening tool following an injury for firefighters. In the context of understating the requirements of a RTW screening tool, the following research objectives were proposed in chapter one; (1) To critically review the characterisation of the role of a firefighter and current uses of RTW assessments within physical occupations, (2) To systematically review current RTW screening tools conducted for athletic occupations following injury and their effectiveness of reducing reinjury risk, (3) To obtain a consensus view of the tasks needed to be included in a RTW assessment for operational firefighters, (4) To explore the psychosocial barriers and facilitators during the RTW process following an injury for a firefighter, (5) To assess the inter-rater and intra-rater reliability of a RTW screening tool to be used on UK firefighters following injury. This chapter will summarise the main findings and will discuss how each research study has contributed to the main aim of this thesis.

9.1.1 Objective 1: To critically review the characterisation of the role of a firefighter and current uses of return to work assessments for physical occupations.

The first objective was met in chapter two and provided an overview of the characteristics required from a firefighter to successfully undertake the physical demands of firefighting job tasks (91, 100, 101, 103). Whilst attending emergency incidents, a firefighter is required to possess adequate levels of aerobic fitness, muscular strength and endurance (5) to cope with the challenging physical demands

(41). Due to these physical demands, firefighters are at increased risk of suffering a MSK injury (28, 344).

RTW approaches are limited within UK fire and rescue services leading to inconsistencies in their applications across the country. If a firefighter RTW before being able to meet the minimum physical demands of operational duties, they could compromise their safety whilst on duty and increase the risk of reinjury.

Other physical occupations have implemented specific functional capacity evaluations for individuals when returning to their occupations following an injury (100, 101). Functional capacity evaluations are standardised tests consisting of a range of tasks related to an individual's job role activities (88). Functional capacity evaluations provide a structure for assessing the ability of the individual to meet the required standards for the demands of the job to RTW safely (89).

Previous research has developed national physical selection tests to assess an individual's ability to meet the minimum physical demands of firefighting job tasks (16). However, certain tasks, such as hose running, and ladder carries were not included. In addition, no assessment of aerobic capacity exists the national physical selection tests. Therefore, using the national select tests alone do not produce a comprehensive understanding of a firefighter's readiness to RTW following injury.

The review highlighted that there were limitations in our understanding regarding the structure of a RTW screening tool for UK firefighters. Before a screening tool could be created for UK firefighters, it was deemed necessary to understand current RTW screening tools used for similarly physically demanding occupations and their effectiveness at reducing reinjury rates.

9.1.2 Objective 2: To systematically review current return to work screening tools conducted for athletic occupations following injury and their effectiveness of reducing reinjury risk.

The second objective was met in chapter three and was the first systematic review to consider the link between current screening tools conducted for athletic occupations following injury and their effectiveness of reducing reinjury risk. The review was reported in accordance with the PRISMA statement (159).

Research has identified similarities in the physical characteristics for both athletes and firefighters (139). Athletes, like firefighters are required to maintain physical fitness and undergo fitness assessments to ensure that they are able to meet the physical demands of their job role (140, 141). This similarity between occupations has prompted suggestion that the role of a firefighter could be considered as a tactical athletic occupation and fire services could consider adopting athletic-based approaches when assessing health and physical performance amongst firefighters (139, 142, 143). Tactical athletic occupations include firefighters, police officers, paramedics and members of the armed forces (142).

The review demonstrated very low level of certainty for the effectiveness of RTW screening tools reducing the risk of reinjury in sports athletes. Interpretation from the results suggested that a series of physical screening tests, assessing muscular strength and endurance, specific to occupational demands may provide more accurate information relating to reinjury risk compared to a singular physical test used in isolation for athletic occupations (172).

All studies used in this review assessed a population of sports athletes on their RTW following an injury (170-174). No studies were found involving firefighters, or any other tactical athletic occupation, highlighting a shortfall in our understanding for the use of RTW screening tools on firefighters following MSK injury.

In a first step to address this, further research was required to provide a consensus of tasks needed to be included in a RTW screening tool for firefighters returning to work following MSK injury.

9.1.3 Objective 3: To obtain a consensus view of the tasks needed to be included in a return to work assessment for operational firefighters following musculoskeletal injury.

The third objective was met in chapter five. A two round online Delphi study was conducted, and a consensus was gained for eleven tasks to be included in the novel Fit for Duty screening tool to assess the physical readiness of firefighters to return to operational duties following MSK injury. The key tasks to be included in the Fit for Duty screening tool for firefighters involve an aerobic fitness test and lifting and carrying equipment including ladders, hoses, casualties and a light portable pump. The eleven tasks to be included in the Fit for Duty screening tool are displayed in Table 20.

Table 20: Tasks which gained consensus to be included in the Fit for Duty screening tool.

Fit for Duty screening tool tasks	
1. Aerobic fitness assessment	7. Light portable pump carry
2. Enclosed space crawl	8. Light portable pump lift
3. Hose carry	9. Putting on and removing a BA set
4. Hose run	10. Simulated casualty evacuation
5. Ladder carry	11. Simulated ladder lift
6. Ladder climb and leg lock	

A consensus was reached on three out of five tasks relating to the total number of repetitions a task had to be performed (Figure 7). Consensus was reached for all five tasks relating to the total distance to be complete (Figure 8). Consensus was reached for the mass of the casualty to be used in a simulated evacuation task (Figure 9).

Figure 7: Results from the online consensus meeting for the total number of repetitions for each operational task.

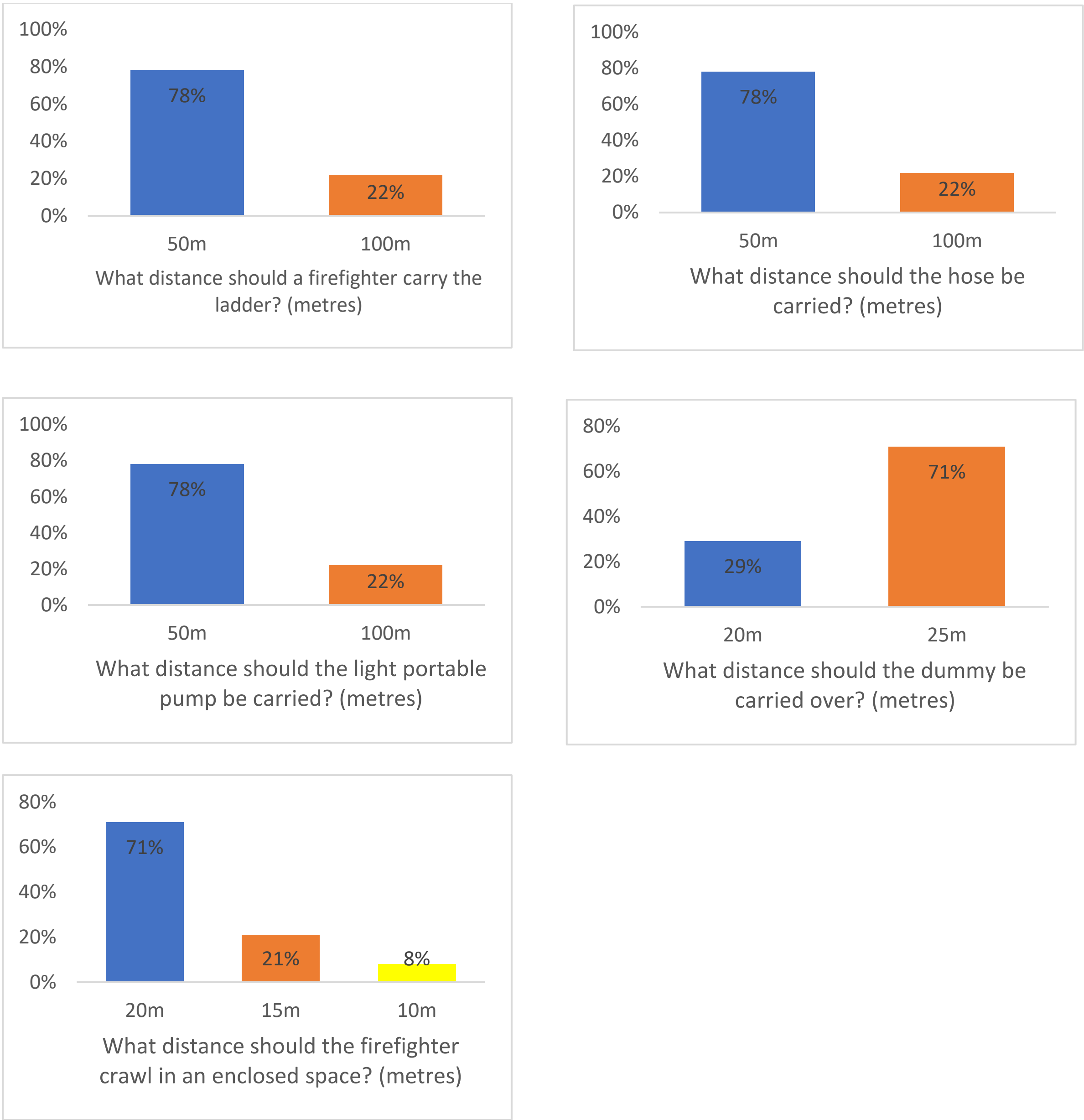

Figure 8: Results from the online consensus meeting for the total distance to be completed for each operational task.

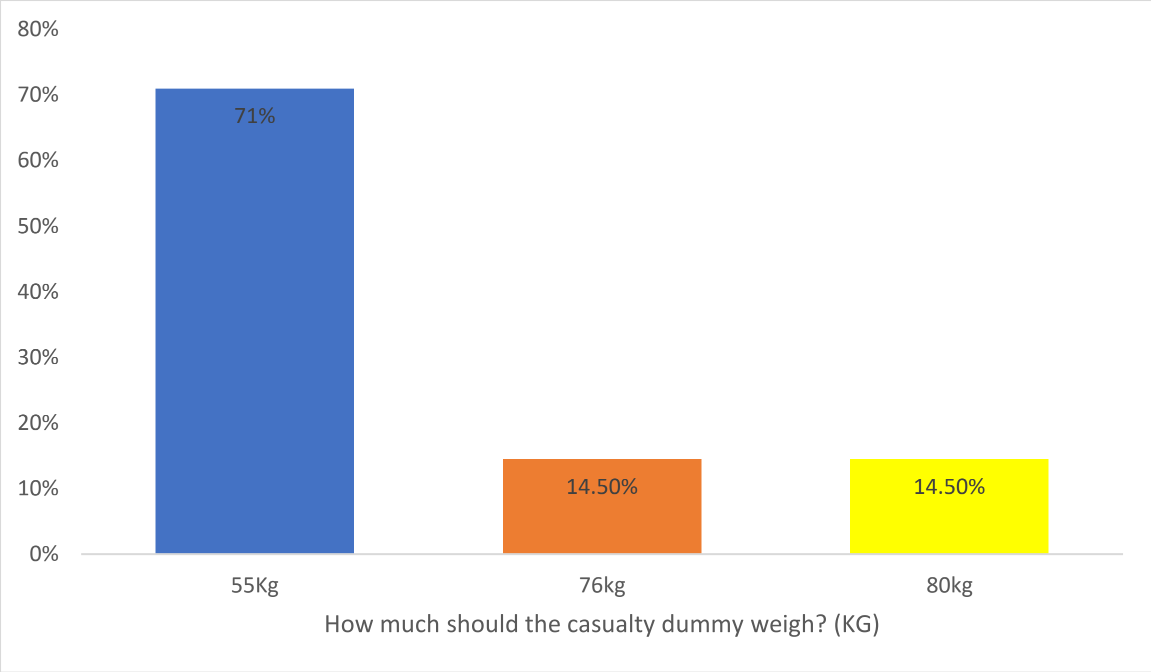

Figure 9: Results from the online consensus meeting of the total mass (KG) to be used during a simulated casualty evacuation.

Further research was required to identify firefighters perceived psychosocial barriers and facilitators experienced during their injury rehabilitation to understand if the implementation of the Fit for Duty screening tool could improve a firefighters perceived RTW experience following injury.

9.1.4 Objective 4: To explore the psychosocial barriers and facilitators during the return to work process following an injury for a firefighter.

The fourth objective was met in chapter six. This study outlined the perceived barriers and facilitators firefighters faced during their RTW process following an injury. Nine sub-themes were identified; communication, confidence in physical activity participation, modified duties, physiotherapy, return to operational duties, support, inconsistency in the RTW process, use of station gyms and detachment from the watch.

Consideration should be made for the consistency of procedures followed during an individual's RTW following an injury. This could include communication between the occupational health department, the fitness team and the physiotherapists to provide a rehabilitation plan for the firefighter. Consistency could be improved by using the Fit for Duty screening tool developed (see Chapter 5), however assessment of the reliability and feasibility of this screening tool was required before it could be implemented within fire and rescue services.

9.1.5 Objective 5: To assess the inter-rater and intra-rater reliability of a return to work screening tool to be used on UK firefighters following injury.

The fifth objective was met in chapter seven. The Fit for Duty screening tool demonstrated good inter-rater reliability (F_K=0.77-0.79) and good-excellent intra-rater reliability (α= 0.86-1.00) for 94.3% of participants. Due to the reliability of the Fit for Duty screening tool, it allows conclusions to be made from the results which can inform a RTW decision for a firefighter following injury.

The Fit for Duty screening tool provides a RTW physical assessment for UK fire and rescue services to adopt which could increase the consistency of RTW processes nationally. However, before the Fit for Duty screening tool can be implemented within UK fire and rescue services, the effectiveness of the Fit for Duty screening tool in reducing reinjury rates needs to be evaluated.

Conducting a RCT for the purpose of evaluating the effectiveness of a screening tool in reducing reinjury rates can be complex and expensive (345, 346). Therefore, a study protocol for a feasibility study to evaluate the feasibility to conduct a main RCT to compare the effectiveness of the Fit for Duty screening tool versus current UK fire and rescue services RTW procedures in reducing reinjury risk in firefighters following injury has been proposed (see Chapter 8).

One strength of conducting a feasibility study is that it allows for feedback to be provided from all participants of their experience. Feedback will allow for improvements of the study protocol to increase the success of a main RCT to test the effectiveness of the Fit for Duty screening tool in reducing reinjury rates for firefighters.

9.2 Strengths and limitations

The research in this thesis provided several strengths. Firstly, the participation from fire and rescue services across the UK helped to obtain data from occupational health professionals, fitness professionals and operational firefighters. Secondly, appropriate reporting guidelines were applied in Chapter 3 to help increase the transparency and credibility, and strengthen the trustworthiness of the findings (347). In addition, four of the chapters have been based on papers which have published following external peer review (see Chapters 3, 5, 6 & 7). The peer review process has added robustness and rigour to the thesis, with reviewers confirming the validity, significance and originality of the studies in order for them to be published (348).

This research has several limitations which could be addressed by researchers in the future. The effectiveness of a RTW screening tool in reducing reinjury rates within firefighters remains unknown (see Chapter 3). To address this, a study protocol has been proposed to assess the feasibility of administering a multicentre

RCT to assess the effectiveness of the Fit for Duty screening tool in reducing firefighter reinjury rates (see Chapter 8).

In addition, the consensus for the tasks to be included in a RTW screening tool for firefighters following injury only included fire services within the UK. The online approach of the Delphi study would allow for representation from fire services internationally. This would improve knowledge on a RTW screening tool for firefighters on an international level (see Chapter 5).

The findings of perceived psychosocial barriers and facilitators from firefighters who had returned to work following injury were obtained from just one fire service. Therefore, it remains unknown if such barriers and facilitators are the same in other fire services across the UK (see Chapter 6). In addition, the use of pre-determined themes during the semi-structured interviews could have prevented any other themes from emerging from the firefighters RTW experience which could have resulted in them being omitted during the analysis.

9.3 Future directions

The research in this thesis has identified a few areas for further research that could be proposed based upon the finding in the previous chapters. This research has developed a novel screening tool which is reliable and can be used to assess the physical readiness of a firefighter to return to operational duties following MSK injury. Chapter three highlighted a shortfall in our understanding of the effectiveness of a RTW screening tool in reducing reinjury rates for firefighters. A study protocol has been developed to assess where it is feasible to conduct a multicentre RCT to evaluate the effectiveness of the Fit for Duty screening tool in reducing reinjury rates in firefighters returning to operational duties following MSK injury, compared to current fire service RTW procedures.

The Fit for Duty screening tool has been developed to assess all operational firefighters regardless of their rank. Future research could focus on the job task demands of different firefighter ranks (including crew manager, watch manager, station manager and area manager) or if a firefighter has a specialist role (including water rescue, animal rescue and urban search and rescue) to assess if the physical requirements are deemed the same as a firefighter or if a rank specific RTW screening tool is required.

Whilst the Fit for Duty screening tool has been developed for fire and rescue services in the UK, the requirements for such a screening tool in other countries remains unknown. The operational requirements of a firefighter can differ between countries due to the area fire stations are located (urban, suburban, rural) and climate conditions (68, 349-351). Therefore, future research could seek to gain a consensus for the tasks to be included in a RTW screening tool for firefighters across different countries to aid in assessing readiness to return to operational duties following MSK injury.

9.4 Practical implications

The research presented in this PhD thesis has provided a novel RTW screening tool to assess firefighters' physical readiness to return to operational duties. Consistency of RTW procedures in a UK fire service was found to be a barrier for firefighters (see Chapter 6).

By adopting this research, fire and rescue services across the UK will be able to implement a reliable screening tool to assess firefighters' physical readiness to undertake operational duties as part of their RTW process. Additionally, implementing a standardised RTW process could increase the consistency of RTW processes used within fire services. As a result, it could increase the support provided to firefighters by managers as they will have a clear understanding of the physical requirements that a firefighter needs to achieve before they can return to operational duties.

In addition, the Fit for Duty screening tool will provide the opportunity for rehabilitation services and exercise professionals working with firefighters, including the firefighter's charity, to have an increased understanding of the physical requirements of a firefighter before they can RTW. Physiotherapists can use the tasks included in the Fit for Duty screening tool as a target for firefighters to work towards during their rehabilitation. Once cleared from physiotherapy treatment, exercise professionals can use the Fit for Duty screening tool to structure a fitness plan for firefighters to use to help them monitor their physical readiness to return to operational duties.

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Appendices

Appendix 1

JUNE 2ND

MORNING

09:30 - 10:00

10:00 - 10:30

10:30 - 11:00

Liam Noll : How UK firefighters can return to operational duties successfully after injury

11:00 - 11:30

11:30 - 12:00

12:00 - 12:30

Appendix 2

NFCC
National Fire
Chiefs Council

OFFICIAL

The professional voice of the UK Fire & Rescue Service

FireFit Conference 2022

29-30 November 2022
St Georges Park, Staffordshire

29th November

11.30 – 13.00	**Registration, lunch and exhibition viewing**
13.00 – 13.30	Welcome and NFCC Health and Wellbeing Update
13.30 – 14.00	'25 years on, the FireFit Story' – Dr Philip Turner
14.00 – 14.40	Return to work practical assessment – Liam Noll
14.40 – 15.00	The British Firefighter Challenge & workplace culture – Chesney Conu-Heywood
15.00 – 15.30	**Coffee and exhibition viewing**
15.30 – 16.15	Healthy retirement – Gary Bankhead
16.15 – 17.00	What if we got enough sleep? – Dr Sophie Bostock
17.00 – 17.45	Fatigue Risk Management; a public health approach – Prof Kristy Sanderson
17.45 – 18.00	Panel discussion
19.00	**Networking dinner**

30th November

09.00 – 09.15	Welcome back and recap of day one
09.15 – 10.00	FFC wellbeing workshops – Dr Greg Lessons
10.00 – 10.45	Suicide risk reduction – Dr Karen Slade
10.45 – 11.15	**Coffee and exhibition viewing**
11.15 – 11.45	'WHO classify Firefighting as a carcinogen' – Dr Emily Watkins
11.45 – 12.15	Health data collection update – Colin Cartwright
12.15 – 12.45	FRS Health and Wellbeing Pre-Covid – Dr Philip Turner & Dr Rich Stevenson
12.45 – 13.15	FRS Health and Wellbeing Post-Covid – Dr Rowena Hill

Appendix 3

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	Page 35
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	-
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	Pages 37-39
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	Page 39
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	Pages 39-42
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	Page 39
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	Table 1
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	Pages 42-43
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	Pages 42-44
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	Pages 42-44
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	Page 42
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	Pages 42-44
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	Page 43-44
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	Pages 42-44
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data	Pages 43-

Section and Topic	Item #	Checklist item	Location where item is reported
		conversions.	44
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	Pages 43-44
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	Pages 43-44
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	Pages 43-44
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	Pages 43-44
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	Pages 43-44
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	Page 44
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	Figure 1
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	Figure 1
Study characteristics	17	Cite each included study and present its characteristics.	Table 4
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	Table 2
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	Tables 5,6,7
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	Page 7
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	N/A
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	N/A
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	N/A
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	N/A
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	Table 3
DISCUSSION			

Section and Topic	Item #	Checklist item	Location where item is reported
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	Pages 58-62
	23b	Discuss any limitations of the evidence included in the review.	Pages 58-62
	23c	Discuss any limitations of the review processes used.	Page 61
	23d	Discuss implications of the results for practice, policy, and future research.	Pages 58-62
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	Page 39
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	Page 39
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	Page 39
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	Page 61
Competing interests	26	Declare any competing interests of review authors.	Page 61
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	N/A

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71

For more information, visit: http://www.prisma-statement.org/

Appendix 4

Physical Therapy in Sport 58 (2022) 141–150

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Identifying current uses of return to work screening tests and their effectiveness of reducing the risk of reinjury in athletic occupations – A systematic review

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ABSTRACT

Objective: To identify the current return-to-work (RTW) screening tests conducted for athletic occupations following injury and their effectiveness of reducing reinjury risk.
Methods: A search was made of multiple databases (BioMed Central, CINAHL through ebscohost, EMBASE, Google Scholar, PUBMED, Scopus, SPORTDiscus and Web of Science) from their inception to March 2022, using relevant terms to identify articles meeting predefined inclusion/exclusion criteria. The search, data extraction, risk of bias, and evaluation of the certainty of the findings were completed independently by two authors. To understand the effectiveness of screening tests and their impact in reducing in reinjury rates, results were split into the following three time points: "Short-term" ($\leq$1 year), "Medium-term" ($\geq$2 years) and "Long-term" ($\geq$3 years).
Results: Five studies ($n = 507$) met the inclusion criteria. There was a very low level of certainty for the effectiveness of screening tools reducing reinjury risk at short-term, medium-term and long-term follow ups. Only one study recorded a large effect in the reducing reinjury risk.
Conclusion: The results demonstrated very low level of certainty for the effectiveness of screening tests reducing the risk of reinjury. A gap in our understanding currently exists for the effectiveness of RTW screening tests in tactical athletic occupations following injury and further research investigating is required.

