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Effects of an Unsupervised Home Exercise Program to Improve Volunteer Firefighter Fitness and Occupational Performance: A Pilot Study

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Abstract: Volunteer firefighters perform the same job tasks as professional firefighter but may have lower levels of fitness and may be at greater risk of cardiovascular disease. The aim of this study was to determine the effects of an 8-week unsupervised home exercise program on the physical fitness and occupational performance of volunteer firefighters. Firefighters (n = 15 male) volunteered to participate. Outcome measures included measures of stature, health (blood pressure and percentage body fat – %BF), fitness (cardiovascular endurance, muscular strength, power and endurance, flexibility) movement skills (i.e., Functional Movement Screen – FMS) and occupational performance (stair climb, hose drag, equipment carry and victim drag). Between data collection points, participants undertook an unsupervised 8-week home exercise training program of 3 sessions per week plus corrective exercises based on FMS scores. Of the five firefighters that completed the program the compliance rates were 47% (33–70%). Right hand grip strength and FMS scores improved significantly ($p < 0.05$) with a trend towards improved blood pressure ($p = 0.054$), and %BF ($p = 0.084$). Given difficulties in providing a supervised exercise program for volunteer firefighters, an unsupervised home exercise program did lead to some improvements in their health and fitness. An unsupervised home exercise program may improve the elements of firefighter fitness but participation rates and compliance are major challenges. Provision of an unsupervised home exercise program alone will potentially be of limited value. Future research should investigate the means of improving unsupervised exercise program compliance in this population.

Keywords: firefighting, health, safety, wellness program, occupational performance.

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INTRODUCTION

Firefighters are known to hold one of the most perilous civilian occupations (Khoshakhlagh et al., 2024). Their occupational duties entail various physically demanding activities performed within hazardous environments and under adverse conditions (Perroni et al., 2014). Duties undertaken can include a range of tasks such as climbing stairs while carrying equipment, fire suppression, rescuing victims, manoeuvring a charged hose, and entering and exiting firefighting vehicles (Ferreira et al., 2024). Furthermore, similar to other tactical occupations, firefighters are mandated to wear personal protective equipment (PPE), which can weigh between 17 and 25 kg (Orr et al., 2019b; Walker et al., 2019). These occupational tasks and the physical demands of PPE load carriage are known to increase injury risk to firefighters (Orr et al., 2019b; Taylor et al., 2012). Considering the importance of fitness, research suggests that higher fitness levels may both reduce injury risk and enhance operational efficacy during firefighting scenarios (Elsner & Kolkhorst, 2008). Cardiovascular and neuromuscular fitness in particular have been shown to be of importance in task completion and injury risk mitigation (Ferreira et al., 2024). Consequently, it is imperative for firefighters to employ training methodologies that efficiently address cardiovascular fitness, as well as neuromuscular strength and endurance (Pawlak et al., 2015). However, challenges to developing and maintaining the levels of fitness required may be influenced by employment status (i.e., volunteer versus career firefighter).

The National Fire Protection Association (NFPA) defines a volunteer firefighter as any active part-time (volunteer) firefighter, while career firefighters encompass full-time uniformed firefighters, irrespective of their assigned roles, such as suppression, prevention/inspection, or administrative duties (Evarts & Stein, 2019). In some countries, career firefighters are mandated to engage in exercise training as an integral component of their daily duties, whereas volunteer firefighting departments lack uniform standards concerning physical fitness training. The absence of physical fitness training may result in these individuals having a reduced level of physical fitness, therefore potentially raising their vulnerability to musculoskeletal injuries or cardiac events (Morris et al., 2022). This supposition is supported by research reporting volunteer firefighters as having lower levels of health and fitness across multiple parameters in comparison to career firefighters and of being at an elevated risk for cardiovascular disease (CVD) (Morris et al., 2022). These research findings underscore the importance of implementing a physical conditioning program among volunteer firefighters.

Previous research has shown that a dedicated conditioning program can increase firefighter health and fitness. A study by Stone et al. (2020) found that an 11-week conditioning program increased firefighter trainee fitness. The program included two resistance training sessions and one aerobic conditioning session per week and led to decreases in body mass and body mass index and significant increases in upper body (pull ups) and lower body (hex bar deadlift) strength, and aerobic fitness (20 m shuttle run) performance. In a shorter period, with qualified firefighters preparing for a challenge competition, Čvorović et al. (2020) found increases in firefighter chin ups and aerobic fitness over a period of four weeks. The program in this later study included four sessions per week for the first mesocycles (general preparation) and three sessions per week for the second mesocycle (specific preparation phases). While these studies show that firefighter fitness can be improved with a conditioning program, the studies included formal training and were of trainee or fit firefighters. As such, the impact of an unsupervised home conditioning program for volunteer firefighter warrants further research, especially given the above concerns regarding their lower level of fitness and increased CVD risk in comparison to regular firefighters.

As such, the aim of this study was to determine the effects of an 8-week unsupervised home workout training program on the physical fitness and occupational performance of volunteer firefighters. It was hypothesized that implementing an 8-weeks unsupervised home workout physical training program would enhance overall volunteer firefighter cardiovascular fitness, muscular strength, body composition, and performance on simulated firefighting job tasks.

METHODS

Participants

From an initial 19 firefighters approached, 15 male firefighters volunteered to take part in the study. During the screening process, one participant was excluded due to high blood pressure. Thus, 14 male firefighters (mean height = 181.70 ± 5.28cm; mean body mass = 101.16 ± 18.41 kg; mean Body Mass Index [BMI] = 30.71 ± 6.00 kg/m2; mean percentage body fat [BF%] = 26.26 ± 9.41%) participated in the research. All participants provided written informed consent prior to participation. Ethics approval for this study was provided by Ethics Committee of the Faculty of Technical Sciences, University of Novi Sad (protocol number 01-2082/2, 2023).