1. Introduction

Physical screening tests are a tool to help identify those at an increased risk of disease or disorder (Grimes & Schulz, 2002). Such tests can be used to identify individuals at high risk of developing a musculoskeletal injury (Dallinga et al., 2012) and can involve the assessment of performance factors including balance, muscular strength and range of motion (Stokes et al., 2020). The results from these tests can help determine an individual's readiness to return to work (RTW) following an injury or period of absence (Pikaar, 2012).

Individuals with an athletic occupation, are required to possess certain levels of muscular strength and aerobic fitness to reduce injury risk and perform optimally (García-Pallarés & Izquierdo, 2011; Zouita et al., 2016). Although fitness level criteria may vary between different occupations, it is important that individuals with an athletic occupation are able to reach these standards before returning to work (Ardern et al., 2016; Scofield & Kardouni, 2015). Individuals with athletic occupations can be categorised as professional athletes and tactical athletes. Tactical athletes are individuals working in firefighting, police, paramedic, and military occupations (Scofield & Kardouni, 2015). Again, although fitness level criteria may vary between different occupations, it is important that the tactical athlete is able to reach these standards required before returning to work (Ardern et al., 2016; Scofield & Kardouni, 2015).

A successful RTW following injury in athletic occupations can be defined as when an individual is able to complete all work task demands safely and independently, reaching at least the baseline level of fitness required for their role (Pikaar, 2012). Methods for assessing RTW can be expensive, are often time consuming and

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equipment required can be difficult to transport, creating a potential barrier for their use (Chimera & Warren, 2016; Plisky et al., 2006). To help remove these barriers, screening tests have been created to be more user friendly by being easy to administer, using minimal equipment which is portable (Chimera & Warren, 2016; Plisky et al., 2006). This ease of use for screening tests has resulted in a rise in their popularity as a method to reduce injury risk (Chimera & Warren, 2016; Plisky et al., 2006). Results from a RTW screening test provide data that can help to identify if an individual's present performance is equal to or above their occupational demands (Hart et al., 1993; Isernhagen, 1992). These data are useful to assist in determining suitable recommendations for an individual's RTW, including what tasks are deemed safe to perform, running and lifting and tasks to avoid or perform in a modified manner and running with change of direction or overhead lifting, which could help in reducing the risk of reinjury (Hart et al., 1993; Isernhagen, 1992).

Previous research has identified that injury risk categorisation is population-specific to the required occupational demands (Hewett et al., 2005; Zazulak et al., 2007). Athletic occupations require muscular strength and aerobic fitness to complete job-related tasks (Lovitz, 2019; Nabe-Nielsen et al., 2021). These demands can involve challenging working conditions including lifting heavy loads on a regular basis or continuous repetitive work with lighter loads over a prolonged period of time (Lovitz, 2019; Smith & Mustard, 2004).

Current screening tests including the Functional Movement Screen (FMS) are used in athletic occupations assess injury risk for individuals who are fit and healthy with no prior injury (Agresta et al., 2014; Chorba et al., 2010; Frost et al., 2017; Shojaedin et al., 2014). The main purpose of the FMS is to predict injury risk from identify movement deficits and asymmetries (Teyhen et al., 2012). However, there is limited research on screening tests used for a RTW decision following injury and the risk of reinjury in athletic occupations (Houghton et al., 2016; Noll et al., 2021; Tol et al., 2014). In addition, reinjury following a RTW could cause further economic implications for the workplace including increased sick pay costs and potential increased workload for other members of staff (Black et al., 2018). Updated guidance for the use of best screening tools to reduce injury risk is consequently needed.

Therefore, the aim of this systematic review was to identify the current return-to-work (RTW) screening tests conducted for athletic occupations following injury and their effectiveness of reducing reinjury risk.

2. Methods

This systematic review was guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement (Page et al., 2021) (Appendix 1). This study was prospectively registered and published with PROSPERO (ID:CRD42021260947).

2.1. Data sources and search strategy

An electronic search of BioMed Central, CINAHL through ebscohost, EMBASE, Google Scholar, PUBMED, Scopus, SPORTDiscus and Web of Science was undertaken from their inception to March 2022 (Table 1). Two review authors (L.N. and K.M.) independently screened studies, firstly by title and abstract, and then by full text for eligibility. Disagreements between reviewers were resolved by discussion and if required, by mediation from a third reviewer (A.M. or J.M).

2.2. Eligibility criteria

2.2.1. Population

All included studies contained patients over the age of 18 who were returning to an athletic occupation. There was no restriction on a participant's gender. Any studies including participants who were not involved in an athletic occupation were excluded. There was no restriction on the duration participants had been working in an athletic occupation, length of time since participants' injury or surgery and the use of the screening test and follow up time to assess any reinjury.

2.2.2. Outcome measures

Reinjury Rates after return to work was the primary outcome. Studies not assessing reinjury rates were excluded. Reinjury was defined as an injury of the same type and in the same location on the body (Hägglund et al., 2007). Secondary outcome measures included the nature of the reported injuries, duration away from sport/work and whether participants return to sport participation or full duties.

2.2.3. Study design

Studies were eligible for inclusion if they were, randomised controlled trials (RCTs), non-randomised controlled trials (non-RCTs), cohort studies, case-control studies, case series studies or case studies investigating the effectiveness of screening tests for reducing reinjury rates. Cross sectional studies, reviews and editorials were not included.

2.2.4. Language

Only studies published in English were included.

2.2.5. Risk of bias assessment

The Newcastle Ottawa Scale (NOS) was used by two reviewers (LN & KM) to assess the risk of bias for cohort studies (Stang, 2010). The NOS consists of categories including selection, comparability and outcome or exposure depending on the study type (cohort or case-control series). A star system is used, ranging between zero and nine stars (Stang, 2010) Thresholds set based on overall score; seven to nine stars was considered "Low risk of bias", four to six stars was considered "Unclear risk of bias" and three or less stars was considered "High risk of bias" (Gates et al., 2018).

2.2.6. Data extraction

Two reviewers (LN & KM) extracted the data using a predetermined extraction form. If there was disagreement, a third reviewer (either AM or JM) resolved the disagreement. Data to be extracted included re-injury rates, time to return to work/sport, return to work/sport rates, types of screening tests utilised.

2.2.7. Data synthesis

To understand the effectiveness of screening tests and their impact in reducing in reinjury rates, results were split into the following three time points based on previous literature (de Waard et al., 2017; Delgado-Noguera et al., 2015): "Short-term" ($\leq$1 year), "Medium-term" ($\geq$2 years) and "Long-term" ($\geq$3 years). Within-group effect sizes were reported for each study and each of the time points of interest. Effect size was interpreted as "Small" (<0.5), "Medium" (0.5–0.7), "Large" (0.8–1.2) or "Very Large" (>1.3) (Sullivan & Feinn, 2012). If effect size was not reported it was calculated manually using Cohen's *d* and magnitude of effect size (Chen et al., 2010).

2.2.8. Assessment of the certainty of the body of evidence of findings

The certainty of the body of evidence of findings was assessed

Table 1
Search terms used for database searches.

Search Term
"Firef*" OR "Firefighters" OR "Injured Firefighter" OR "Athlete" OR "Athletes" OR "Tactical Athlete" OR "Tactical Athlete" OR "Injured Tactical Athlete" OR "Injured Athlete" OR "Athletic" OR "Sportsm?n" OR "Sportswom?n" OR "Sportsperson" OR "Individual" OR "Individuals" OR "Injured Individual" OR "Emergency service" OR "Emergency services" OR "Army" OR "Armed Forces" OR "Military"
AND
"Return to duty" OR "Return to play" OR "Return to sport" OR "Return to compe*" OR "Return from injur*" OR "Return to work" OR "Return to physical activity" OR "Suitable return to work" OR "Back to dut*" OR "Back to play" OR "Back to sport" OR "Back to comp*" OR "Back to work" OR "Injury Rehabilitation" OR "Injury Recovery" OR "Musculoskeletal Rehabilitation" OR "Musculoskeletal Recovery" OR "Musculoskeletal Injury" OR "Musculoskeletal disorder" OR "Low back pain" OR "Back pain" OR "Sciatica" OR "Back ache" OR "Back pain" OR "Lumbar Pain OR "Shoulder injury" OR "Shoulder pain" OR "Physi* treatment" OR "Physiotherapy rehabilitation" OR "Physiotherapy recovery" OR "Occupational therapy" OR "Rehabilitation system" OR "Activity limitation" OR "Participation restriction" OR "Expectations" OR "Work capacity" OR "Work exposure" OR "Work related" OR "Job" OR "Employee" OR "Occupation" OR "Reintegration" OR "Work status"
AND
"Climbing stairs" OR "Stair climbing" OR "Climbing ladder" OR "Ladder climbing" OR "Standing" OR "Repetitive movements" OR "Working above shoulder" OR "Working with bend back" OR "Squatting" OR "Kneeling" OR "Lifting" OR "Carrying"
AND
"Traffic light system" OR "Traffic light criteri*" OR "Decision Making" OR "Decision making system" OR "Decision Criteria" OR "Return to work checklist" OR "Work reuptake criteria" OR "Work ability index" OR "Return to work criteria" OR Return to workOR "Work resumption" OR "Fitness assessment" OR "Fitness Test" OR "Aerobic fitness assessment" OR "Aerobic fitness test" OR "Strength assessment" OR "Strength Test" OR "Physical Assessment" OR "Guidelines for return" OR "Screening" OR "Re-injur*" OR "Reinjur*" OR "Re-injur* Risk" OR "Reinjur* Risk" OR "Functional capacity evaluation" OR "Functional capacity" OR "Functional assessment" OR "Disability evaluation" OR "Follow up stud*" OR "Sick leave" OR "Job re-entry" OR "Sustainable return to work" OR "Performance test" OR "Performance assessment" OR "Performance based test" OR "Performance based assessment" OR "Lifting test" OR "Strength test" OR "Carry test"

using the Grading of Recommendations, Assessment, Development and Evaluations (GRADE) approach (Brożek et al., 2009). It was used by two reviewers (LN & KM). If there was a disagreement between the two researchers, a third (either AM or JM) were used to decide on the appropriate action. The GRADE approach categorise the certainty of evidence into four levels; "High" (we are very confident that the true effect lies close to that of the estimate of effect), "Moderate" (we are moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different), "Low" (our confidence in the effect size is limited: the true effect many be substantially different from the estimate of the effect) and "Very Low" (we have very little confidence in the effect estimate) (Balshem et al., 2011).

3. Results

3.1. Study selection

Fig. 1 shows the study identification process. Once duplicates were removed, 2837 studies were identified. After title and abstract screening, 71 studies were considered for full text review with 5 studies remaining to be included for review.

3.2. Study characteristics

Study characteristics are described in Table 4. Studies included a total of 507 participants (Male – 309, Female – 198), all of whom were recruited from athletic occupations (De Vos et al., 2014; Fältström et al., 2021; King et al., 2021; van Melick et al., 2021; Zore et al., 2021). Of the five studies included, all were cohort studies (De Vos et al., 2014; Fältström et al., 2021; King et al., 2021; van Melick et al., 2021; Zore et al., 2021), four involved participants recovering from an anterior cruciate ligament (ACL) injury (Fältström et al., 2021; King et al., 2021; van Melick et al., 2021; Zore et al., 2021) and one study involved participants recovering from a hamstring injury (De Vos et al., 2014). The mean time between injury or surgery and the return to sport screening test in the studies ranged between 40 days and 19 months (De Vos et al., 2014; Fältström et al., 2021; King et al., 2021; van Melick et al., 2021; Zore et al., 2021). Three studies conducted one follow up to assess reinjury rates after 24 months (De Vos et al., 2014; Fältström et al., 2021; van Melick et al., 2021). Two studies used two separate follow ups, at 12 months and 24 months (King et al., 2021) and at 9 months and 60 months (Zore et al., 2021).

3.3. Risk of bias assessment

The risk of bias of the included studies is shown in Table 2. Four of the studies were deemed to have a low risk of bias (De Vos et al., 2014; Fältström et al., 2021; van Melick et al., 2021; Zore et al., 2021) and the remaining article was deemed to have an unclear risk of bias (King et al., 2021).

3.4. Assessment of the certainty of the body of evidence of findings

The assessment of the certainty of the body of evidence was assessed using the GRADE approach (Brożek et al., 2009). There was a very low level of certainty for the effectiveness of screening tests reducing the risk of reinjury at three separate time points (up to and including one year, up to and including two years and greater than three years) (Table 3).

3.5. Return from injury screening test used

All studies used a physical screening test to help predict if an individual was ready to return to their sport following an injury and or surgery (Table 4) (De Vos et al., 2014; Fältström et al., 2021; King et al., 2021; van Melick et al., 2021; Zore et al., 2021). The physical variables measured included ROM, knee extension, knee flexion, jumping and hopping (De Vos et al., 2014; Fältström et al., 2021; King et al., 2021; van Melick et al., 2021; Zore et al., 2021). One study required the participants to reach a set criterion of a limb symmetry index (LSI) > 90% for all movement quantity tests and a single leg hop and hold less than 6 on the Landing Error Scoring System (LESS) before being permitted to return to sport or play (De Vos et al., 2014).

3.6. Reinjury rates following the use of a return to sport or play screening test

All studies provided reinjury rates in participants following their return to work. Four studies involved participants after an ACL injury (Fältström et al., 2021; King et al., 2021; van Melick et al.,

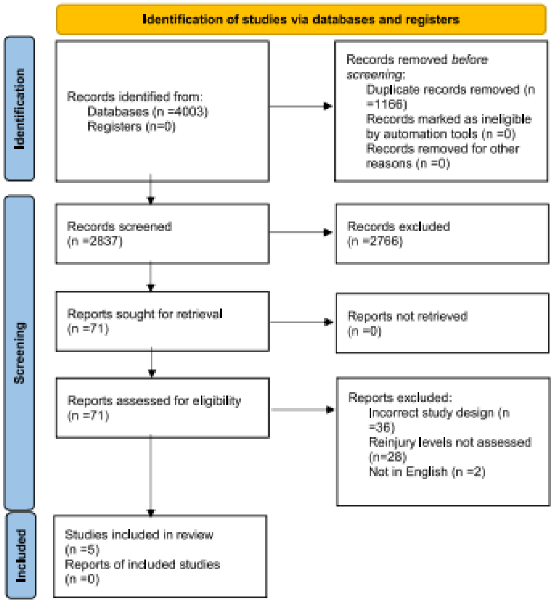

Fig. 1. PRISMA 2020 flow diagram for new systematic reviews which included searches of databases and registers only (Black et al., 2018).

Table 2
Risk of bias assessment of included studies using the Newcastle Ottawa Scale (NOS).

Author (Year)	Selection	Comparability	Exposure/Outcome	Total Stars	Risk of Bias
(De Vos et al., 2014)	****	**	***	9	Low
(Fältström et al., 2021)	****	**	***	9	Low
(King et al., 2021)	****	*	*	5	Unclear
(van Melick et al., 2021)	****	**	**	8	Low
(Zore et al., 2021)	****	*	**	7	Low

Table 3
Assessment of the certainty of the body of evidence findings of reinjury rates following the use of screening tests taken across three time points, with Grading of Recommendations Assessment, Development and Evaluation (GRADE). *Note:* * Downgraded once for risk of bias, ** Downgraded once for inconsistency, *** Downgraded once for imprecision.

Outcome by time point	Studies	No. of studies	Type of studies	No. of participants	Risk of bias	Inconsistency	Indirectness	Imprecision	Publication bias	Level of certainty
≤1 year	(De Vos et al., 2014)	1 study	1 cohort study	64	−1	−1	No	−1	Undetected	*,***Very Low
≤2 years	(Fältström et al., 2021) (King et al., 2021) (van Melick et al., 2021)	3 studies	3 cohort studies	380	−1	−1	No	−1	Undetected	*,**,***Very Low
≥3 years	(Zore et al., 2021)	1 study	1 cohort study	63	No	No	No	−1	Undetected	***Very Low

Table 4
Study characteristics. SD = Standard Deviation, ACL = Anterior Cruciate Ligament, ACLR = Anterior Cruciate Ligament Reconstruction, ROM = Range of motion, RI = Reinjury group, NRI = No reinjury group, SD = Standard deviation, N = Number of participants, M = Male, F= Female, RTP = Return to play, LSI = Limb Symmetry Index, EPIC = Estimated Preinjury Capacity, EPIC- H = Estimated preinjury capacity of uninvolved limb.

Reference (Year)	Study Design	Area of injury	Sample size	Gender	Mean Age (Year)	Physical Occupation	Outcome measure	Screening test used	Duration away from sport (Mean ± SD)	Follow up time after assessment	Returned to sport participation	Reinjury Rates following RTS/RTP assessment
(De Vos et al., 2014)	Cohort Study	Hamstring	N = 64	M = 61 F = 3	28 (Black et al., 2018; de Waard et al., 2017; Delgado-Noguera et al., 2015; Gates et al., 2018; Hägglund et al., 2007; Houghton et al., 2016; Noll et al., 2021; Page et al., 2021; Stang, 2010; Sullivan & Feinn, 2012; Tol et al., 2014)	Soccer (N = 45) Futsal (N = 1) Field Hockey (N = 11) Athletics (N = 4) Tennis (N = 1) American football (N = 1) Fitness (N = 1)	Hamstring reinjury rates	Active knee extension test Passive straight leg raise.	40 days (31 –55 days)	12-month post initial injury	N = 64	N = 17 (27%)
(Faltström et al., 2021)	Cohort Study	ACL	RI = 28 NRI = 89	F = 117	RI = 20 ± 3 NRI = 20 ± 2	Soccer (N = 117)	ACL reinjury rates	Knee extension LSI on single hop for distance(%) LSI on side hop (%) 5-jump test (cm) Tuck jumps	19 (±9) months	24-months post ACL reconstruction	N = 117	N = 28 (24%)
(King et al., 2021)	Cohort Study	ACL	RI = 31 NRI = 57	M = 88	RI = 21.7 (±4.9) NRI = 22.9 (±4.1)	Gaelic Football RI (N = 16) NRI (N = 23) Hurling RI (N = 6) NRI (N = 14) Soccer RI (N = 5) NRI (N = 11) Rugby RI (N = 4) NRI (N = 9)	ACL reinjury rates	Quadricep LSI Hamstring LSI Single leg countermovement jump Single leg drop jump Single leg hop for distance Double leg drop jump (knee flexion, centre of mass to ankle vertical distance and ground contact time))	RI = 9.1 (±3.1) months NRI = 9.3 (±1.2) months	12-months and 24-months post-surgery	N = 88	N = 31 (35%)
(van Melick et al., 2021)	Cohort Study	ACL	N = 175	M = 123 F = 52	24 ± 6	Soccer (N = 129) Volleyball (N = 9) Handball (N = 8) Hockey (N = 7) Korfball (N = 6) Basketball (N = 5) Other pivoting sport (N = 11)	ACL reinjury rates	Strength test battery Hop test battery Movement quantity tests combined Hop and hold CMJ with LESS Movement quality tests combined Movement quantity and quality combined	11.8 months (±2.9)	24-months post surgery	N = 102	N = 7 (5%)

(continued on next page)

Table 4 (*continued*)

Reference (Year)	Study Design	Area of injury	Sample size	Gender	Mean Age (Year)	Physical Occupation	Outcome measure	Screening test used	Duration away from sport (Mean ± SD)	Follow up time after assessment	Returned to sport participation	Reinjury Rates following RTS/RTP assessment
(Zore et al., 2021)	Cohort Study	ACL	N = 63	M = 37 F = 26	34.7 (SD = 12.3)	Professional or recreational sports (N = 63)	ACL reinjury rates	Knee extension LSI Peak torque (ACLR) Peak torque (uninvolved) EPIC EPIC-H Knee flexion LSI Peak torque (ACLR) Peak torque (uninvolved) EPIC EPIC-H	8.5 months (±9.03)	Short term (9 months) following ACL reconstruction. Medium term (60 months) following ACL reconstruction.	N = 63	N = 12 (19%)

2021; Zore et al., 2021), reporting reinjury rates of 24% (Fältström et al., 2021), 35% (King et al., 2021), 5% (van Melick et al., 2021) and 19% (Zore et al., 2021). One study involved participants after a hamstring injury (De Vos et al., 2014), reporting a reinjury rate of 27% following a return to sport or play respectively.

3.7. *Reinjury rates following the use of a screening test across different time points*

The extracted data presented in Tables 5–7 provided three time points at which reinjury rates were recorded. Short-term (≤1 year), medium-term (≥2 years) and long-term (≥3 years). If effect size was not reported it was calculated manually using Cohen's *d* and magnitude of effect size (Chen et al., 2010).

3.8. *Short-term (<1 year)*

One cohort study (De Vos et al., 2014) reported a very low certainty for the effectiveness of screening tests in reducing the risk of reinjury up to and including one year. In the context of this very low certainty, one screening test assessing deficit in knee extension and passive straight leg raise, the effect size was not reported. Knee extension deficit reported a between groups *p* value of 0.059 and passive straight leg raise reported a between group *p* value of 0.376 (Table 5).

3.9. *Medium term (≥2 years)*

Three cohort studies (Fältström et al., 2021; King et al., 2021; van Melick et al., 2021) reported very low certainty for the effectiveness of screening tests reducing the risk of reinjury up to an including two years. In the context of this very low certainty, two tests, demonstrated a small effect in LSI on hopping distance (Fältström et al., 2021; King et al., 2021) and quadricep and hamstring strength for reducing the risk of reinjury (Fältström et al., 2021; King et al., 2021). Two return to screening tests, double leg 5-jump test and double leg drop jump, demonstrated a medium effect for reducing the risk of reinjury (Fältström et al., 2021; King et al., 2021). One study did not report effect size but did report relative risk for some of the screening tests (van Melick et al., 2021) Strength test battery screening tests reported a relative risk of 2.95 (0.37–23.51). Hop and hold screening tests reported a relative risk of 10.17 (1.28–81.10). Counter movement jump (CMJ) with the landing error scoring system reported a relative risk of 2.16 (0.44–10.62). Movement quality tests combined reported a relative risk of 3.86 (0.48–30.85) (van Melick et al., 2021).

3.10. *Long term (≥3 years)*

One cohort study (Zore et al., 2021) reported very low certainty for the effectiveness of screening tests reducing the risk of reinjury greater than three years. In the context of this very low certainty, one screening test, demonstrated a small effect size in limb symmetry index (LSI) in both knee extension and flexion for reducing the risk of reinjury. One screening test, peak torque, demonstrated medium effect during knee extension and small effect during knee flexion in both the leg with ACL reconstruction and the uninvolved leg for reducing the risk of reinjury. One screening test, Estimated Preinjury Capacity (EPIC) demonstrated a large effect during knee extension and a medium effect during knee flexion in both the leg with ACL reconstruction and the uninvolved leg for reducing the risk of reinjury.

4. Discussion

The aim of this systematic review was to identify current RTW screening tests conducted for athletic occupations following injury and understand their effectiveness for reducing reinjury risk. To the authors' knowledge, this is the first review of its kind. Overall, there was very low certainty for the effectiveness of the use of screening tests for reducing the risk of reinjury. Whilst this review does identify data indicating screening tests can reduce the risk of reinjury, the low level of certainty of these findings indicate that they should be interpreted with caution.

All studies used in this review assessed a population of professional athletes returning to a sporting occupation following an injury (De Vos et al., 2014; Fältström et al., 2021; King et al., 2021; van Melick et al., 2021; Zore et al., 2021). No studies were found involving tactical athletes, highlighting a shortfall in our understanding for the use of screening tests in tactical athletes returning to work following injury. All studies in this review assessed ACL and hamstring injuries (De Vos et al., 2014; Fältström et al., 2021; King et al., 2021; van Melick et al., 2021; Zore et al., 2021). Athletic occupations are at risk of sustaining other musculoskeletal injuries with injuries to the back, ankle, shoulder and hip common in these populations (Gray & Finch, 2015; Noll et al., 2021; Orr et al., 2019). Therefore, further research is needed to assess the effectiveness of screening tests in reducing reinjury risk for a range of musculoskeletal injuries.

The screening tests found in this review assessed a range of elements to assess their association with risk of reinjury. These elements were knee extension peak torque (De Vos et al., 2014; Fältström et al., 2021; Zore et al., 2021), knee flexion peak torque (Zore et al., 2021), LSI (Fältström et al., 2021; King et al., 2021; Zore et al., 2021), hop and jumping tests (Fältström et al., 2021; King et al., 2021; van Melick et al., 2021) and EPIC (Zore et al., 2021). The use of EPIC was the only screening test which reported a large effect size (Zore et al., 2021), highlighting the importance that failure to regain knee function prior to Anterior Cruciate Ligament Reconstruction (ACLR) may cause an increased risk for a second ACL injury (Zore et al., 2021). EPIC compared the strength of the previously injured limb of an individual returning to an athletic occupation with the strength of the non-injured limb immediately after the injury or surgery (Zore et al., 2021). Individuals with greater percentage loss to both muscle and strength in their rehabilitating limb were at increased risk of suffering a secondary reinjury (Hannon et al., 2017; Zore et al., 2021).

Because of the increased injury risk, many athletic occupations require individuals to maintain certain strength standards to enable them to perform their job role safely and effectively (Rayson et al., 2000; Siddall et al., 2016). Previous studies have suggested that failure to retain physical standards and poor performances during physical assessments could increase injury risk (Morris et al., 2021; Sarah et al., 2017; Stevenson et al., 2017).

The use of a screening test for athletic occupations aiming to RTW following injury has the potential to assess if the rehabilitated limb is able to achieve at least the minimum physical demands of the workplace tasks before a RTW, as returning prematurely has seen associated increases in reinjury risks (Kaplan & Witvrouw, 2019; Nosanov & Romanowski, 2020). The interpretation from this review indicates that screening for reinjury risk should be comprised of multiple tests to reduce the risk of reinjury when compared to using a single test, with an importance focused on muscular strength (van Melick et al., 2021; Zore et al., 2021). One study in this review claimed that the use of multiple tests assessing jump height, jump length and running change of direction times may offer more accurate information relating to reinjury risk compared to using tests in isolation (King et al., 2021).

In the absence of research on the use of RTW screening tests for tactical athletes following injury and their effectiveness at reducing reinjury risk, further research is required. Currently, multiple tests of aerobic fitness and muscular strength are used in the selection process in tactical athletes including the military, the police and the fire service (Orr et al., 2018; Rayson et al., 2000; Stevenson et al., 2017). Previous research in tactical athletes has provided national recommendations for entry level aerobic fitness and muscular strength standards to ensure that potential candidates are able to reach the job task demands before employment (Morris et al., 2019; Rayson et al., 2000; Siddall et al., 2016; Stevenson et al., 2016).

Many tactical athletes are assessed on their aerobic fitness and muscular strength based on generic tasks experienced during active duties (including weighted carries, weighted lifts and running) (Rayson et al., 2000; Stevenson et al., 2017). These selection tests were created to assess if an individual could achieve the minimum physical attributes required to undertake the task demands of a their role (Rayson et al., 2000; Stevenson et al., 2017). The use of generic tasks during the selection tests required no specialised training, making it possible for them to be used on civilian population (Rayson et al., 2000; Stevenson et al., 2017). However, once employed as a tactical athlete, individuals are trained in more specific tasks related to their job role (Mazzetti, 2013; Strader et al., 2020). Therefore, it may not be suitable to use the generic tasks from selection process tests alone when aiming to reduce reinjury risk for tactical athletes returning following an injury. Instead, return to work screening tests could involve more specific tasks relating to the individuals job task demands.

Previous research has used physical assessment tests for tactical athletes to predict injury rates (Orr et al., 2021). Low levels of aerobic fitness and muscular strength were associated with a high risk of injury whilst on duty (Orr et al., 2021). However, previous research predicting injury risk in tactical athletes included only participants who were physically healthy and with no recent injury (Bock & Orr, 2015; Kollock et al., 2018; Tomes et al., 2020). No research on screening tests aimed at reducing reinjury risk for tactical athletes return to duty following an injury currently exists.

If a screening test could help to reduce the risk of a reinjury in athletic occupations, it could be advantageous for the employer as it could result in fewer days employees were absent from the workplace and lower expenses from sick pay for the organisation (Griffin et al., 2016; Hilyer et al., 1990).

4.1. Strengths and limitations

This review is the first of its kind to evaluate the current screening tests used in tactical athletes and their effectiveness in reducing the risk of reinjury. These findings are robust given the

Table 5
Reinjury rates following the use of screening tests in short term follow-up (≤1 year).

Study	Area of Injury	Design	Outcome Measure	Follow up	Return to Sport/Play assessment	Effect Size	Magnitude	Between groups *P*-value
(De Vos et al., 2014)	Hamstring	Cohort	Hamstring reinjury rates	12 months	Active knee extension deficit	Not reported	Not reported	0.059
					Passive straight leg raise			0.376

Table 6
Reinjury rates following the use of screening tests in medium term follow-up (≥2 years). ACL = Anterior Cruciate Ligament, LSI = Limb Symmetry Index, CMJ = Counter-movement jump, LESS = Landing Error Scoring System. *Significant Difference ($P = \leq 0.05$) **Relative Risk.

Study	Area of Injury	Design	Outcome Measure	Follow up	Return to Sport/Play assessment	Effect Size	Magnitude	Between groups P-value
(Faltström et al., 2021)	ACL	Cohort	ACL reinjury rates	24 months	Knee extension	0.39	Small	0.044*
					LSI on single hop for distance(%)	0.12	Small	0.630
					LSI on side hop (%)	0.24	Small	0.237
					5-jump test (cm)	0.55	Medium	0.007*
					Tuck jumps	0	None	0.286
(King et al., 2021)	ACL	Cohort	ACL reinjury rates	24 months	Quadricep LSI	0.1	Small	0.652
					Hamstring LSI	0.24	Small	0.275
					Single leg countermovement jump	0.01	Small	0.964
					Single leg drop jump	0.19	Small	0.445
					Single leg hop for distance	0.21	Small	0.388
					Double leg drop jump (knee flexion, centre of mass to ankle vertical distance and ground contact time)	0.52–0.64	Medium	0.21–0.3
(van Melick et al., 2021)	ACL	Cohort	ACL reinjury rates	24 months	Strength test battery	2.95 (0.37–23.51)**	Not reported	0.420
					Hop test battery	Not reported	Not reported	0.047*
					Movement quantity tests combined	Not reported	Not reported	0.348
					Hop and hold	10.17 (1.28–81.10)**	Not reported	0.010*
					CMJ with LESS	2.16 (0.44–10.62)**	Not reported	0.445
					Movement quality tests combined	3.86 (0.48–30.85)**	Not reported	0.240
					Movement quantity and quality combined	Not reported	Not reported	0.591

Table 7
Reinjury rates following the use of screening tests in long term follow-up (≥3 years). ACL = Anterior Cruciate Ligament, ACLR = Anterior Cruciate Ligament Reconstruction, LSI = Limb Symmetry Index, EPIC = Estimated Preinjury Capacity, EPIC- H = Estimated preinjury capacity of uninvolved limb. *Significant difference ($P = \leq 0.05$).

Study	Area of Injury	Design	Outcome Measure	Follow up	Return to Sport/Play assessment	Effect Size	Magnitude	Between groups P-value
(Zore et al., 2021)	ACL	Cohort	ACL reinjury rates	5 Years	**Knee extension**			
					LSI	0.15	Small	0.663
					Peak torque (ACLR)	0.53	Medium	0.114
					Peak torque (uninvolved)	0.54	Medium	0.096
					EPIC	0.84	Large	0.028*
					EPIC-H	1.6	Large	<0.001*
					Knee flexion			
					LSI	0.12	Small	0.664
					Peak torque (ACLR)	0.38	Small	0.258
					Peak torque (uninvolved)	0.35	Small	0.251
					EPIC	0.52	Medium	0.127
					EPIC-H	0.6	Medium	0.052

adherence to PRISMA 2020 guidelines. This review highlighted several limitations of the evidence found. Firstly, a very low level of certainty was found at all three time points for reinjuries. Secondly, only cohort studies were found during the search and all studies involved individuals returning to sport. No studies were identified for any tactical athletes returning to duty following an injury. Finally, language was restricted to English language only.

5. Conclusion

This review sought to investigate screening tests amongst all athletic occupations. The results demonstrated very low level of certainty for the effectiveness of RTW screening tests reducing the risk of reinjury. The use of EPIC reported a large effect size and highlighted the importance of regaining muscular strength in the rehabilitating limb before a RTW in professional sport athletes (Zore et al., 2021). Interpretation from this review indicates that the use of multiple tests of muscular strength and endurance are more beneficial than the use of a singular test in isolation (van Melick et al., 2021; Zore et al., 2021). A gap in our understanding currently exists for RTW screening tests in tactical athletic occupations. Research is required to investigate the effectiveness of RTW screening tests for tactical athletes returning to work following injury.

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Ethics approval

None declared. The manuscript is a systematic review.

Declaration of competing interest

All authors declare they have no conflict of interests.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ptsp.2022.10.010.

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Appendix 5

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ORIGINAL ARTICLE

Consensus on tasks to be included in a return to work assessment for a UK firefighter following an injury: an online Delphi study

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Abstract

Objective The aim was to provide a consensus tasks needed to be included in a return to work assessment for operational firefighters.

Methods A two round online Delphi study was conducted with twenty-four participants including firefighters, service fitness advisers and occupational health managers. A consensus was set at 70% agreement. In round one, participants completed an online survey relating to tasks to be included during a return to work assessment for firefighters following an injury. Round two was an online consensus meeting to discuss the tasks where consensus was not achieved.

Results A consensus was reached for ten of the thirteen tasks, including the number of repetitions required when lifting a light portable pump and climbing a ladder. A consensus was reached for the total distance equipment which should be carried. This included carrying a ladder, a hose and a light portable pump.

Conclusions This study has provided a consensus for tasks to be included when assessing a firefighter for return to work. Further research is needed to understand how to use this assessment optimally

Keywords Firefighter · Return to work · Injury · United Kingdom

Introduction

The role of a firefighter requires individuals to be ready to respond to emergencies within minutes (Fjelstad and Gravatt 1977), this means that they can go from a state of rest to high levels of physical exertion very quickly (Smith 2011). During these emergencies, firefighters can be exposed to conditions which are stressful and unpredictable (Bos et al. 2004). Such environments can be dangerous for firefighters to work in as they can be exposed to high temperatures and toxic smoke which can reduce visibility (Bos et al. 2004). In addition, firefighters are expected to respond to the emergencies with urgency which can add psychological stress (Bos et al. 2004).

During these emergencies, firefighters are required to complete tasks requiring certain physical aspects including aerobic fitness, muscular strength and endurance (Smith 2011) which can cause challenging physical demands on the body (Bos et al. 2004). Associated tasks include, climbing stairs, evacuating casualties, lifting ladders, extending and lowering ladders, carrying equipment and hose running (Stevenson et al. 2016). At other emergencies that requires the use of breathing apparatus, the firefighter may need to wear PPE that adds an additional 22 kg on their weight (Smith 2011).

The combination of these tasks, the unpredictable and varied working conditions that firefighters are faced with a high risk of work-related injuries (Karter et al. 2001; Orr et al. 2019). In the UK there were 2646 injuries to operational firefighters between the years 2018–2019. From the injuries, 340 resulted in more than three days' work absence while 54 were classified as major. The major injuries were grouped as fractures, dislocations to the shoulder, hip or knees. Injuries were also classed as major if the firefighter was required to stay in hospital for more than 24 h (Fire statistics data tables 2020). Reports show that firefighters suffer over three times more injuries when compared with other similarly physical jobs including construction workers and labourers within the private sector (Matticks et al. 1992). Firefighters are not only at risk of fire-related injuries including burns (Fire statistics data tables. 2020), but also

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musculoskeletal injuries (Gray and Finch 2015), with muscle strains and sprains, upper and lower extremity injuries and back injuries being the most common (Gray and Finch 2015). Almost half (49%) of all overexertion injuries are caused by lifting movements (Orr et al. 2019), which is a critical task for a firefighter in their normal job role (Stevenson et al. 2016).

On return to work following an injury, firefighters are expected to return to their normal job role. However, if a firefighter returns to work with an injury which hasn't fully recovered then the performance of their role is potentially compromised (Stover 2011), as well as the safety of their colleagues and the public (Smith 2011). In addition, if a muscle has not fully recovered it may not be fully functional, meaning that the risk factor of re-injury is increased (Arnason et al. 2004). Re-injury rates can suggest that individuals may be returning to their job role too soon due to sufficient return to work protocols not being in place (Erickson and Sherry (2017). Therefore, screening tests/functional capacity evaluations have been created to help identify the return to work readiness of an individual by measuring their ability to complete work-related activities (Gray and Finch 2015; Soer et al. 2008).

Functional capacity evaluations usually consist of a series of movements relating to an individual's job role (Manske and Reiman 2013), examples of these movements can involve lifting, carrying, bending, reaching and climbing (Jahnke et al. 2013). These movements can be used in comparison with normative workload requirements from healthy workers (Soer et al. 2008), if the individual is able to equal or surpass the required workload then they would be deemed ready to return to work (Soer et al. 2008).

All fire services in the United Kingdom use standard assessment requirements for their entry level and yearly annual aerobic fitness testing (Stevenson et al. 2016). This consistency across the nation is considered important to fire services (King et al. 1998). Currently, no such consensus exists for return to work physical assessments following an injury. Therefore, the aim of this study is to provide a consensus view of the tasks needed to be included in a return to work assessment for operational firefighters.

Study design

An online Delphi study was conducted aiming to achieve consensus on relevant tasks which were deemed to be important for firefighters to perform before returning to operational duties following an injury. The Delphi technique is an accepted method used for collecting opinions from experts within a chosen area of research, usually concerning real world knowledge and can be used to discover information which may result in a consensus from the group of experts (Hsu and Sandford (2007). A prior literature review was conducted to ensure tasks included in the decision making were exhaustive of tasks currently performed by operational firefighters. These tasks included lifting, carrying and climbing a ladder, lifting and carrying a hose, hose running, lifting and carrying a light portable pump, evacuating a casualty and crawling through enclosed spaces.

Data Collection

Round one—online survey

The first round of this study was completed with the use of an online survey (Appendix 1). The data were collected using Qualtrics survey software (Qualtrics 2005). It was password protected and did not attempt to collect personal details from participants, but might have collected an IP addresses. Participants were emailed a link to the survey. The start of the survey gave a brief overview of the study and reminded the participants to read the participant information sheet (PIS) should they have required more information before starting the survey. Participants were then asked to give their consent to take part in the survey, these questions were mandatory and progression to the rest of the survey was not allowed unless consent was given. The survey was live for two weeks to allow participants time to take part. A reminder email was sent seven days after the initial invitation to help increase participation. Participants were asked to rate each operational task as either important, not important or not sure. All tasks rated as important had a follow on question asking specific details to that task, this included the weight of the equipment, the distance it needed to be carried and the number of repetitions it needed to be lifted. The last section of the online survey required participants to rank the tasks of importance to be included in a return to work assessment following an injury (one = most important, eleven = least important). Participants were asked to provide an email address at the end of the survey. Email addresses were used to invite participants to a consensus meeting for the second round of the study. Personal details were not included in the study, all participants remained anonymous. After the two week period the results from the survey were collected. In order for a task to receive consensus, a minimum of 70% agreement that the task is important was required.

Round two—online consensus meeting

Participants were invited via email to attend an online meeting for the second round of the study. An online meeting was chosen to increase inclusivity and decrease travel costs to participants. An online Doodle poll was used to identify a date for the online meeting. A link to this poll was sent to the participants via email four weeks before the earliest proposed date. The email also contained details about the meeting. Once a majority date had been agreed, a further email was sent inviting participants to the online meeting. This email contained the link to the zoom meeting invitation. The aim of this meeting was to gain a consensus for the questions that did not achieve 70% agreement in the first round online survey. The results of the online consensus meeting were reported.

Recruitment

A purposive sample of participants, who work in occupational health or fitness departments for fire services in the United Kingdom were invited to participate in the study. Operational firefighters in the Essex county fire and rescue service were also invited. The design of the study was very specific to the fire service and operational tasks. Therefore, purposive sampling was used to capture consensus from experts working within the fire service. No minimum number of services years or minimum rank was required to take part in this study, however they needed to be an operational firefighter, part of the national FireFit steering group or the South East fire service fitness advisors regional group.

Sample size

Thirty-eight participants were invited to participate in the study across three main groups, all members from the national firefit steering group ($n = 18$), all members from the south east fire service fitness advisors group ($n = 6$) and operational trainers from Essex county fire and rescue service ($n = 14$). The total number of participants recruited was representative of the sampled population.

Data management

The management of data from the study followed the Data Protection Act (Act 1998).

Data analysis

Descriptive statistics of the results was presented to describe the participant's characteristics and survey responses.

Ethical Approval

Ethical approval was sought and granted on 8th April 2020 by The University of Essex research ethics committee. Ethics reference; ETH1920-0832.

Results

Participants

A total of thirty-eight participants met the inclusion criteria and were invited to take part in this study. Of these, twenty-four (63%) took part in the online survey of the first round. This sample included a representation across the United Kingdom (Fig. 1). Overall, the demographic of the participants were proportionally representative of the original invitation list. The mean age of the participants from round one was 43.4 + 9.26 years and the mean duration they had worked for the fire service was 16 + 7.26 years. There was representation from different fire service departments

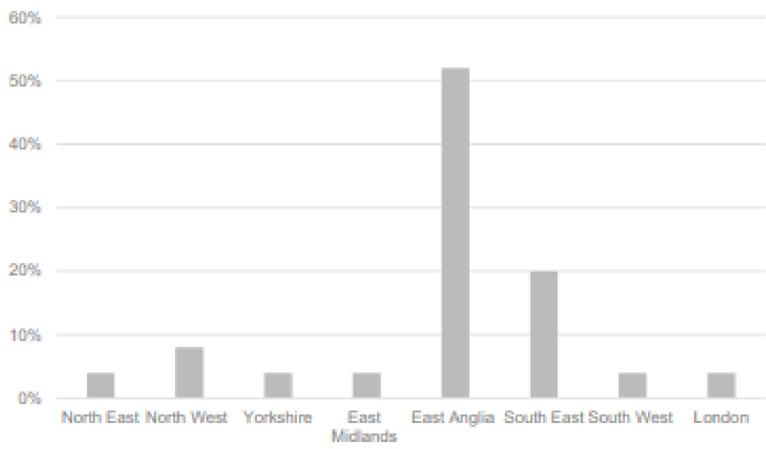

Fig. 1 Bar chart showing the region representation in the United Kingdom of the participants

($n=8$), service fitness advisors (40%), operational firefighters (48%) and occupational health managers (12%) (Appendix 2). From the twenty-four participants who completed the online survey, a total of fourteen participants (58% retention rate) attended the online consensus meeting.

Round one—online survey

All twelve tasks were classed important (100%), therefore a consensus was agreed on the tasks to be included in a return to work assessment (Table 1).

Aerobic fitness levels, task repetition, distance and weight

A 90% consensus was agreed that firefighters should reach this fitness level prior to returning to operational duties (Fig. 2).

Consensus could not be reached for the number of repetitions required for ladder lift, ladder climb with leg lock, lifting a light portable pump, putting on and removing a breathing apparatus set (Fig. 3). Consensus could not be reached for the distance required when carrying a ladder, a light portable pump, a hose and a simulated casualty (Fig. 4). Consensus could not be reached for the distance required to crawl in an enclosed space (Fig. 4). Consensus could not be reach for the weight of the simulated casualty (Fig. 5).

Survey results—task order of importance

The results were varied and a consensus could not be made as no task rank reached > 70% agreement (Table 2). Therefore, the task related order of importance was carried forward onto round 2, the online consensus meeting for further discussion.

Table 1 Results of perceived importance of operational tasks to be included in a return to work assessment

Task	Important	Not Important	Unsure
Ladder lift	100%	0%	0%
Ladder carry	100%	0%	0%
Ladder climb & leg lock	100%	0%	0%
Light portable pump lift	100%	0%	0%
Light portable pump carry	100%	0%	0%
Hose carry	100%	0%	0%
Hose run	100%	0%	0%
Casualty evacuation	100%	0%	0%
Putting on & removing breathing apparatus set	100%	0%	0%
Enclosed space crawl	100%	0%	0%
Aerobic fitness test	100%	0%	0%

Round two—online consensus meeting

Fourteen participants (58% retention rate) took part in the online consensus meeting. The duration of the meeting lasted 2 h. Twelve items were brought forward from round one to be discussed further in this meeting. Of these, a consensus (> 70% agreement) was reached on nine items with three items failing to reach a consensus.

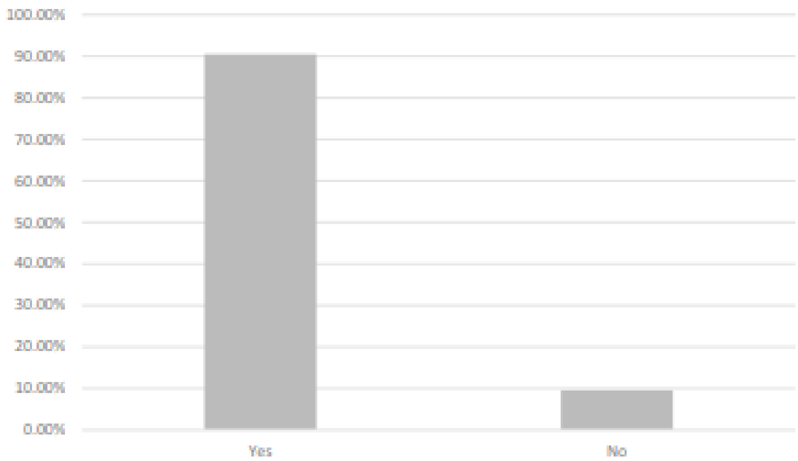

Fig. 2 Should a firefighter meet the minimum aerobic fitness level (42.3 ml/kg/min) before returning to operational duties?

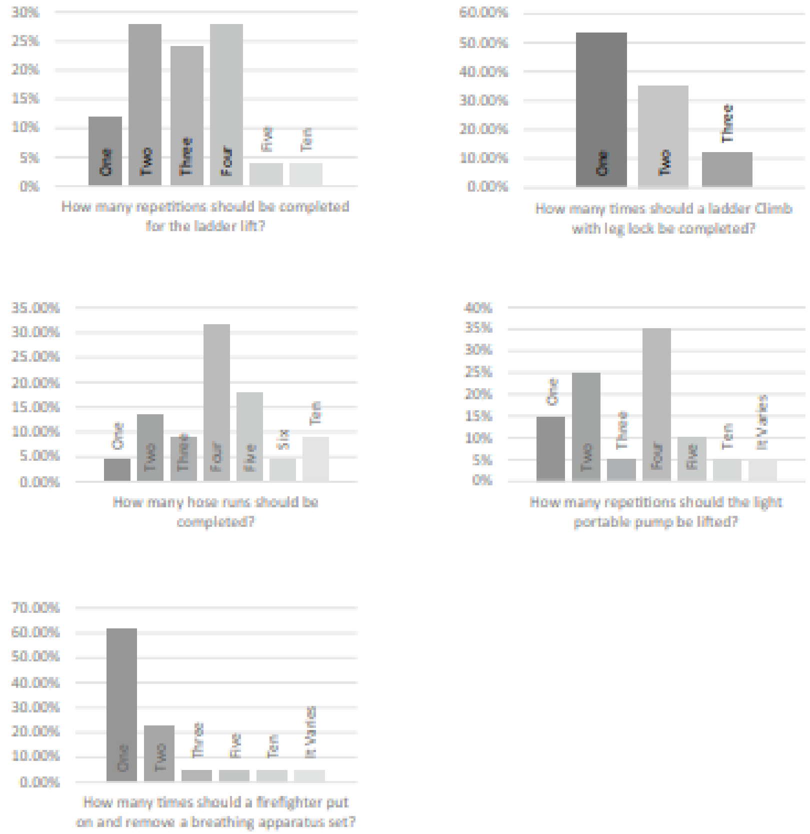

Fig. 3 Bar charts showing the survey results for the number of repetitions in each operational task to be used in a return to work assessment following injury

Online consensus meeting—task repetition, distance and weight

Consensus was reached on three out of the five tasks relating to total number of repetitions. Ladder climb and leg lock was agreed to be performed once, a light portable pump lift was agreed to be performed twice and a hose run was agreed to be performed twice. Consensus was not gained for ladder lift and putting on and removing a breathing apparatus set (Fig. 6). Consensus was reached for all five tasks relating to total distance. The distance of the ladder carry, hose carry and the light portable pump carry had an agreed consensus of 50 m. The casualty evacuation distance had a consensus agreement at 25 m and the enclosed space crawl was agreed at 20 m (Fig. 7). The weight of the casualty to be used in a simulated evacuation was the only task related to weight. A consensus was agreed that the weight should be 55 kg (Fig. 8).

Online consensus meeting—task order of importance

A consensus could not be agreed on the order of importance for the eleven tasks to be completed. An aerobic fitness test was agreed to be the most important task to be tested. However, there was not an agreement for the order of the remaining tasks, instead a consensus was agreed that the order of the remaining tasks didn't matter as long as they were all included in a return to work assessment.

Discussion

Currently, no nationally agreed assessment for return to work within fire services in the United Kingdom exists. Given the importance of firefighters returning safely to work, the purpose of this study was to gain consensus on the tasks to be

Fig. 4 Bar charts showing the results of the total distance to be completed in each operational task to be used in a return to work assessment

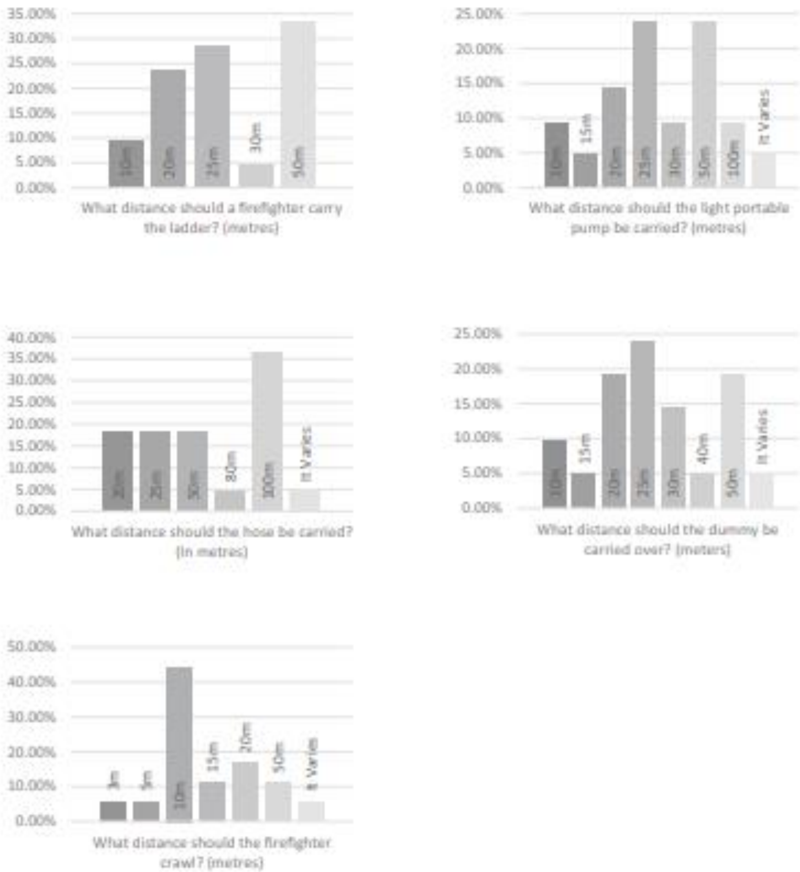

Fig. 5 Bar chart from the survey results of the total weight (KG) to be used during a simulated casualty evacuation in a return to work assessment

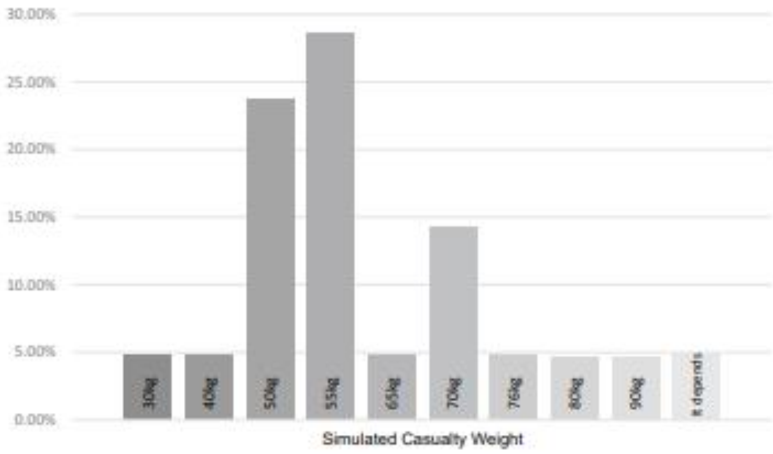

Table 2 Survey results of the task order of importance for a return to work assessment following injury (One = most important, Eleven = least important)

Task	1	2	3	4	5	6	7	8	9	10	11
Lifting a ladder	4.6%	18.2%	9.1%	4.6%	9.1%	27.3%	9.1%	4.6%	0.0%	9.1%	4.6%
Climbing a ladder	0.0%	0.0%	0.0%	9.1%	4.6%	9.1%	18.2%	18.2%	27.3%	13.6%	0.0%
Carrying a light portable pump	0.0%	0.0%	0.0%	0.0%	9.1%	4.6%	4.6%	27.3%	18.2%	18.2%	18.2%
Carrying a Hose	0.0%	18.2%	13.6%	22.7%	13.6%	13.6%	4.6%	0.0%	4.6%	4.6%	4.6%
Hose Running	0.0%	4.6%	18.2%	13.6%	22.7%	18.2%	9.1%	4.6%	4.6%	0.0%	4.6%
Carrying a ladder	0.0%	4.6%	9.1%	9.1%	13.6%	9.1%	27.3%	13.6%	4.6%	4.6%	4.6%
Casualty Evacuation	0.0%	0.0%	18.2%	9.1%	13.6%	13.6%	13.6%	13.6%	9.1%	9.1%	0.0%
Putting on/ Taking off a breathing apparatus set	9.1%	22.7%	13.6%	22.7%	9.1%	4.6%	4.6%	9.1%	4.6%	0.0%	0.0%
Climbing into a fire appliance	18.2%	22.7%	9.1%	4.6%	0.0%	0.0%	4.6%	0.0%	9.1%	22.7%	9.1%
Crawling through enclosed spaces	0.0%	4.6%	0.0%	0.0%	4.6%	0.0%	4.6%	4.6%	18.2%	13.6%	50.0%
Aerobic Fitness Test	68.1%	4.6%	9.1%	4.6%	0.0%	0.0%	0.0%	4.6%	0.0%	4.6%	4.6%

included in such an assessment. To the authors' knowledge, this is the first study that is specifically focussed on a return to work assessment for firefighters following injury.

Discussion was largely around how the tasks related to the role of a firefighter and expectations during an operational incident. Consensus was subsequently gained for eleven of the thirteen tasks; these eleven tasks should now be considered as the structure for a return to work assessment. This structure draws similarities with current United Kingdom national firefighter recommendations for minimum operational aerobic fitness levels (Siddall et al. 2016) and recruitment selection tests (Blacker et al. 2016). This could have influenced the choices made for the total number of repetitions, distance to be covered and weight to be used during a return to work assessment. However, the recruitment selection tests (Blacker et al. 2016) do not include all key operational tasks required from a firefighter, including hose running and would therefore not be suitable for a return to work assessment. In addition, these national standards are based on minimal aerobic and strength requirements, therefore this consensus could also be considered as minimal standards. Such similarities also bring similar challenges; how to interpret test / task results and what order to undertake tasks.

One potential solution to address these challenges would be to attach a traffic light system to each task, similarly used to assess aerobic fitness levels for firefighters in the United Kingdom (Ltd 2020). This system uses colours to indicate an individual's performance level on a particular task (Ltd 2020). For example, if a firefighter's VO2 max is greater than 42.2 ml/kg/min they would be in the 'green' category and ready to return to work. In the event that their VO2 max level is between 35.6 and 42.2 ml/kg/min they are placed into an 'amber' category where they are allowed to participate in the drill ground assessment test. Whenever the firefighter is unable to attain the required threshold, a referral to occupational health is required where a decision is made to either remove a firefighter from operational duties until they have completed remedial training with a service fitness adviser or allow them to retake the drill ground assessment and remain on operational duties (Ltd 2020). If their VO2 max level falls below 35.6 ml/kg/min an immediate removal from operational duties occurs and they are referred to occupational health (Ltd 2020). If no improvement in aerobic fitness is made through remedial training, the firefighter's line manager is then able to provide options for extra support or proceed with disciplinary action if necessary.

One benefit of this traffic light system is that it allows for a shared decision making model between key stakeholders. A shared decision making process has been used for athletes return to sport (Pollock and Ardern (2016). Where a healthcare professional would assess the athlete's health and provide advice on management and outcome. The coach would assess the athlete's ability to perform and the athlete would make a subjective informed preference decision (Pollock and Ardern 2016). Implementing a shared decision model could help to reduce conflict between different stakeholders involved in an individual's rehabilitation (Aubree Shay and Lafata 2015).

Although consensus was not reached for the order of importance of task, it was agreed that an aerobic fitness test should be conducted first. Aerobic fitness underpins vital operational duties; dragging a casualty out of a burning building or carrying a hose or a ladder, for example (Blacker et al. 2016). Therefore, it is important that a firefighter possesses both the required aerobic and strength levels to reduce the risk of overexertion and potential injury (Stevenson et al. 2017).

Considering the order of the tasks to be undertaken, it may be helpful to divide them into 'push', 'pull' and

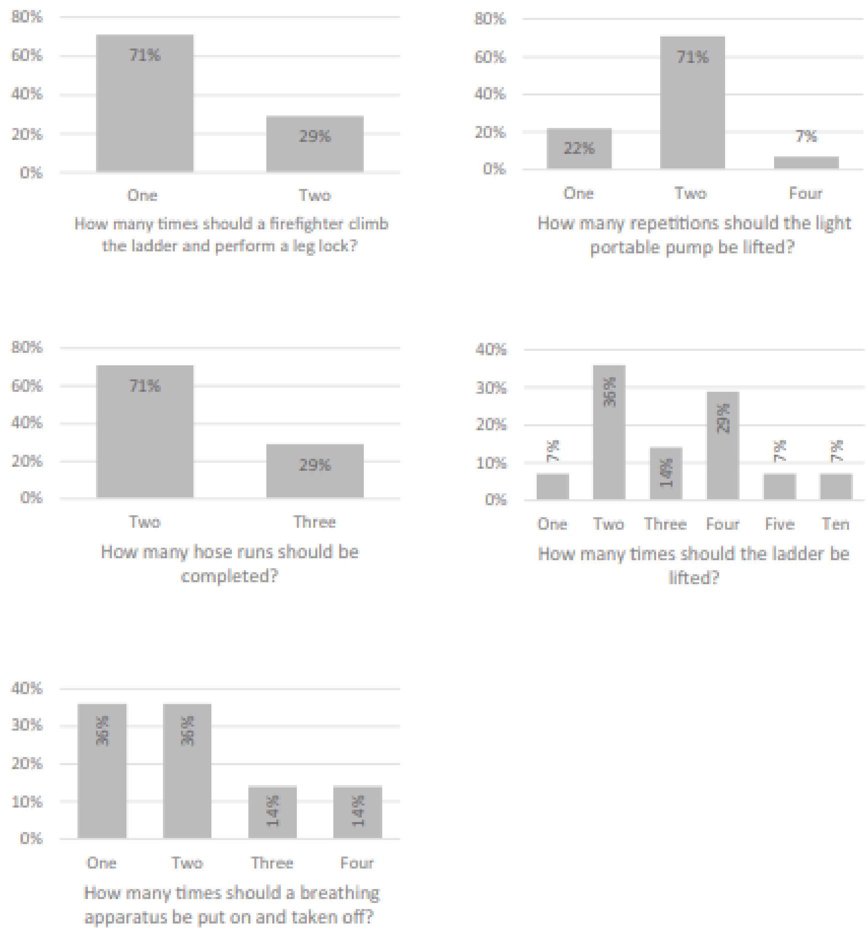

Fig. 6 Bar charts showing the results from the consensus meeting for the total number of repetitions for each operational task

'carry' movements where possible (Reiman et al. 2011). This could help reduce unnecessary repetition of task movements and avoid fatigue which could cause an individual to unfairly fail a subsequent task (Reiman et al. 2011). Each movement could be assessed using one's own bodyweight to ensure the correct technique is performed initially. Additional load can then be added until the demand of the tasks have been reached (Kritz et al. 2010). The benefits of this progressive approach helps to ensure that movement patterns are not compromised by external loads placed on the individual which helps reduce injury risk (Myer and Kushner 2014).

Strengths and limitations

This study included experts from fire service fitness and occupational health departments as well as operational firefighters in the United Kingdom. These experts were selected from national and regional steering groups, but did not include representation from every fire service in the United Kingdom. Nevertheless, those on the national and regional steering groups have previously been involved in creating national guidance (Stevenson et al. 2016; Siddall et al. 2016). The online approach helped to reduce the impact on participants; those who took part in both the survey and

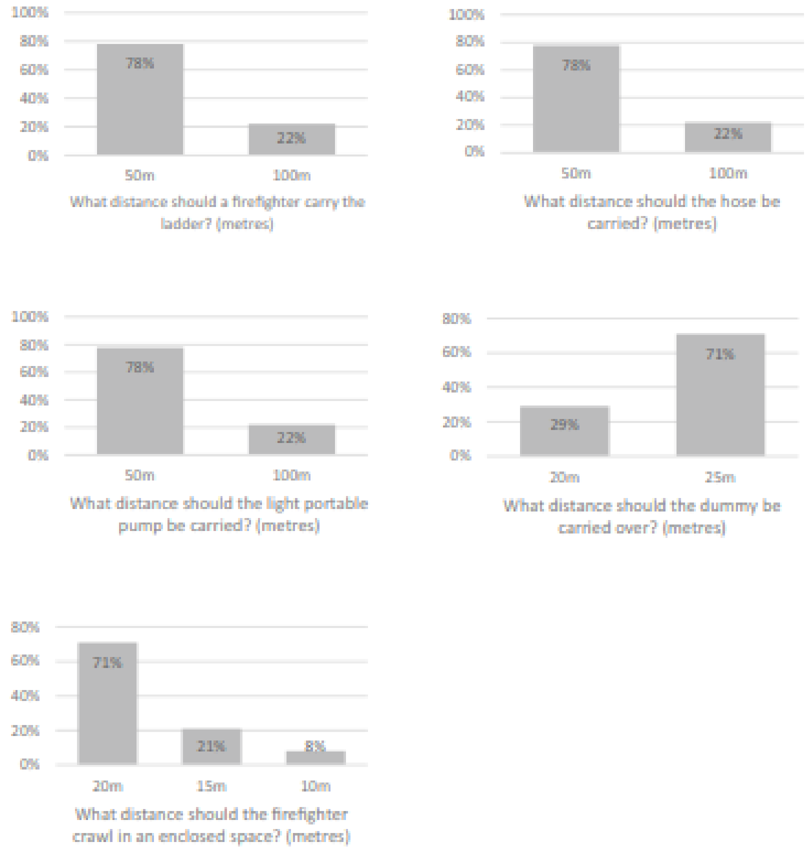

Fig. 7 Bar charts showing the results from the consensus meeting for the total distance to be completed for each operational task

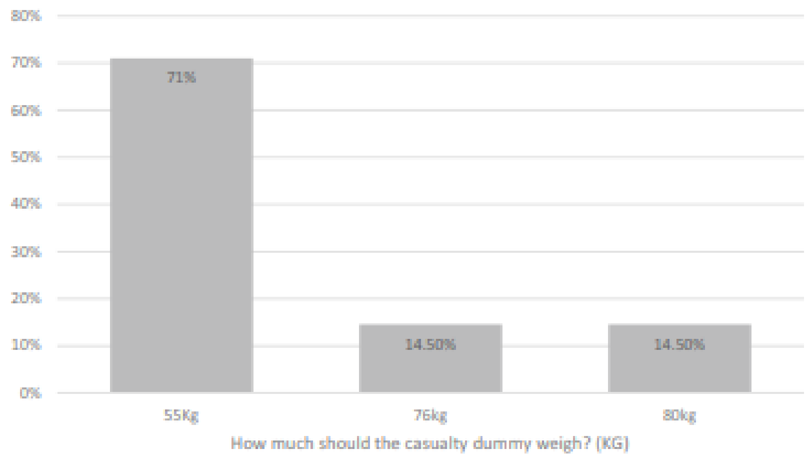

Fig. 8 Bar chart from the consensus meeting results of the total weight (KG) to be used during a simulated casualty evacuation in a return to work assessment

consensus meeting were able to do so without any travel or expenditure required. One limitation was that recruitment only included fire services from within the United Kingdom. The online approach allows for representation from fire services internationally. This would improve knowledge on a return to work assessment for firefighters on an international level. Whilst this consensus has determined the content of physical tasks to be undertaken in a return to work assessment, there is no consideration given to psychological readiness to return to work. This can include negative responses of fear of re-injury and stress (Crossman 1997) which can lead to reduced levels of self-esteem and increased anxiety levels (Smith 1996). The extent these factors play for a firefighter's return to work following injury has not yet understood. Further research exploring potential psychosocial barriers and enablers influencing a firefighter's return to work is warranted.

Conclusion

This study has provided a consensus for tasks to be included when assessing a firefighter for return to work. The key tasks to be included in a return to work involve lifting and carrying equipment including ladders, hoses, casualties and a light portable pump. Aerobic fitness testing is another vital task required for a firefighter's return to work. Further research is needed to understand how to use this assessment optimally. This includes how to determine if a task has been 'passed' and the order to undertake the tasks. Consideration should be given to grouping the tasks into 'push', 'pull' and 'carry' requirements and utilising a traffic lights system to rate how successfully the fire firefighter completed the task for readiness to return to work.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s00420-021-01661-7.

Funding No funds were received in support of this work.

Compliance with ethical standards

Conflict of interest None declared.

Ethical approval Ethical approval was sought and granted on 8th April 2020 by The University of Essex research ethics committee. Ethics reference; ETH1920-0832.

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Appendix 6

From: ERAMS <erams@essex.ac.uk>

Sent: Wednesday, April 8, 2020 9:13:21 AM

To: Noll, Liam A <lnoll@essex.ac.uk>

Subject: Decision - Ethics ETH1920-0832: Mr Liam Noll

University of Essex ERAMS

08/04/2020

Mr Liam Noll

Sport, Rehabilitation, and Exercise Science

University of Essex

Dear Liam,

Ethics Committee Decision

I am writing to advise you that your research proposal entitled “Consensus of tasks to be included in a return to work screening tool for a UK firefighter following an injury: an online Delphi study." has been reviewed by the Science and Health Ethics Sub Committee.

The Committee is content to give a favourable ethical opinion of the research. I am pleased, therefore, to tell you that your application has been granted ethical approval by the Committee.

Please do not hesitate to contact me if you require any further information or have any queries.

Yours sincerely,

Izzie Easton

Ethics ETH1920-0832: Mr Liam Noll

Appendix 7

University of Essex

Participant Information Sheet

The use of a physical return to work assessment to reduce re-injury risk in firefighters

Researchers:

Liam Noll, Postgraduate Student & Chief Investigator
Jason Moran, PhD, Academic Supervisor
Adrian Mallows, PhD, Academic Supervisor

We would like to invite you to take part in our research study. Before you make your decision, we would like to give you an understanding of why the research is being done and what is involved for you. Please contact one of us if you have any questions.

Purpose of the Study:

The aim of this study is to better understand how to help injured firefighters return to work more safely. The operational tasks of a firefighter in the United Kingdom will be investigated and the perceived importance of them considered by ranking their importance.

Why have you been invited?

You have been invited because you work in occupational health, are a fitness advisor or an operational firefighter for a fire service in the United Kingdom.

Do you have to take part?

No, it is your decision if you want to take part in the study. You can also change your mind at any time and withdraw from the study. If you have any questions before making your decision we are happy to answer them.

What will you have to do?

We would like you to complete an online survey which will take approximately fifteen minutes to complete. The focus of this study is helping injured firefighters returning to work. You will be asked to decide if you perceive certain tasks a firefighter undertakes as "important", "not important" or you can state that you are "unsure". Finally, you will be asked to rank the tasks selected from most important to least important.

Once the results from the survey have been collected you will be invited to a follow up meeting. This meeting will be held online. The aim of this meeting will be to gain a consensus for the questions that did not achieve 70% agreement in the first round online survey.

Expenses and payments:

There are no expenses or payments for your participation.

Possible disadvantages and risks of taking part:

The survey will take around 5 minutes to complete. The follow up meeting may last up to 2 hours. There are no anticipated risks associated with your participation.

Benefits from Participation:

There are no direct benefits to you, but we hope that the information collected from this study will help to create an assessment which will reduce the re-injury risk to firefighters.

What happens if you withdraw from the study?

All information collected with your permission before your withdrawal from the study will be used but no further data will be collected.

What if there is a problem?

If you have any concerns about any aspect of this study, please contact the Chief Investigator, Liam Noll. You can do this by email lnoll@essex.ac.uk or by telephone 01376 576588. You can also contact Sarah Manning-Press, Research Governance and Planning Manager on 01206 873561 or sarahm@essex.ac.uk. They will do their best to answer your questions, however, if you remain unhappy and wish to provide any feedback, or formally complain you can do this by contacting Professor Jo Jackson, Director of Research, SRES, University of Essex, jo.jackson@essex.ac.uk or by telephone 01206 874230.

Participants' Rights:

We will follow ethical and legal practice and all information about you will be handled in confidence and will not be shared with anyone. The questionnaire will not collect any personally identifiable data, but will ask you for your email address so that you can be invited to the follow up discussion. The follow up discussion is not recorded in any way. All data storage will comply with EU data protection regulation. The data collected are stored on a secure, encrypted website called Qualtrics. The website is password protected with only the Chief Investigator having access to the survey's data.

What will happen to the results of the research study?

It is anticipated the results from the study will be published and presented at scientific meetings. There is no formal plan to make the results available to participants, however if you would like to obtain a copy please contact Liam Noll by email lnoll@essex.ac.uk.

Organisation and function of the research

This study is being organised by Liam Noll as part of his Masters by Research at The University of Essex. There is no external funding.

Who has reviewed the study?

The School of Sport, Rehabilitation and Exercise Science have reviewed the study and given approval for the conduct of the research

Further information and contact details

For further information, please contact Liam Noll by email lnoll@essex.ac.uk or by telephone 01376 576588.

Appendix 8

Operational firefighter tasks for a return to work post injury assessment

Research Project Survey - The use of a physical return to work assessment to reduce reinjury risk in firefighters

The following questions require you to rate the importance of operational firefighter tasks to be included in a return to work post injury assessment.

Q1 How important is it that a firefighter can lift a ladder? (Of any size)

- ◯ Important
- ◯ Not important
- ◯ Unsure

Q1A How many times should the ladder be lifted during an assessment?

____

Q2 How important is it that a firefighter can carry a ladder? (Of any size)

- ◯ Important
- ◯ Not important
- ◯ Unsure

Q2A What distance should a firefighter carry the ladder? (In metres)

____

Q3 How important is it that a firefighter can climb a ladder and perform a leg lock?

- ◯ Important
- ◯ Not important
- ◯ Unsure

Q3A How many times should a firefighter climb the ladder and perform a leg lock?

____

Q4 How important is it that a firefighter can lift and carry a light portable pump?

- ◯ Important
- ◯ Not important
- ◯ Unsure

Q4A How many repetitions should the light portable pump be lifted?

____

Q4B What distance should the light portable pump be carried? (In metres)

____

Q5 How important is it that a firefighter can carry a hose?

- ◯ Important
- ◯ Not important
- ◯ Unsure

Q5A What distance should the hose be carried? (In metres)

____

Q6 How important is it that a firefighter can hose run?

- ○ Important
- ○ Not important
- ○ Unsure

Q6A How many hose runs should be completed?

____

Q7 How important is it that a firefighter can evacuate a casualty?

- ○ Important
- ○ Not important
- ○ Unsure

Q7A How much should the casualty dummy weigh? (In KG)

____

Q7B What distance should the dummy be carried over? (In meters)

____

Q8 How important is it that a firefighter can put on / remove a breathing apparatus set?

○ Important

○ Not important

○ Unsure

Q8A How many times should a firefighter put on and remove a breathing apparatus set?

____

Q9 How important is it that a firefighter can crawl through enclosed areas?

- ◯ Important
- ◯ Not important
- ◯ Unsure

Q9A What distance should the firefighter crawl? (In metres)

____

Q10 How important is it that a firefighter undertakes an aerobic test?

- ◯ Important
- ◯ Not Important
- ◯ Unsure

Q10 Should a firefighter meet the minimum aerobic fitness level (42.3 ml/kg/min) before returning to operational duties?

- ○ Yes
- ○ No

Q10B Please explain why not?

____

____

____

____

____

Q11 With reference to a return to work assessment following an injury, can you please rank the following operational tasks in their order of importance to be tested? (1-11) (1 being most important and 11 being least important).

_______ Lifting a ladder.

_______ Carrying a ladder.

_______ Climbing a ladder.

_______ Carrying a light portable pump.

_______ Carrying a Hose

_______ Hose Running

_______ Casualty Evacuation

_______ Putting on/ Taking off a breathing apparatus set.

_______ Climbing into a fire appliance.

_______ Crawling through enclosed spaces

_______ Aerobic Fitness Test

Appendix 9

An overview of the participants' demography

Participant	Job Role	Region in UK	Number of years worked for the fire service (Years)
1	Fitness Advisor	North West	32
2	Fitness Advisor	East Midlands	12
3	Fitness Team Manager	South West	10
4	Fitness Team Manager	North West	35
5	Fitness Team Manager	East Anglia	13
6	Fitness Advisor	Yorkshire	11
7	Operational Firefighter	East Anglia	13
8	Operational Firefighter	South East	15
9	Operational Firefighter	East Anglia	15
10	Operational Firefighter	South East	17
11	Operational Firefighter	East Anglia	16
12	Operational Firefighter	East Anglia	20
13	Operational Firefighter	East Anglia	26
14	Operational Firefighter	East Anglia	22
15	Fitness Team Manager	South East	13
16	Operational Firefighter	East Anglia	19
17	Fitness Advisor	South East	12
18	Operational Firefighter	South East	22
19	Fitness Advisor	London	16
20	Operational Firefighter	East Anglia	19
21	Operational Firefighter	East Anglia	18
22	Fitness Advisor	East Anglia	1.5
23	Occupational Health Manager	East Anglia	15
24	Occupational Health Manager	North East	3.5
25	Occupational Health Manager	East Anglia	4.5

Appendix 10

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https://doi.org/10.1007/s00420-021-01712-z

ORIGINAL ARTICLE

Psychosocial barriers and facilitators for a successful return to work following injury within firefighters

Liam Noll[1] · Adrian Mallows[1] · Jason Moran[1]

Received: 2 February 2021 / Accepted: 11 April 2021 / Published online: 11 May 2021

Abstract

Objective The aim was to explore firefighter's experiences during their recovery from injury. Focused specifically on exploring perceived psychosocial barriers and facilitators firefighters faced during recovery and return to work.

Methods Semi-structured interviews were used to provide an in-depth understanding of the firefighter's experiences. The semi-structured interviews were informed by a topic guide. The topic guide focused on five main themes, (1) overall experience of returning to operational duties following an injury, (2) perceived barriers experienced during their return to work, (3) perceived facilitators experienced during their return to work, (4) confidence in participating in physical activity following injury and (5) where they felt areas of improvement could be made with the return to work process. Thematic analysis of the data collected was undertaken using The Framework Method.

Results Two main themes were sought after transcription: barriers and facilitators. From these, nine subthemes were identified (1) communication, (2) confidence in physical activity participation, (3) modified duties, (4) physiotherapy, (5) return to operational duties, (6) support, (7) inconsistency, (8) use of station gyms, (9) detachment from the watch.

Conclusions Consideration should be made for the consistency of procedures followed during an individual's return to work following an injury. Further research is needed to understand if the themes identified in this study are the same for other fire services. Further research is also needed to understand how the findings may be best implemented within the fire service.

Keywords Firefighter · Return from injury · Semi-structure interview · United Kingdom

Introduction

The recovery from injury and return to work is complex (Cancelliere et al. 2016). For firefighters, the physical demands of the job and the need for recovery to meet these demands is well documented (Stevenson et al. 2016; Smith 2011). Government statistics showed that 2466 firefighters in the United Kingdom suffered an injury between 2019–20 (Home Office 2020). Return to work for firefighters following common occupational-related injuries, such as musculoskeletal strains and sprains and stress fractures (Orr et al. 2019), can take from 3 to 12 weeks (Wright-Carpenter et al. 2004; Matheson et al. 1987). Re-injury rates for musculoskeletal sprains and strains are reported between 7 and 34% (Schmitt et al. 2012; Holme et al. 1999) and stress fractures have been reported at 29% (Ekstrand and Torstveit 2012). Such high re-injury rates suggest that current processes are suboptimal and the need to understand factors which influence a successful return work. A recent consensus study highlighted the need for a physical return to work assessment for firefighters following an injury, assessing physical parameters including muscular strength and aerobic fitness (Noll et al. 2021). Physical assessments including hose running, hose carrying, ladder lifting, ladder climbing and casualty evacuation were agreed to be included during a firefighters return to work process (Noll et al. 2021). Other factors including social support (Prang et al. 2015), and psychological factors including fear of re-injury and stress (Hsu et al. 2017) also need to be considered.

Negative psychological responses can lead to low levels of self-esteem as well as feelings of anxiety, depression and increased stress (Smith 1996). Progression through rehabilitation and recovery can be negatively affected by increased stress levels (Crossman 1997). Negative responses have been shown to peak at two particular points (Morrey et al. 1999);

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when the injury occurred and when the individual is allowed to return to physical activity in the same capacity before becoming injured (Hsu et al. 2017).

Fear of re-injury is an example of a negative response which can be a common factor amongst individuals returning to physical activity (Hsu et al. 2017). Despite pain resolving and function and strength returning, hesitancy to return to physical activity due to a fear of re-injury can remain (Schilaty et al. 2016; Russell et al. 2018). Reasons can include increased anxiety and catastrophic thinking (Fischerauer et al. 2018) which can decrease motivation to return to physical activity (Barber-Westin et al. 2019). In addition, previous experience of injury has been documented to relate to a feeling of 'coming to terms' with the injury and reduce motivation to meet the demands required to return to pre-injury status (Podlog and Eklund 2005). This decrease in motivation can then lead to physical inactivity (Barber-Westin et al. 2019).

Physical inactivity decreases aerobic fitness and strength levels (Kulinski et al. 2014; Leblanc et al. 2015). Decreased fitness and strength levels negatively impacts on firefighters performance level and safety when completing job-related tasks (Smith 2011). Included tasks involve hose running, hose carrying, ladder lifting, ladder climbing and casualty evacuation (Stevenson et al. 2016). The majority of operational tasks are completed by a firefighter within a group setting with other firefighters on duty with them (Podlog and Eklund 2005). The duty system is also known as a watch and firefighters can spend a long time working with the same watch, attending to both physically and psychologically challenging incidents (Johnston and Carroll 1998). This contributes to creating strong bonds and friendships between them (Johnston and Carroll 1998).

A reduction in social contact with colleagues whilst being off work injured can cause feelings of frustration due to the sudden lack of involvement (Sonnentag and Fritz 2007). Being away from colleagues due to injury can create a feeling of psychological detachment, which can be related to a reduced sense of wellbeing (Bianco 2001). Social support during recovery from an injury can increase motivation and a sense of inclusion, in addition to decreasing symptoms of depression and anxiety when returning to physical activity (Yang et al. 2014; Carless et al. 2013; Gill et al. 2008).

There is limited research focused on firefighters in the United Kingdom returning from work following an injury. The importance of understanding psychological and social factors for a successful return to work is clear from other active populations such as athletes and military personnel (Hsu et al. 2017; Smith 1996; Crossman 1997; Morrey et al. 1999; Schilaty et al. 2016; Russell et al. 2018; Fischerauer et al. 2018; Barber-Westin et al. 2019; Podlog and Eklund 2005; Yang et al. 2014), but to date this has not been investigated with firefighters. The aim of this study was to explore firefighter's experiences during recovery from injury. Specifically, we sought to explore perceived psychosocial barriers and facilitators firefighters faced during recovery and return to work.

Ethical approval

Ethical approval was sought and granted on 26th June 2020 by the University of Essex research ethics committee. Ethics reference; ETH1920-1683.

Methods

Study design

This study used semi-structured interviews to provide an in-depth understanding. A post-positivist perspective was used to underpin the design of this project.

The study is reported in accordance with the consolidated criteria for reporting qualitative (COREQ) research guidance (Tong et al. 2007).

Data collection

Semi-structured interviews were informed by a topic guide (O'keeffe et al. 2015). The topic guide was developed by the chief investigator (LN) and was focused on five themes for a firefighter returning to operational duties following an injury: (1) overall experience of returning to operational duties following an injury, (2) perceived barriers experienced during their return to work, (3) perceived facilitators experienced during their return to work, (4) confidence in participating in physical activity following injury and (5) where they felt areas of improvement could be made with the return to work process [Appendix 1].

The interviews were conducted one to one with LN as the interviewer. LN is a male PhD research candidate who had received training in conducting semi-structured interviews. Both LN and the participants in this study were employed by the fire service, LN was a member of the support staff team working as a fitness advisor and the participants were operational firefighters. The interviews were held via Zoom (Gray et al. 2020) and recorded. Field notes were made during and after the interviews in this study. Two pilot interviews were conducted by LN with work colleagues within the fire service fitness department prior to the start of the interviews with the participants. Pilot interviews allowed LN to familiarise themselves with the questions and assess if any of the questions in the topic guide needed amending following feedback from colleagues. In addition, pilot interviews allowed for testing the run time of each interview and testing of the recording function to test the sound quality from both the researcher and the individual interviewed.

Participants

All current operational firefighters for Essex county fire and rescue service who had previously been injured and returned to work were identified from records and invited to participate ($n = 20$). Records extended to the past 24 months. Twenty participants were emailed an invitation by LN to take part in an interview, along with the participant information sheet. Interested participants had an opportunity to ask questions via email or telephone prior to organising an interview date and time at a mutually convenient time. Prior to commencing the interview, the participant had a further opportunity to ask any questions prior to providing written consent via email. Consent was also audio recorded. Data saturation was determined when all pre-determined themes had been represented adequately in the data collected. (Saunders et al. 2018; Strauss and Corbin 1998).

Data management

Data from all sources were maintained and stored on a password-protected laptop computer. All data were anonymised at source and no identifiable data was kept.

Data analysis

The recordings were transcribed verbatim and then coded using NVIVO 12 software by LN (Richards 1999). The coding was checked and verified by AM. Thematic analysis of the data collected was undertaken using The Framework Method. The Framework Method has been developed specifically for applied research in which the objectives of the investigation are set a priori (Pope et al. 2000). The Framework Method allows for a systematic approach to qualitative analysis which provided the ability to compare and contrast data by themes across individual cases (Gale et al. 2013). The Framework Method consists of seven steps of data analysis (Table 1). LN sent the results framework to all participants to give them an overview of the results for interpretation.

Results

Twenty firefighters met the inclusion criteria and were invited to participate in the study. Of these, 12 (60%) agreed to participate (Table 2). No response was received from the remaining eight firefighters (40%) invited. Interviews lasted up to 30 min.

Findings

Two main themes were sought after transcription: barriers and facilitators. From these, nine subthemes were identified; (1) communication, (2) confidence in physical activity participation, (3) modified duties, (4) physiotherapy, (5) return to operational duties, (6) support, (7) inconsistency, (8) use of station gyms, (9) detachment from the watch (Fig. 1).

Barriers

Theme one: communication

Communication between different departments involved in the return to work process was perceived as being a barrier:

> "It could have helped with a quicker return if everyone were in communication with each other. I felt all different departments were separate and the lack of communication dragged the process along".—Participant 3.

Theme two: confidence in physical activity participation

A common theme reported was a confidence to participate in physical activity following an injury was low.

> "I started to take myself out for short jogs, but was nervous as hell doing it"—Participant 2.
> "My confidence was completely shot if I'm honest. I was so worried about doing any damage that I did the bare minimum, which was frustrating because I kept comparing to how I was. Even though I wanted to get back to my original fitness, I just didn't have the confidence to push myself."—Participant 12.

Theme three: modified duties

Whilst recovering from their injury, some firefighters were given the opportunity to work on modified duties. However, other firefighters were not given this opportunity and because of this they perceived it as a barrier during their return to work experience.

> "I would have loved to be able to return to work in a format where I could do some things and not others, that way I could still help out. Instead of this all or nothing approach."—Participant 11.

Table 1 Use of The Framework Method during analysis of data

Step of analysis	Description
1. Transcription	The recordings of the interviews were transcribed verbatim by the chief investigator (LN)
2. Familiarisation with the interview	All recordings where relistened to and quality checked with the transcripts by LN
3. Coding	All transcripts were read line by line and codes were applied to the parts of the interviews that were deemed to be relevant by LN. The parts were coded in relation to the pre-existing themes which were informed by the topic guide. Open coding was also used during this process for parts of the interviews which were interesting but did not fit with the initial coding framework. This was to ensure that potential important pieces of data were not missed. Coding was reviewed and verified by AM (Fig. 1)
4. Developing a working analytical framework	Once all coding was completed, LN analysed the coding to establish that there were no new themes to add relevant to the research aims
5. Applying the analytical framework	The transcripts were then indexed, and codes were used relating to the pre-existing themes by LN. NVIVO 12 software was used to code the transcripts
6. Charting data into the framework matrix	The coded data from the transcripts was inputted into a final report, the quotations from the participants were numbered to keep anonymity. LN was assured that data saturation, in relation to the research aims, had been achieved and no new themes had been found from the final interviews
7. Interpreting the data	LN interpreted the coded data and explored the relationship between the pre-existing themes in relation to the research aims. From these, nine subthemes were identified

Theme four: physiotherapy

All of those interviewed had some form of treatment from a physiotherapist during their rehabilitation. Some found that the expectations from the physiotherapists for recovery were not meeting work demands.

> "The physio's were mainly looking for weight-bearing movements and walking but I knew in the back of my mind what I would be required to do when returning to operational duties."—Participant 5.
> "They helped and I did benefit from them, however, I knew that the level I needed to reach was beyond their expected level from me"—Participant 6.

Theme five: return to operational duties

Once they had returned to operational duties, some firefighters felt that the aftercare from human resources (HR) could have been better.

> "I felt like I was expected to just return to normal as if nothing had happened. I didn't mind it, but it would have been nice for someone from HR to check in to see how I was doing."—Participant 6.

Many firefighters reported that there needed to be an improvement in the aftercare following a return to work from injury.

> "It would be good for the fitness team to create a training package where firefighters could go to and select a

Table 2 Participants characteristics

Participant	Gender	Rank	Duty type	Type of injury	Time out of operational duties
1	Male	Firefighter	On-Call	Rotator cuff sprain	3 months
2	Female	Firefighter	Wholetime	Anterior cruciate ligament surgery	14 months
3	Male	Firefighter	On-Call	Neck and back sprain	5 months
4	Female	Firefighter	Wholetime	Broken wrist	3 months
5	Male	Crew Manager	Wholetime	Back sprain	2 months
6	Male	Firefighter	Wholetime	Knee surgery	3 months
7	Male	Firefighter	Wholetime	Knee sprain	1 month
8	Male	Firefighter	On-Call	Shoulder surgery	2 months
9	Male	Firefighter	Wholetime	Fractured wrist	2 months
10	Male	Firefighter	On-Call	Back sprain	3 months
11	Male	Firefighter	On-Call	Fractured thumb	6 months
12	Male	Watch Manager	Wholetime	Heart surgery	12 months

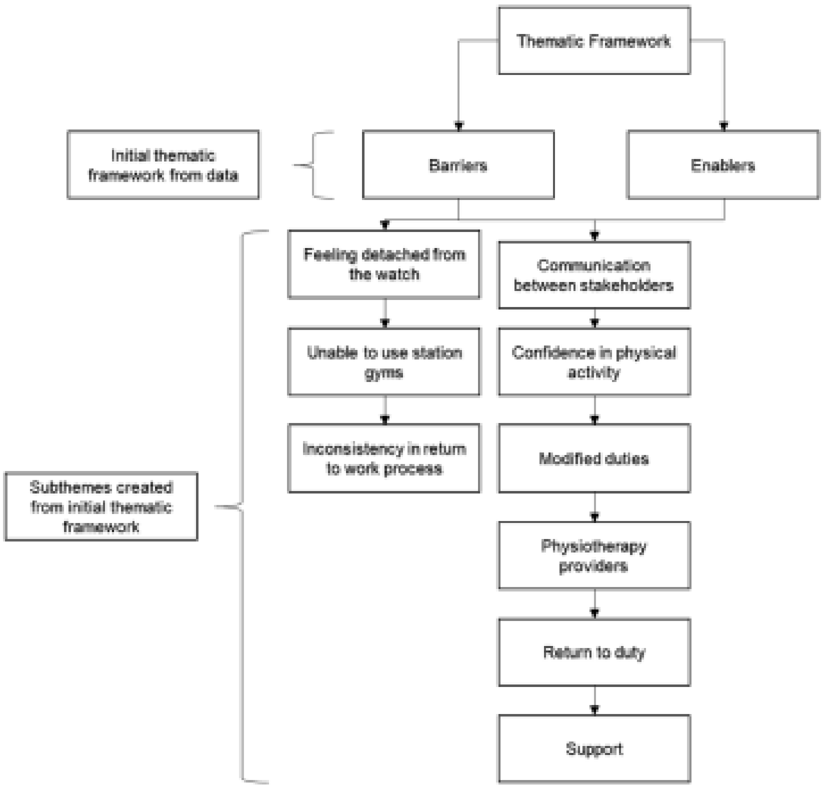

Fig. 1 Mapping of the thematic framework

workout suitable for the equipment they have or body part they want to train. It could go up on the wall to make it easily accessible." Participant 3.

Theme six: support

The support from the fire service varied across the firefighters interviewed. Some firefighters felt mistreated and that the service was putting barriers in their way to return to work.

> "My manager was also fully aware that I needed to do a functional assessment so I guess it would have been nice for him to let me know to reduce the delay. If I had known I would have got it booked in advance for the day my sick certificate ran out. I just wanted to get back and it felt like there were hurdles put in my way for what was in my opinion a simple injury."—Participant 7.

Theme seven: inconsistency

A common barrier reported was the inconsistency of the process for a firefighter to return to operational duties following an injury.

> "I feel that there needs to be consistency in the service for return to work. So, no matter where you are based you are aware of what needs to be achieved to return to work. That way it would stop managers adding in extra assessments here and there because they feel like it."—Participant 4.

Other firefighters reported that the return to work process needed to be clearer to increase consistency.

> "I think there should be a clear guidance of if you're off work for an injury you are required to do a return to work assessment with the fitness team. Because it would clear any confusion I experienced and also possibly reduce the amount of time of spent on modified duties."—Participant 7.

Theme eight: use of station gyms

Whilst injured, many firefighters were not allowed on the station. This meant that they were unable to use the gym facilities during their recovery, which many perceived as a barrier.

> "I didn't have any weights at home to help increase my strength in my wrist which was a bit frustrating. It would have been nice to be able to go to the station to use the gym to help with my recovery or have the opportunity to have supervised gym sessions with someone from the fitness team maybe?"—Participant 9.

Theme nine: detachment from the watch

Being away from the station also meant that injured firefighters were unable to meet up with the colleagues on their watch. This was reported as a barrier by many.

> "I wasn't allowed on station. I was considered a visitor and lost contact with the watch, the meals together, the environment, the banter. I felt completely disconnected with the watch. Normally, you are there to see the morning tests and routines but being away I feel separated. We have WhatsApp but it's not the same as face to face contact."—Participant 2.
> "It was frustrating being off that long, not being able to see my friends down at the station, I felt a bit like I was being punished for being injured. I felt really detached from the station."—Participant 10.

Facilitators

Theme one: communication

Interviews found that communication regarding the return to work process and requirements to pass the functional assessment was good between different stakeholders including line managers and occupational health. This was a facilitator with their return to work process.

> "I spoke to occupational health about what I was required to do to return to work and they said it would be a functional assessment, that's when I contacted you and asked what was involved. From there I worked with the physio to build up my fitness levels, specifically in my shoulder."—Participant 8.

Theme two: confidence in physical activity participation

For some firefighters, their confidence was affected but they were comfortable participating in physical activity, building their strength back up gradually.

> "Going back to running I was very cautious, so I started with a light jog and increased the speed slightly each week. Confidence to train on my own was okay, it was just having the confidence to push my knee."—Participant 6.

Theme three: modified duties

Whilst recovering from their injury, some firefighters were given the opportunity to work on modified duties. This was perceived as a facilitator during their return to work experience.

> "I was allowed back into the training department to do light duties, this involved admin, cleaning equipment, nothing too strenuous but got me back in the rhythm of working again. I also was allowed to work flexible times as my medication made me tired towards the latter part of the afternoon."—Participant 12.

Theme four: physiotherapy

Some firefighters used private physiotherapy providers who had a contract with the fire service to allow six free treatment sessions for each firefighter per injury. These were perceived as a facilitator for many firefighters.

> "For me, the physio didn't just help with the physical side but also the mental side for reassurance my injury was getting better."—Participant 3.
> "They were very good in my opinion, they assessed my shoulder and we worked towards strengthening it for the functional assessment."—Participant 8.

Theme six: support

Many firefighters reported that they felt supported throughout their time off being injured and during their return to work process.

> "In terms of getting me back on the run, I was supported from my line manager, the service, the fitness team and the occupational health team. With sufficient time to get back onto the run and come along to do a return to work assessment."—Participant 5.

Discussion

The aim of this study was to explore the psychosocial barriers and facilitators during the return to work process following an injury for a firefighter. Nine sub-themes were identified; communication, confidence in physical activity participation, modified duties, physiotherapy, return to operational duties, support, inconsistency in the return to work process, use of station gyms and detachment from the watch.

The findings suggest that providing station access to see their colleagues could increase social contact whilst being off sick. The reported feelings of detachment and frustration from being away from the fire station and their colleagues in this study are similar to those experienced in other active populations including athletes (Crossman 1997; Barber-Westin et al. 2019). Providing access to see colleagues could help to decrease the feelings of detachment from the watch. Examples could include joining meals or attending educational training lectures where no physical activity is required.

Future practice should consider allowing injured firefighters access to gym facilities on their fire stations to aid with their rehabilitation. An individual's muscular strength and aerobic fitness levels can decrease with physical inactivity (Prang et al. 2015) and the majority of fire services in the United Kingdom require their firefighters to achieve a maximal aerobic capacity level ($VO_{2\,max}$) of 42.3 ml/kg/min as a minimum to be considered safe to carry out operational duties (Siddall et al. 2016). A strength standard of a 32 kg shoulder press and a 60 kg rope pull down has also been recommend (Stevenson et al. 2017). Sport scientists and physiotherapists need to consider the basic physical requirements an operational firefighter needs to achieve before returning to duty in addition to injury rehabilitation. Therefore, restricting access to gym facilities could be a barrier to achieving these standards for returning to operational duties, especially as resistance training has been identified as critical for the recovery of musculoskeletal function following injury in athletic populations (Wayda et al. 1998).

However, providing access to station gym facilities could be further enhanced with a training plan. At present, injured firefighters are not given a fitness training plan to help with their return to work preparation unless they specifically request one from a qualified professional, in this case a fitness advisor, to help increase the effectiveness of the firefighter's injury rehabilitation (Andersen et al. 2019). The multidisciplinary team, including physiotherapists, occupational health, the fitness team and line management, should keep in regular contact with the firefighter monitor the firefighter's progression through the exercise programme and progress as required.

To improve the development of an exercise plan for firefighters, good communication between physiotherapists and the fire service occupational health department is needed (Andersen et al. 2019). Communication was a barrier reported in this study, specifically between physiotherapists, occupational health, fitness advisors and managers. Firefighters all had treatment from a physiotherapist before they were referred to the 'in house' occupational health service and fitness team to carry out a functional assessment. Once they were referred, firefighters were responsible to update occupational health on their progress. Leaving firefighters to be solely responsible to provide this progress update could result in important information being missed. Instead, if the physiotherapist liaised directly with occupational health and the fitness team a professional update could be provided to ensure all information is handed over. This improved communication could also help improve physiotherapists' awareness of the physical expectations required of a firefighter during their return to work assessment and align rehabilitation goals with strength and aerobic goals. This could help give the injured firefighter a sense of control and increased motivation as they could monitor their strength and aerobic fitness levels (Wayda et al. 1998).

Motivation can also come from the support of management providing a positive experience for individuals returning to work following an injury (Andersen et al. 2019). Our findings showed an inconsistency in management support across the fire service; some managers in this study were perceived as enablers for firefighters to return to work, others were perceived as barriers. Inconsistency between managers was evident. Some offered firefighters the opportunity to perform modified duties; others were not. This could relate to the duty system; whole-time firefighters work full time for the fire service, on-call firefighter's work part time on a pager and are employed elsewhere. Providing whole-time firefighters modified duties could be easier as they do not have alternate employment. Future practice should allow all firefighters to be given the opportunity where possible to perform modified duties. This could include carrying out safety checks and station administration tasks regardless of their duty system. This would increase a firefighter's interaction with their colleagues and manager and prevent feelings of isolation.

Consistency would be increased by the introduction of a guidance framework for a return to work following injury. For example, the creation of a flow chart staging each process of a return from injury, who is responsible at that stage and what their role is during that process (Slevin and Roberts 1987). This would also help communication expectations between physiotherapists, occupational health, fitness advisors, managers and firefighters. This would help ensure all firefighters received the same level of support whilst recovering from an injury.

Strengths and limitations

This study included current operational firefighters from the United Kingdom. There was representation from both whole-time and on-call duty systems. All interviews were conducted via video call without the need for travel or expenditure. The study only used one fire service. It is not known if such barriers and facilitators are the same across the fire service.

The use pre-determined themes during the semi-structured interviews could have prevented any other themes from emerging from the firefighters return to work experience which could have resulted in them being missed during the analysis.

Conclusion

This study provided the perceived barriers and facilitators firefighters faced during their return to work process following an injury. Consideration should be made for the consistency of procedures followed during an individual's return to work following an injury. This could include communication between the occupational health department, the fitness team and the physiotherapists to provide a rehabilitation plan for the firefighter. Access to the fire station should also be considered to encourage social contact and allow physical training as part of their rehabilitation in preparation for the functional assessment. Further research is needed to understand if the themes identified in this study are the same for other fire services. Further research is also needed to understand how the findings may be best implemented within the fire service.

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Availability of data and materials All data generated or analysed during this study are included in this published article [and its supplementary information files].

Declarations

Conflict of interest All authors declare that they have no competing interests.

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Appendix 11

Topic Guide for semi structured interviews

START RECORDING

1. **Introduction**
    - Introduction to researcher and study topic
    - Explanation of the aim of the study
    - Explain confidentiality and anonymity.
    - Explain recording length (up to 30 minutes) and nature of discussion.
    - Go through consent issues and explain they may withdraw at any time, and they do not have to answer any interviews they would prefer not to
    - Check whether they have any questions.
    - Check they are happy to continue.

2. **Experience of returning to work following an injury**
    - Describe overall experience.
    - Establish any perceived barriers faced during their experience.
    - Establish any perceived enablers faced during their experience.
    - Where they feel their confidence is to participate in physical activity alone.
    - Where they feel areas for improvement lie during the return to work process – Fitness, Occupational health, HR, management support, physio provisions.
    - Check for any unintended consequences.
    - Check for any other comments.

3. **In conclusion**
    - Summarise and check key issues.
    - Thank the participant for their time.
    - Reiterate confidentiality.

END RECORDING

Appendix 12

healthcare

MDPI

Article

Inter-Rater and Intra-Rater Reliability of Return-to-Work Screening Tests for UK Firefighters Following Injury

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Abstract: The aim of this study was to assess the inter-rater and intra-rater reliability of a return-to-work (RTW) screening test to be used on UK firefighters following injury. The inter rater and intra-rater reliability of eight tasks involved in a screening test was used to assess readiness to RTW for UK firefighters following injury. These tasks included the following: (1) putting on and removing a breathing apparatus set (BA), (2) a ladder lift simulation, (3) a ladder carry simulation, (4) a light portable pump (LPP) lift and carry simulation, (5) a hose run, (6) a ladder climb with leg lock, (7) a casualty evacuation and (8) a confined space crawl simulation. The inter-rater reliability between each individual screening task was interpreted as Excellent (ICC = 0.94–1.00) for eleven (68.75%) of the screening task videos and as Good (ICC = 0.75–0.88) for five (31.25%) of the screening task videos. Intra-rater reliability was interpreted as Excellent (ICC = 1) for twenty-six participants (74.3%), Good (ICC = 0.76–0.88) for eight participants (22.9%) and Moderate for one participant (2.8%). Due to the reliability of this screening test, it allows conclusions to be made from the results which can inform a RTW decision for a firefighter.

Keywords: return to work; firefighter; tactical athlete; functional capacity; physical assessment

check for updates

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1. Introduction

Musculoskeletal injuries can account for one-third of all workplace-related injuries [1,2]. Common causes include overexertion, contact with equipment, slips, trip and falls [2]. Many work tasks contain some risk of injury; however, the extent of these risks differs depending on the type of sector and job role [3]. The risk of a work-related injury increases for individuals with athletic occupations, including firefighters, military personnel, police officers and paramedics, whose job role requires higher physical demands; for example, heavy lifting, kneeling and crouching [4–7]. Of these injuries, more than 40% were musculoskeletal-related [4,8].

Following a musculoskeletal-related injury, assessing an individual's readiness to return to work (RTW) can be complex; many factors need to be considered, including physical performance in relation to the work task demands [9,10]. An individual may believe that they are ready to RTW, but if they are unable to meet the minimum work-related physical demands, an increase to reinjury has been shown [11,12].

To assess physical performance in relation to work task demands, during recruitment of athletic occupations, a physical screening test is used to determine if individuals possess the minimum required aerobic fitness and muscular strength standards [13–15]. However, no such test exists to determine if an individual can meet the minimum standards after injury. For example, the physical screening test used for recruitment of firefighters does not include all tasks involved during operational duties, including hose running and ladder carry [1,16]. Instead, UK firefighter selection tests were designed to help identify applicants physically suited to roles within UK fire and rescue services [17] and then once employed, individuals are trained in more specific tasks related to their firefighting role [18]. If operational tasks are unable to be completed effectively in emergency situations, a firefighter could put themselves at risk of danger, their operational colleagues and members of the public [19].

To date, limited research exists for the effectiveness of RTW screening tests to reduce reinjury rates for individuals returning to work in an athletic occupation, for example a professional athlete [20–24]. No research has included athletic populations who are not professional athletes, for example firefighters [20–24]. To start to address this, a recent study provided consensus for the inclusion of tasks to be adopted into a screening test that could be used to assess a firefighter's readiness to RTW following injury [1].

However, before any screening test can be used to assess readiness to RTW, its reliability must be determined [25]. The reliability of a screening test should be of important consideration especially in settings where decisions on an individual's ability to perform job related tasks at the required level as based on interpretation of the results [26]. A reliable screening test ensures the same or compatible results across different assessments, regardless of when the test took place, the environment in which the test is conducted in, or the professional administering the test [25,27]. Without sufficient inter-rater and intra-rater reliability, any screening test holds little value in determining if an individual is ready to return to the demands of their job role [28].

The aim of this study was to assess the inter-rater and intra-rater reliability of a RTW screening test to be used on UK firefighters following injury.

2. Materials and Methods

2.1. Study Design

An inter-rater and intra-rater reliability study of eight tasks involved in a screening test was used to assess readiness to RTW for UK firefighters following injury. The eight tasks in the screening test were gained by consensus during a recent Delphi study [1] and include the following; (1) putting on and removing a breathing apparatus set (BA), (2) a ladder lift simulation, (3) a ladder carry simulation, (4) a light portable pump (LPP) lift and carry simulation, (5) a hose run, (6) a ladder climb with leg lock, (7) a casualty evacuation and (8) a confined space crawl simulation.

2.2. Participant Criteria

A purposive sample, of occupational health, fitness professionals or operational firefighters working within fire services in the United Kingdom (UK) was recruited to be participants. Purposive sampling aimed to capture experts within the fire service. All participants were currently involved in health and fitness assessments of operational firefighters. There was no requisite on the number of years a participant had worked within their role.

2.3. Recruitment

Participants were recruited from the National Fire Chiefs Council Fitness Advisers and Occupational Health online groups. The researcher (LN) emailed fitness advisors, occupational health managers, occupational health nurses, occupational health advisors and operational firefighter trainers who currently work for UK fire and rescue services, inviting them to participate in the study. The email included a hyperlink to the study website page and a participant information sheet (PIS). All participants were required to give their consent by answering the pre-study questions before progressing further in the study.

2.4. Sample Size

A priori power analysis was conducted to estimate the sample size required using G* Power software (version 3.1.9.4), Franz Faul, Germany [29]. The results estimated that a sample size of thirty-five would be required to establish inter-rater and intra-rater reliability ($H0 = 0.00$, $H1 = 0.70$, $\alpha = 0.05$, single tail, power = 0.95) [30]. To allow for attrition, we increased this estimated sample size by 10% and rounded up to the nearest whole number [31,32], leaving a sample size of thirty-nine.

2.5. Data Collection/Testing Procedure

Participants were provided access to a website, created using the E-learning tool Moodle [33]. The website hosted videos of the screening tests were recorded in 1080p HD video at 60 frames per second using an iPhone 12 and were edited in iMovie [34]. The iPhone 12 was set up on a tripod at approximately two meters [35] from the individual being recorded, from a front view. Each screening test was recorded two times with predetermined outcomes, (1. Pass, 2. Fail). All participants were unaware of the predetermined outcome for each video. The scoring criteria were based on the current national firefighter guidance for correct technique required for the tests [17].

All participants were required to watch an online training video detailing the online screening criteria form (SCF) before completing any rating as part of this study. The online training video was created by one of the researchers (LN) by screen recording of a mock screening test rating using Microsoft Teams [36]. The mock screening test was different from the included screening tests to avoid any influence on participants rating. After viewing the online training video, all participants were required to complete a multiple-choice questionnaire based on the training video with 100% pass mark required to pass the training. If any participants had difficulties with the online training, they were able to contact one of the researchers (LN) via email for assistance. To ensure audio and video quality, a pilot test was undertaken by one of the researchers (LN).

Participants visually assessed the technique used in the video for each screening test using a score criteria ("Pass" or "Fail"). Scores were based on a participant's judgment regarding technique throughout the task using the scoring criteria provided for each task as a reference (Appendix A Table A1).

For each participant, two rating sessions were performed with two weeks separating each session as used in previous reliability studies [25,26]. The measures obtained from both rating sessions were used to estimate inter-rater reliability. The initial and follow up testing measures from participants were used to estimate intra-rater reliability. All participants were blinded to other participants' scores by viewing the videos of the screening test online individually. All participants were advised to prevent any communication about the screening videos and/or ratings between each other. All videos were required to be rated in one sitting.

2.6. Statistical Analysis

Descriptive data were used to characterise the participants using means with standard deviations (SD) where applicable using a Microsoft Excel spreadsheet. Scores from the participants were initially stored in a Microsoft Excel spreadsheet.

Inter-rater and intra-rater reliability was assessed using Intra-class Correlation Coefficients (ICC) [25]. For inter-rater reliability, a two-way random-effects model, mean of k raters, and absolute agreement (ICC(2,k)) was used. For intra-rater reliability, a two-way mixed-effects model, mean of k measurements, and absolute agreement (ICC(3,1)) was used. Interpretation of reliability results was based on the following criterion: Excellent reliability (>0.90), Good reliability (0.75–0.90), Moderate reliability (0.50–0.75) and Poor reliability (<0.50) [37]. All statistical analysis were conducted using Statistical Package for the Social Services (SPSS) version 27 for Windows [38].

3. Results

3.1. Participants

Forty-two participants volunteered to participate in this study. Participants' job roles within their service included fitness advisors (n = 14) (40%), occupational health doctor (n = 1) (2.8%), occupational health manager (n = 1) (2.8%), occupational health nurse (n = 1) (2.8%), occupational health advisor (n = 7) (20%) and operational firefighter trainer (n = 11) (31.4%) (Figure 1). From these, a total of thirty-five participants completed both online rating screening sessions (83.3% retention rate). There was representation from different fire and rescue services across the UK (n = 8) (Figure 2). Overall, the demographic of the participants was proportionally representative of the original invitation list. The mean age of the participants in this study was 40.34 + 9.02 years and the mean duration they had worked for their fire service was 12.40 + 8.11 years (Table 1).

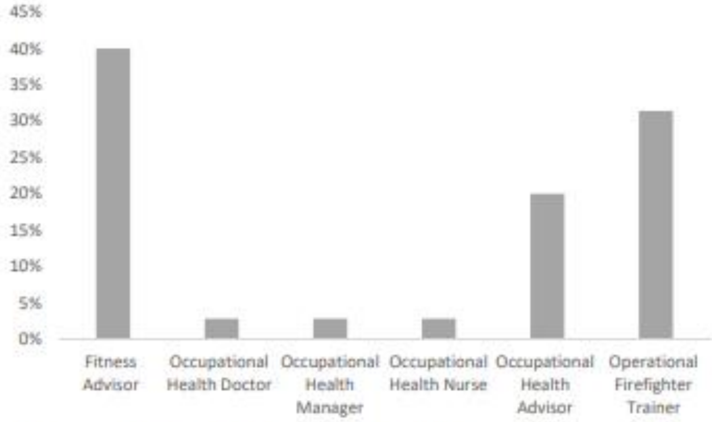

Figure 1. Bar Chart showing the job role of the participants.

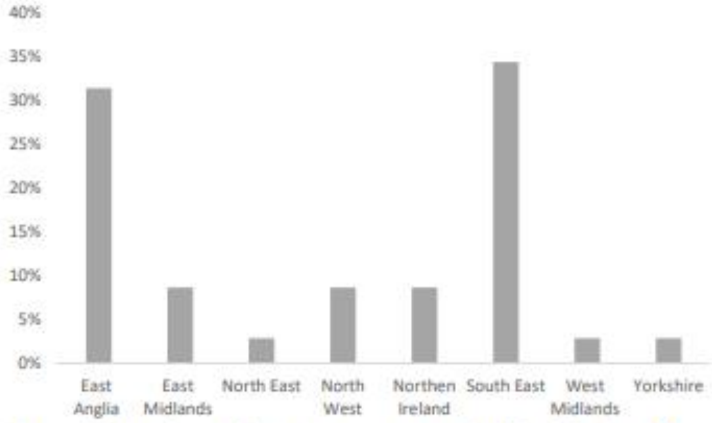

Figure 2. Bar chart showing the region representation in the United Kingdom of the participants.

Table 1. Overall inter-rater reliability of all screening tests for both rating sessions. ICC = Intraclass correlation coefficients, CI = Confidence interval.

Inter-Rater Reliability			
Rating Session	**$ICC_{2,3,5}$**	**95% CI**	**Interpretation**
1	0.77	0.67–0.85	Good
2	0.79	0.71–0.87	Good

3.2. Inter-Rater Reliability between All Screening Tasks

The inter-rater reliability between all screening tasks during both rating sessions was interpreted as Good (ICC = 0.77–0.79) (Table 1). For participants with 0–9 years of service, the inter-rater reliability between all screening tasks during both rating sessions was interpreted as Good (ICC = 0.76–0.81) and Good (ICC = 0.77–0.82) for participants with more than nine years of service (Table 2).

Table 2. Inter-rater reliability of all screening tests for both rating sessions based on years worked with the fire service. ICC = Intraclass correlation coefficients, CI = Confidence interval.

	Inter-Rater Reliability			
	Rating Session	$ICC_{2,35}$	95% CI	Interpretation
0–9 years of service	1	0.76	0.66–0.85	Good
	2	0.81	0.72–0.89	Good
9+ years of service	1	0.77	0.68–0.86	Good
	2	0.82	0.75–0.89	Good

3.3. Inter-Rater Reliability between Each Individual Screening Task

The inter-rater reliability between each individual screening task was interpreted as Excellent (ICC = 0.94–1.00) for eleven (68.75%) of the screening task videos across both rating sessions. These tasks included, Ladder lift (Pass Video), Putting on a BA set (Fail Video), Ladder carry (Pass and Fail video), LPP lift and carry (Pass and Fail video), Hose run (Pass and Fail video), Casualty evacuation (Pass and Fail video) and Confined Space (Fail video) (Table 3).

Table 3. Inter-rater reliability of each individual screening test video over two rating sessions. ICC = Intraclass correlation coefficients, CI = Confidence interval.

	Rating Session	Inter-Rater Reliability		
		$ICC_{2,35}$	95% CI	Interpretation
Ladder lift (pass)	1	1.00	1.00–1.00	Excellent
	2	1.00	1.00–1.00	Excellent
Ladder lift (fail)	1	0.88	0.55–1.00	Good
	2	0.88	0.55–1.00	Good
Putting on a BA set (pass)	1	0.76	0.32–1.00	Good
	2	0.76	0.33–1.00	Good
Putting on a BA set (fail)	1	0.94	0.74–1.00	Excellent
	2	0.94	0.74–1.00	Excellent
Ladder carry (pass)	1	0.94	0.74–1.00	Excellent
	2	0.94	0.74–1.00	Excellent
Ladder carry (fail)	1	0.94	0.74–1.00	Excellent
	2	0.94	0.74–1.00	Excellent
LPP lift and carry (pass)	1	1.00	1.00–1.00	Excellent
	2	1.00	1.00–1.00	Excellent
LPP lift and carry (fail)	1	1.00	1.00–1.00	Excellent
	2	1.00	1.00–1.00	Excellent
Hose run (pass)	1	0.94	0.74–1.00	Excellent
	2	1.00	1.00–1.00	Excellent
Hose run (fail)	1	0.91	0.70–1.00	Excellent
	2	0.94	0.74–1.00	Excellent
Ladder climb and leg lock (pass)	1	0.82	0.43–1.00	Good
	2	0.82	0.43–1.00	Good
Ladder climb and leg lock (fail)	1	0.81	0.42–1.00	Good
	2	0.88	0.55–1.00	Good
Casualty evacuation (pass)	1	0.94	0.74–1.00	Excellent
	2	0.94	0.74–1.00	Excellent
Casualty evacuation (fail)	1	0.94	0.74–1.00	Excellent
	2	0.94	0.74–1.00	Excellent
Confined space (pass)	1	0.81	0.42–1.00	Good
	2	0.81	0.42–1.00	Good
Confined space (fail)	1	1.00	1.00–1.00	Excellent
	2	1.00	1.00–1.00	Excellent

Inter-rater reliability was interpreted as Good (ICC = 0.75–0.88) for five (31.25%) of the screening task videos across both rating sessions. These tasks included, Ladder lift (Fail video), Putting on a BA Set (Pass video), Ladder climb and leg lock (Pass and Fail video), Confined space (Pass video) (Table 3).

Table 2. Inter-rater reliability of all screening tests for both rating sessions based on years worked with the fire service. ICC = Intraclass correlation coefficients, CI = Confidence interval.

	Inter-Rater Reliability			
	Rating Session	$ICC_{2,3,5}$	95% CI	Interpretation
0–9 years of service	1	0.76	0.66–0.85	Good
	2	0.81	0.72–0.89	Good
9+ years of service	1	0.77	0.68–0.86	Good
	2	0.82	0.75–0.89	Good

3.3. *Inter-Rater Reliability between Each Individual Screening Task*

The inter-rater reliability between each individual screening task was interpreted as Excellent (ICC = 0.94–1.00) for eleven (68.75%) of the screening task videos across both rating sessions. These tasks included, Ladder lift (Pass Video), Putting on a BA set (Fail Video), Ladder carry (Pass and Fail video), LPP lift and carry (Pass and Fail video), Hose run (Pass and Fail video), Casualty evacuation (Pass and Fail video) and Confined Space (Fail video) (Table 3).

Table 3. Inter-rater reliability of each individual screening test video over two rating sessions. ICC = Intraclass correlation coefficients, CI = Confidence interval.

		Inter-Rater Reliability		
	Rating Session	$ICC_{2,3,5}$	95% CI	Interpretation
Ladder lift (pass)	1	1.00	1.00–1.00	Excellent
	2	1.00	1.00–1.00	Excellent
Ladder lift (fail)	1	0.88	0.55–1.00	Good
	2	0.88	0.55–1.00	Good
Putting on a BA set (pass)	1	0.76	0.32–1.00	Good
	2	0.76	0.33–1.00	Good
Putting on a BA set (fail)	1	0.94	0.74–1.00	Excellent
	2	0.94	0.74–1.00	Excellent
Ladder carry (pass)	1	0.94	0.74–1.00	Excellent
	2	0.94	0.74–1.00	Excellent
Ladder carry (fail)	1	0.94	0.74–1.00	Excellent
	2	0.94	0.74–1.00	Excellent
LPP lift and carry (pass)	1	1.00	1.00–1.00	Excellent
	2	1.00	1.00–1.00	Excellent
LPP lift and carry (fail)	1	1.00	1.00–1.00	Excellent
	2	1.00	1.00–1.00	Excellent
Hose run (pass)	1	0.94	0.74–1.00	Excellent
	2	1.00	1.00–1.00	Excellent
Hose run (fail)	1	0.91	0.70–1.00	Excellent
	2	0.94	0.74–1.00	Excellent
Ladder climb and leg lock (pass)	1	0.82	0.43–1.00	Good
	2	0.82	0.43–1.00	Good
Ladder climb and leg lock (fail)	1	0.81	0.42–1.00	Good
	2	0.88	0.55–1.00	Good
Casualty evacuation (pass)	1	0.94	0.74–1.00	Excellent
	2	0.94	0.74–1.00	Excellent
Casualty evacuation (fail)	1	0.94	0.74–1.00	Excellent
	2	0.94	0.74–1.00	Excellent
Confined space (pass)	1	0.81	0.42–1.00	Good
	2	0.81	0.42–1.00	Good
Confined space (fail)	1	1.00	1.00–1.00	Excellent
	2	1.00	1.00–1.00	Excellent

Inter-rater reliability was interpreted as Good (ICC = 0.75–0.88) for five (31.25%) of the screening task videos across both rating sessions. These tasks included, Ladder lift (Fail video), Putting on a BA Set (Pass video), Ladder climb and leg lock (Pass and Fail video), Confined space (Pass video) (Table 3).

job role or help provide further rehabilitation interventions [39]. In addition, screening tests help provide a consistent method of assessment used within a workforce [39,40].

Similar studies assessing functional capacity set an ICC criterion of >0.75 for screening tests to be classed as "reliable" [41,42]. The inter-rater results from this study (ICC = 0.77–0.79) suggest that this screening test can be used to identify if a firefighter undertaking the RTW tasks passes or fails on a reliable basis. These data are important, as it is essential to have reliable screening methods when assessing a firefighter's ability to complete operational tasks with the correct technique to determine their physical readiness to return to operational duties [43]. By identifying reliable RTW screening tests for the physically demanding role of a firefighter is key to help highlight those firefighters who are able to undertake their role effectively, therefore improving the safety of themselves, their colleagues and the public on their RTW [44]. Previous research concluded that reliability studies should focus on multiple raters of varying background and experiences [45,46]. This was achieved as thirty-five participants from eight fire and rescue service regions across the UK completed both of the required screening sessions. The results obtained were provided from professionals working across a range of occupational health, fitness and operational training departments, with an average of 12.40 + 8.11 years' experience.

Intra-rater reliability is important in such measures because it determines the accuracy of an assessment where a single rater may make multiple assessments over time [47,48]. Our study showed that intra-rater reliability ICC ranged from 0.63–1.00 with 97% of participants achieving a reliability interpretation above the ICC criterion of >0.75 as shown in previous studies [41,42]. This suggests that the RTW screening test for firefighters following musculoskeletal injury used in this current study is suitable for repeated measures in assessing a firefighter's readiness to RTW.

Reliability for repeated measures is especially important in assessing the consistency of the RTW screening test. A lack of consistency for RTW assessments following injury was perceived as a barrier amongst firefighters experienced during their RTW process [49]. Therefore, if this RTW screening test was used as good practice within UK fire and rescue services, it could potentially remove this barrier by adding trustworthiness to the RTW process and help to increase the consistency of the RTW assessment.

The online design of the RTW screening test used in this study increased the ease of access for participants, as they were able to complete the rating sessions for the RTW screening test on desktop or portable devices, including laptops, smartphones, and tablets. As a result, future practice could allow for this RTW screening test to be used in various locations across different fire and rescue services provided they have the required equipment for the screening test. This could increase the availability in RTW screening test appointments within fire and rescue services and as a result, help decrease potential waiting times for firefighters looking to return to their job role. Further research is needed to assess the validity of the use of this RTW screening test to help reduce firefighter reinjury rates in UK fire and rescue services.

Strengths and Limitations

This study included experts from fire service fitness and occupational health departments as well as operational firefighters in the UK. Experts from fire and rescue services across the UK were invited to participate but this study participation did not include representation from every fire and rescue service in the UK. Nevertheless, those who did take part provided representation from a large range of UK fire and rescue services. The online approach helped reduce the impact on the participants. This study was focused on participants working for UK fire and rescue services. The online approach allows for representation from fire and rescue services internationally in future studies.

A training video and clear SCF provided the participants with the information required of what was required from them. The videos filmed, provided clear visual information for participants to decide if the video should be marked as pass or fail. The design of the website allowed the SCF and the assessment videos to be on the webpage. This allowed participants to use one screen/device and it could be completed on a computer desktop, tablet or mobile device.

5. Conclusions

The return-to-work screening test used in this study provided evidence that it has good inter-rater reliability (ICC = 0.77–0.79) and good-excellent intra-rater reliability (ICC = 0.76–1.00) for 97% of participants. Due to the reliability of this screening test, it allows conclusions to be made from the results which can inform a return-to-work decision for a firefighter. This return-to-work screening test provides a method for fitness and occupational health experts as well as operational trainers working for UK fire and rescue services to refer to when assessing the readiness of a firefighter to return to operational duties. If used, this screening test could increase the consistency of return-to-work process within UK fire and rescue services and add trustworthiness to the decisions made. Further research is needed on the validity of this return-to-work screening test in reducing reinjury rates within firefighters.

Author Contributions: Conceptualization, L.N.; methodology, L.N.; software, L.N.; validation, L.N.; formal analysis, L.N.; investigation, L.N.; resources, L.N.; data curation, L.N.; writing—original draft preparation, L.N.; writing—review and editing, L.N.; visualization, L.N.; supervision, J.M. and A.M.; project administration, L.N.; funding acquisition, Not applicable. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement: The University of Essex research ethics committee granted approval for the study. (Ethics reference; ETH2122-1516).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Screening Video Criteria Form (SCF).

Screening Test	Pass Criteria
Putting on and Removal of Breathing Apparatus Set	Firefighter squats behind the BA set with the top of the cylinder between their feet. Firefighter stands the set onto the cylinder bump stop so that it is in a vertical position Firefighter draws the set close to their body, bending the knees and keeping the spine in a neutral position whilst standing up. Firefighter places the right-hand shoulder strap over their right shoulder and then places left arm into the left shoulder strap. Firefighter fastens shoulder straps and then fastens waist belt buckle ensuring that the belt is not twisted. Firefighter fastens chest and waist clips then stands up straight.
Ladder lift simulator	Firefighter starts with an underhand grip on the bar with palms facing upwards. Firefighter bicep curls the bar, keeping back straight. Firefighter rotates their wrists one at a time so that the bar is now gripped with the bottom of their palms facing outwards. Firefighter shoulder presses the bar, without any assistance from the lower body, ensuring that the bar is above the designated yellow marker. Firefighter lowers the bar in a controlled manner back to chest height, changing wrists back over so that the bottoms of their palms are facing towards them. Firefighter lowers bar to the start position by extending their arm and places the bar into the rest position, bending their knees if required.

Table A1. *Cont.*

Screening Test	Pass Criteria
Ladder carry simulator	Firefighter starts with their feet flat on the ground and positioned between hip and shoulder width apart. Firefighter squats down and grasps the dumbbell in one hand. Firefighter lifts the dumbbell off the floor, by extending their knees and hips, until standing in a upright position. Firefighters back should maintain a rigid spine with a constant torso angle to the floor. Firefighter holds the dumbbell down by their side with a straight arm and proceeds to walk forwards, keeping an upright position. Once the firefighter has reached the required distance, they lower the dumbbell to the floor whilst maintaining a neutral spine, flexing the hips and squatting. Firefighter turns around and repeats the process, lifting the dumbbell with the opposite hand. Once the firefighter has reached the required distance, they lower the dumbbell to the floor whilst maintaining a neutral spine, flexing the hips and squatting.
Light portable pump lift and carry simulator	Firefighter starts with their feet flat on the ground and positioned between hip and shoulder width apart. Firefighter squats down and grasps the barbell with both hands. Firefighter lifts the barbell off the floor by extending knees and hips until they are in an upright position. Their back should maintain a rigid spine with a constant torso angle to the floor. Firefighter holds the barbell down in front of them with straight arms and proceeds to walk forwards keeping in an upright position. One the firefighter has reached the required distance, the barbell is lowered to the floor whilst maintaining a neutral spine, flexing the hips and squatting.
Casualty evacuation	Firefighter grasps the casualty, with both hands, by the carrying handle located at the back of the dummy's head. Firefighter positions themselves body upright, back neutral and legs slightly bent. Firefighter drags casualty by walking backwards. Once the firefighter reaches the required distance, grasp on the carrying handle is released in a controlled manner.
Hose run	Firefighter places their foot on the hose and grasps the lugs with their hands. Firefighter lifts hose to shoulder height and holds it to the side of their body. Firefighter runs hose out until the end is reached and the female coupling is placed carefully on the ground. Firefighter runs back and underruns the hose.
Ladder climb and leg lock	Firefighter climbs the ladder and takes a leg lock. Firefighter releases their hands from the ladder, outstretches both arms to the side and looks over each shoulder. Firefighter regains hand hold on the ladder, removes their leg lock and descend the ladder to the ground.
Confined space crawl	Firefighter crawls on their hands and knees through the confined space. Once the firefighter reaches the end of the confined space, they turn around and make their way back to the start. The crawl should be completed in a calm and controlled manner by the firefighter.

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Appendix 13

Scoring criteria Form

All points in “Pass Criteria” need to be achieved before a pass can be awarded.

Screening Test	Pass Criteria
Putting on & Removal of Breathing Apparatus Set	Firefighter squats behind the BA set with the top of the cylinder between their feet. Firefighter stands the set onto the cylinder bump stop so that it is in a vertical position. Firefighter draws the set close to their body, bending the knees and keeping the spine in a neutral position whilst standing up. Firefighter places the right-hand shoulder strap over their right shoulder and then places left arm into the left shoulder strap. Firefighter fastens shoulder straps and then fastens waist belt buckle ensuring that the belt is not twisted. Firefighter fastens chest and waist clips then stands up straight.

Ladder Lift Simulator	Firefighter starts with an underhand grip on the bar with palms facing upwards. Firefighter bicep curls the bar, keeping back straight. Firefighter rotates their wrists one at a time so that the bar is now gripped with the bottom of their palms facing outwards Firefighter shoulder presses the bar, without any assistance from the lower body, ensuring that the bar is above the designated yellow marker Firefighter lowers the bar in a controlled manner back to chest height, changing wrists back over so that the bottom of their palms are facing towards them. Firefighter lowers bar to the start position by extending their arm and places the bar into the rest position, bending their knees if required.

Ladder Carry Simulator	Firefighter starts with their feet flat on the ground and positioned between hip and shoulder width apart. Firefighter squats down and grasps the dumbbell in one hand Firefighter lifts the dumbbell off the floor, by extending their knees and hips, until standing in a upright position. Firefighters back should maintain a rigid spine with a constant torso angle to the floor. Firefighter holds the dumbbell down by their side with a straight arm and proceeds to walk forwards, keeping an upright position. Once the firefighter has reached the required distance, they lower the dumbbell to the floor whilst maintaining a neutral spine, flexing the hips and squatting. Firefighter turns around and repeats the process, lifting the dumbbell with the opposite hand. Once the firefighter has reached the required distance, they lower the dumbbell to the floor whilst maintaining a neutral spine, flexing the hips and squatting.

Light portable pump lift and carry simulator	Firefighter starts with their feet flat on the ground and positioned between hip and shoulder width apart. Firefighter squats down and grasps the barbell with both hands. Firefighter lifts the barbell off the floor by extending knees and hips until they are in an upright position. Their back should maintain a rigid spine with a constant torso angle to the floor. Firefighter holds the barbell down in front of them with straight arms and proceeds to walk forwards keeping in an upright position. One the firefighter has reached the required distance, the barbell is lowered to the floor whilst maintaining a neutral spine, flexing the hips and squatting.

Casualty Evacuation	Firefighter grasps the casualty, with both hands, by the carrying handle located at the back of the dummy's head. Firefighter positions themselves body upright, back neutral and legs slightly bent. Firefighter drags casualty by walking backwards. Once the firefighter reaches the required distance, grasp on the carrying handle is released in a controlled manner

Hose Run + Carry	Firefighter places their foot on the hose and grasps the lugs with their hands. Firefighter lifts hose to shoulder height and holds it to the side of their body. Firefighter runs hose out until the end is reached and the female coupling is placed carefully on the ground Firefighter runs back and underruns the hose. Firefighter makes up the hose by rolling it around the female coupling in a hand by hand method and looking up in front of them to check their route.

Ladder Climb and leg lock	Firefighter climbs the ladder and takes a leg lock Firefighter releases their hands from the ladder, outstretches both arms to the side and looks over each shoulder. Firefighter regains hand hold on the ladder, removes their leg lock and descend the ladder to the ground.
Confined Space Crawl	Firefighter crawls on their hands and knees through the confined space Once the firefighter reaches the end of the confined space, they turn around and make their way back to the start. The crawl should be completed in a calm and controlled manner by the firefighter.

Appendix 14

	Intra-rater reliability		
	Cronbach's Alpha	**95% CI**	**Interpretation**
Participant 1	1.00	1.00-1.00	Excellent
Participant 2	1.00	1.00-1.00	Excellent
Participant 3	0.77	0.63-1.00	Acceptable
Participant 4	1.00	1.00-1.00	Excellent
Participant 5	1.00	1.00-1.00	Excellent
Participant 6	0.93	0.88-1.00	Excellent
Participant 7	0.77	0.63-1.00	Acceptable
Participant 8	1.00	1.00-1.00	Excellent
Participant 9	0.86	0.75-1.00	Good
Participant 10	1.00	1.00-1.00	Excellent
Participant 11	1.00	1.00-1.00	Excellent
Participant 12	1.00	1.00-1.00	Excellent
Participant 13	0.86	0.75-1.00	Good
Participant 14	1.00	1.00-1.00	Excellent
Participant 15	0.93	0.88-1.00	Excellent
Participant 16	1.00	1.00-1.00	Excellent
Participant 17	1.00	1.00-1.00	Excellent
Participant 18	1.00	1.00-1.00	Excellent
Participant 19	0.93	0.88.1.00	Excellent
Participant 20	1.00	1.00-1.00	Excellent
Participant 21	1.00	1.00-1.00	Excellent
Participant 22	1.00	1.00-1.00	Excellent
Participant 23	0.93	0.88-1.00	Excellent
Participant 24	1.00	1.00-1.00	Excellent
Participant 25	1.00	1.00-1.00	Excellent
Participant 26	1.00	1.00-1.00	Excellent
Participant 27	1.00	1.00-1.00	Excellent
Participant 28	0.93	0.88-1.00	Excellent
Participant 29	1.00	1.00-1.00	Excellent
Participant 30	1.00	1.00-1.00	Excellent
Participant 31	1.00	1.00-1.00	Excellent
Participant 32	1.00	1.00-1.00	Excellent
Participant 33	1.00	1.00-1.00	Excellent
Participant 34	1.00	1.00-1.00	Excellent
Participant 35	1.00	1.00-1.00	Excellent

Appendix 12: Intra-rater reliability between each rating session. CI = Confidence interval

Appendix 15

University of Essex

<u>Date: 20/06/2023</u>

Dear Liam,

Please accept this letter as confirmation of our fire service's cooperation with your proposed research study; Implementation of the Fit for Duty tool for firefighters following injury within fire and rescue services in the United Kingdom – Study protocol for a feasibility randomised controlled trial.

Kind Regards,

Name (PRINT): Natalie Pavey

Signature: *NJPavey*

Fire service: Kent Fire and Rescue Service

University of Essex

Date: 21.06.2023

Dear Liam,

Please accept this letter as confirmation of our fire service's cooperation with your proposed research study; Implementation of the Fit for Duty tool for firefighters following injury within fire and rescue services in the United Kingdom – Study protocol for a feasibility randomised controlled trial.

Kind Regards,

Name (PRINT): Damien Cassidy

Signature: Damien Cassidy

Fire service: Northern Ireland Fire & Rescue Service

Northern Ireland Fire & Rescue Service

Damien Cassidy
Health & Wellbeing Advisor
Occupational Health and Wellbeing
NIFRS | FRSHQ
T 028 9266 4221 ext 6452

Safer Together

Our Values

Community | Integrity | Improvement | Respect

Together we can STOP Fire
Smoke alarms | Test alarms weekly | Obvious dangers | Plan your escape

Appendix 16

STANDARD PROTOCOL ITEMS: RECOMMENDATIONS FOR INTERVENTIONAL TRIALS

SPIRIT 2013 Checklist: Recommended items to address in a clinical trial protocol and related documents*

Section/item	Item No	Description	Addressed on page number
Administrative information			
Title	1	Descriptive title identifying the study design, population, interventions, and, if applicable, trial acronym	Page 143
Trial registration	2a	Trial identifier and registry name. If not yet registered, name of intended registry	Page 160
	2b	All items from the World Health Organization Trial Registration Data Set	N/A
Protocol version	3	Date and version identifier	N/A
Funding	4	Sources and types of financial, material, and other support	N/A at this time
	5a	Names, affiliations, and roles of protocol contributors	N/A at this time

Roles and responsibilities	5b	Name and contact information for the trial sponsor	N/A
	5c	Role of study sponsor and funders, if any, in study design; collection, management, analysis, and interpretation of data; writing of the report; and the decision to submit the report for publication, including whether they will have ultimate authority over any of these activities	N/A
	5d	Composition, roles, and responsibilities of the coordinating centre, steering committee, endpoint adjudication committee, data management team, and other individuals or groups overseeing the trial, if applicable (see Item 21a for data monitoring committee)	N/A
Introduction			
Background and rationale	6a	Description of research question and justification for undertaking the trial, including summary of relevant studies (published and unpublished) examining benefits and harms for each intervention	Page 145-148

	6b	Explanation for choice of comparators	Page 146-147
Objectives	7	Specific objectives or hypotheses	Page 147-148
Trial design	8	Description of trial design including type of trial (eg, parallel group, crossover, factorial, single group), allocation ratio, and framework (eg, superiority, equivalence, noninferiority, exploratory)	Page 148
Methods: Participants, interventions, and outcomes			
Study setting	9	Description of study settings (eg, community clinic, academic hospital) and list of countries where data will be collected. Reference to where list of study sites can be obtained	Page 148
Eligibility criteria	10	Inclusion and exclusion criteria for participants. If applicable, eligibility criteria for study centres and individuals who will perform the interventions (eg, surgeons, psychotherapists)	Page 150
Interventions	11a	Interventions for each group with sufficient detail to allow replication, including how and when they will be administered	Page 150-154
	11b	Criteria for discontinuing or modifying allocated interventions for a given trial participant (eg, drug dose change in response to harms, participant request, or improving/worsening disease)	Page 150

	11c	Strategies to improve adherence to intervention protocols, and any procedures for monitoring adherence (eg, drug tablet return, laboratory tests)	Page 157
	11d	Relevant concomitant care and interventions that are permitted or prohibited during the trial	N/A
Outcomes	12	Primary, secondary, and other outcomes, including the specific measurement variable (eg, systolic blood pressure), analysis metric (eg, change from baseline, final value, time to event), method of aggregation (eg, median, proportion), and time point for each outcome. Explanation of the clinical relevance of chosen efficacy and harm outcomes is strongly recommended	Page 158-160
Participant timeline	13	Time schedule of enrolment, interventions (including any run-ins and washouts), assessments, and visits for participants. A schematic diagram is highly recommended (see Figure)	Page 148
Sample size	14	Estimated number of participants needed to achieve study objectives and how it was determined, including clinical and statistical assumptions supporting any sample size calculations	Page 151
Recruitment	15	Strategies for achieving adequate participant enrolment to reach target sample size	Page 151-152

Methods: Assignment of interventions (for controlled trials)

Allocation:

Sequence generation	16a	Method of generating the allocation sequence (eg, computer-generated random numbers), and list of any factors for stratification. To reduce predictability of a random sequence, details of any planned restriction (eg, blocking) should be provided in a separate document that is unavailable to those who enrol participants or assign interventions	N/A
Allocation concealment mechanism	16b	Mechanism of implementing the allocation sequence (eg, central telephone; sequentially numbered, opaque, sealed envelopes), describing any steps to conceal the sequence until interventions are assigned	N/A
Implementation	16c	Who will generate the allocation sequence, who will enrol participants, and who will assign participants to interventions	N/A
Blinding (masking)	17a	Who will be blinded after assignment to interventions (eg, trial participants, care providers, outcome assessors, data analysts), and how	N/A

	17b	If blinded, circumstances under which unblinding is permissible, and procedure for revealing a participant's allocated intervention during the trial	N/A

Methods: Data collection, management, and analysis

Data collection methods	18a	Plans for assessment and collection of outcome, baseline, and other trial data, including any related processes to promote data quality (eg, duplicate measurements, training of assessors) and a description of study instruments (eg, questionnaires, laboratory tests) along with their reliability and validity, if known. Reference to where data collection forms can be found, if not in the protocol	Page 157-158
	18b	Plans to promote participant retention and complete follow-up, including list of any outcome data to be collected for participants who discontinue or deviate from intervention protocols	Page 157-158
Data management	19	Plans for data entry, coding, security, and storage, including any related processes to promote data quality (eg, double data entry; range checks for data values). Reference to where details of data management procedures can be found, if not in the protocol	N/A
Statistical methods	20a	Statistical methods for analysing primary and secondary outcomes. Reference to where other details of the statistical analysis plan can be found, if not in the protocol	Page 161

	20b	Methods for any additional analyses (eg, subgroup and adjusted analyses)	N/A
	20c	Definition of analysis population relating to protocol non-adherence (eg, as randomised analysis), and any statistical methods to handle missing data (eg, multiple imputation)	Page 149

Methods: Monitoring

Data monitoring	21a	Composition of data monitoring committee (DMC); summary of its role and reporting structure; statement of whether it is independent from the sponsor and competing interests; and reference to where further details about its charter can be found, if not in the protocol. Alternatively, an explanation of why a DMC is not needed	A data monitoring committee was not used as there was no need for interim data analysis.
	21b	Description of any interim analyses and stopping guidelines, including who will have access to these interim results and make the final decision to terminate the trial	N/A
Harms	22	Plans for collecting, assessing, reporting, and managing solicited and spontaneously reported adverse events and other unintended effects of trial interventions or trial conduct	Page 156-157

Auditing	23	Frequency and procedures for auditing trial conduct, if any, and whether the process will be independent from investigators and the sponsor	N/A
Ethics and dissemination			
Research ethics approval	24	Plans for seeking research ethics committee/institutional review board (REC/IRB) approval	Page 160
Protocol amendments	25	Plans for communicating important protocol modifications (eg, changes to eligibility criteria, outcomes, analyses) to relevant parties (eg, investigators, REC/IRBs, trial participants, trial registries, journals, regulators)	Page 160
Consent or assent	26a	Who will obtain informed consent or assent from potential trial participants or authorised surrogates, and how (see Item 32)	Page 151
	26b	Additional consent provisions for collection and use of participant data and biological specimens in ancillary studies, if applicable	N/A
Confidentiality	27	How personal information about potential and enrolled participants will be collected, shared, and maintained in order to protect confidentiality before, during, and after the trial	Page 160
Declaration of interests	28	Financial and other competing interests for principal investigators for the overall trial and each study site	N/A at this time

Access to data	29	Statement of who will have access to the final trial dataset, and disclosure of contractual agreements that limit such access for investigators	N/A at this time
Ancillary and post-trial care	30	Provisions, if any, for ancillary and post-trial care, and for compensation to those who suffer harm from trial participation	N/A
Dissemination policy	31a	Plans for investigators and sponsor to communicate trial results to participants, healthcare professionals, the public, and other relevant groups (eg, via publication, reporting in results databases, or other data sharing arrangements), including any publication restrictions	N/A
	31b	Authorship eligibility guidelines and any intended use of professional writers	N/A
	31c	Plans, if any, for granting public access to the full protocol, participant-level dataset, and statistical code	N/A
Appendices			
Informed consent materials	32	Model consent form and other related documentation given to participants and authorised surrogates	Page 151
Biological specimens	33	Plans for collection, laboratory evaluation, and storage of biological specimens for genetic or molecular analysis in the current trial and for future use in ancillary studies, if applicable	N/A

Appendix 17

PARQ

Start of Block: Physical Activity Readiness Questionnaire

Q1 Research Project Physical Activity Readiness Questionnaire (PARQ) - Implementation of the Fit For Duty screening tool for firefighters following injury within fire and rescue services in the United Kingdom – Study protocol for a feasibility randomised controlled trial.

Liam Noll, Postgraduate Student & Chief Investigator

Jason Moran, PhD, Academic Supervisor

Adrian Mallows, PhD, Academic Supervisor

End of Block: Physical Activity Readiness Questionnaire

Start of Block: Block 4

Q6 Please provide the following details

Q7 Full Name

____

Q8 Date of Birth

____

End of Block: Block 4

Start of Block: Block 2

Q5 Please carefully read the following questions and tick the appropriate box below.

Q6 1. Has your doctor ever said that you have a heart condition and that you should only do physical exercise recommended by a doctor?

- No (1)
- Yes (2)

Q7 2. Do you feel pain in your chest when you take part in physical exercise?

- No (1)
- Yes (2)

Q8 3. In the past month have you had chest pain when you are not taking part in physical activity?

- ◯ No (1)
- ◯ Yes (2)

Q9 4. Do you ever lose your balance because of dizziness or ever lose consciousness?

- ◯ No (1)
- ◯ Yes (2)

Q10 5. Have you ever suffered from epilepsy?

- ◯ No (1)
- ◯ Yes (2)

Q12 7. Have you ever had asthma or suffered from any breathing difficulties?

- ◯ No (1)
- ◯ Yes (2)

Q13 8. Are you suffering from diabetes?

○ No (1)

○ Yes (2)

Q14 9. Have you been cleared by a medical professional to undertake physical activity?

○ No (1)

○ Yes (2)

Q15 10. Is your doctor currently prescribing drugs for blood pressure or a heart condition?

○ No (1)

○ Yes (2)

Q16 11. Are you pregnant or have you had a baby in the last 6 months?

○ No (1)

○ Yes (2)

Q17 12. Do you know of any other reason why you should not take part in physical activity?

- No (1)
- Yes (2)

End of Block: Block 2

Start of Block: Block 3

Q18 I have read this questionnaire and confirm that the answers I have given are correct to the best of my knowledge.

- I confirm (1)

End of Block: Block 3

Appendix 18

Online consent form & demographic survey

Start of Block: Block 1

Q2 Implementation of the Fit For Duty screening tool for firefighters following injury within fire and rescue services in the United Kingdom – Study protocol for a feasibility randomised controlled trial.

Liam Noll, Postgraduate Student & Chief Investigator

Jason Moran, PhD, Academic Supervisor

Adrian Mallows, PhD, Academic Supervisor

End of Block: Block 1

Start of Block: Default Question Block

Q1 You have been invited to take part in our online survey which will take approximately five minutes to complete. This research study is focused assessing the feasibility of a return to work screening tool to be used on firefighters following injury. Before you start the survey please make sure that have read the participant information form.

The information and data collected in this survey will be kept confidential and will not be shared with any third parties.

End of Block: Default Question Block

Start of Block: Block 2

Q4 Implementation of the Fit For Duty screening tool for firefighters following injury within fire and rescue services in the United Kingdom – Study protocol for a feasibility randomised controlled trial.

Please read the statements below and feel free to ask any questions which you may have.

Q3 I confirm that I have read and understand the participant information sheet for the above study. I have had the opportunity to consider the information, ask questions and have had these questions answered satisfactorily.

○ I Agree (1)

Q5 I understand that my participation is voluntary and that I am free to withdraw from the project at any time without giving any reason and without penalty.

○ I Agree (1)

Q6 I understand that the identifiable data provided will be securely stored and accessible only to the members of the research team directly involved in the project, and that confidentiality will be maintained.

○ I Agree (1)

Q7 I understand that data collected in this project might be shared as appropriate and for publication of findings, in which case data will remain completely anonymous.

○ I Agree (1)

Q8 I agree to take part in the study

○ I Agree (1)

End of Block: Block 2

Start of Block: Block 3

Q10 Please confirm your sex

○ Male (1)

○ Female (2)

○ Non-binary / third gender (3)

○ Prefer not to say (4)

Q9 Please confirm your age

____

Q11 How many years have you worked for ECFRS?

____

Q12 Please provide an email address

____

End of Block: Block 3

Appendix 19

Participant follow up survey

Start of Block: Landing Page

Q1 **Implementation of the Fit For Duty screening tool for firefighters following injury within fire and rescue services in the United Kingdom – Study protocol for a feasibility randomised controlled trial. - Participant follow up survey.**

Liam Noll, PhD Student & Chief Investigator

Jason Moran, PhD, Academic Supervisor

Adrian Mallows, PhD, Academic Supervisor

Q2 We would like to invite you to participant in a short follow up survey regarding your previous injury since returning to operational duties. This survey should take approximately five minutes to complete.

End of Block: Landing Page

Start of Block: Follow up questions.

Q3 Please answer the following statements.

	Never (1)	Sometimes (2)	About half the time (3)	Most of the time (4)	Always (5)
Since returning to operational duties. Have you had any reoccurring pain from your previous injury? (1)	○	○	○	○	○

Display This Question:

If Please answer the following statements = Sometimes

And Please answer the following statements = About half the time

And Please answer the following statements = Most of the time

And Please answer the following statements = Always

Q4 Please provide details of your reoccurring pain.

____

Q5 Click to write the question text.

	No (1)	Yes (2)
Have you suffered a reinjury to your previous injury since returning to operational duties? (1)	○	○

Display This Question:

If click to write the question text = Yes

Q6 Please provide details of your reinjury (including the date of your reinjury and if this was a work-related injury).

____

End of Block: Follow up questions.

Appendix 20

Site administrator experience survey

Start of Block: Landing Page

Q2 **Implementation of the Fit for Duty screening tool for firefighters following injury within fire and rescue services in the United Kingdom – Study protocol for a feasibility randomised controlled trial. - Follow up survey.**

Liam Noll, PhD Student & Chief Investigator

Jason Moran, PhD, Academic Supervisor

Adrian Mallows, PhD, Academic Supervisor

Q3 We would like to invite you to participant in a short follow up survey regarding your experience of the online training used in this study. This survey should take approximately five minutes to complete.

End of Block: Landing Page

Start of Block: Liker Score Scale

Q1 Impact of Fit for Duty screening tool on current workflow.

	Not at all (11)	A little (12)	A moderate amount (13)	A lot (14)	A great deal (15)
How did the administration of the Fit for duty screening tool impact your current workflow in comparison with your current return to work processes (1)	○	○	○	○	○

Display This Question:

If Impact of Fit for Duty screening tool on current workflow = A moderate amount

And Impact of Fit for Duty screening tool on current workflow = A lot

And Impact of Fit for Duty screening tool on current workflow = A great deal

Q5 Please give some detail on how the Fit for Duty screening tool impacted your workflow.

____

Q4 Your experience of the online training

	Strongly agree (11)	Somewhat agree (12)	Neither agree nor disagree (13)	Somewhat disagree (14)	Strongly disagree (15)
The online training video was easy to access (6)	○	○	○	○	○
The online training provided me with the information required to administer the Fit for Duty screening tool (1)	○	○	○	○	○

End of Block: Liker Score Scale