Research Approach

Prior to data collection and following the obtaining of informed consent, potential participants were screened to minimize potential health risks using a prescreening questionnaire and blood pressure (BP) measures. Participant inclusion criteria were: a) currently serving volunteer firefighter, b) no current musculoskeletal injuries, and c) volunteered to participate in the study. The exclusion criterion was failing initial screening requirements.

Following the screening of participants, individual height, weight, body composition measures, level of cardiorespiratory fitness, level of muscular fitness (power, strength, endurance, and flexibility) and movement quality (functional movement screen – FMS) were assessed. In addition, performance on a series of occupational tasks was assessed to characterize occupational performance. Data collection occurred over two days. Day 1 included participant screening and physical fitness assessments and lasted for six hours. Day 2 consisted of assessing the occupational tasks and lasted for five hours.

Following these assessments, participants undertook an unsupervised 8-week home exercise training intervention. The group was advised to train 3 days per week (i.e., total 24 exercise sessions), for approximately 30 minutes per exercise session, and to perform individual FMS exercises for 2–3 days per week. Subjects were encouraged to continue with their existing exercise habits while participating in the study and were asked to monitor their exercise program compliance. After 8 weeks of the training program, the measures taken on Day 1 and Day 2 were repeated and conducted in the same order.

Screening

A pre-participation screening questionnaire, following the American College of Sports Medicine's (ACSM) Exercise Preparticipation Health Screening Questionnaire for Exercise Professionals (American College of Sports Medicine, 2020) was prepared by the researchers and used as a data collection form. This pre-participation screening form was designed to accompany the pre-participation screening algorithm outlined by ACSM in their Guidelines for Exercise Testing and Prescription (American College of Sports Medicine, 2020; Thompson et al., 2013; Liguori et al., 2021). In addition, BP was assessed (Omron, M7, Kyoto, Japan). The recommended procedures for assessing resting blood pressure in the ACSM Guidelines for Exercise Testing and Prescription were followed given it is a precise and proven method for measuring BP (Liguori et al., 2021) with the Classification and Management of Blood Pressure for Adults (Thompson et al., 2013) used as a criterion reference for study exclusion.

Body Stature and Morphology

Participant standing height was measured using a stadiometer (Seca, SE213, Hanover, MD, USA). Participants wore personal physical exercise clothing and were barefoot. Height was measured in cm. Given that insufficient physical activity can result in weight gain, increased body fat, and related health issues and injuries (Lockie et al., 2022), body mass, BMI, and BF% were measured via a multichannel bioelectric impendence analyser (InBody Co. 270, LTD, Seoul, South Korea). This device has been found to be valid and reliable (Aandstad et al., 2014). Firefighters were evaluated barefoot, standing with their feet placed on marked positions and their hands gripping handles by aligning their fingers with designated spots. They maintained an upright posture, with their arms extended alongside their body and slightly abducted, avoiding contact with the sides of their torso. Participants were informed about procedures before the testing ahead of time and were asked to abstain from strenuous exercise 12 h prior to testing, to avoid drinking alcohol for 48 hours before the assessment, to avoid consuming products that have diuretic properties (e.g., caffeine, chocolate) 24 hours before testing, to refrain from consuming a large meal the night before (dinner) and to avoid eating breakfast or drinking fluids on the morning of the test (Kukić et al., 2020). The device's software recorded the body composition results, which were then printed as a results sheet.

Cardiorespiratory Fitness

The Queen's College Step Test was used to predict maximal aerobic capacity. This test is used in some firefighter research to measure maximal oxygen uptake using sub maximal exercise in the form of bench stepping to a cadence (Perroni et al., 2014). A plastic stepping bench (41.25 cm height) was used along with a metronome and stopwatch. The metronome was employed to regulate the stepping cadence, set at 96 beats per minute (24 complete steps ups and downs per foot per minute). Participants were instructed to perform each stepping cycle following a four-step cadence (up-up-down-down) continuously for 3 minutes. Upon completing the test, they sat on the bench while their heart rate was measured via a biometric monitor (Polar Electro Oy, H10, Kempele, Finland). The heart rate at the 20th second was recorded as the number of heartbeats. The following equation was used to determine maximal aerobic uptake: VO_{2max} (mL/kg/min) = 111.33 – (0.42 x heart rate beats/min) (McArdle et al., 1972).

Muscular Strength

Handgrip measurements have been shown to be associated with firefighter performance and this is a valid and reliable measure of handgrip strength (Rhea et al., 2004). Using a handheld dynamometer (Baseline, LiTE 12-0241, USA), isometric handgrip strength was measured. Without holding their breath (to avoid the Valsalva manoeuvre), firefighters were directed to grip the dynamometer's handle and squeeze it as firmly as possible. The grip handle was adjusted to the individual's hand size and the test was repeated twice per hand with the highest value recorded in kg (Bajić et al., 2023).

Muscle Power

The vertical jump is considered a measure of explosive leg power, often utilized to measure total muscle power (Alvar et al., 2017). The vertical jump was performed with a counter movement, where the knees were allowed to flex immediately prior to the jump, and was measured by calculating vertical displacement time (Microgate, OptoGait, USA). The participants were instructed to stand with their feet slightly apart between two sensors of the OptoGait system. Participants were instructed to propel their bodies upward as high as possible by swinging both arms, using a two-foot take-off and landing and without falling forward or backward on landing. Following the completion of the jump, the results were shown on a screen. The better of two attempts served as their final result with the data presented in cm.

Muscular Endurance

The highest number of consecutive push-ups performed without pausing is a commonly used field test in tactical populations to determine upper body and trunk muscular endurance. Participants were directed to start in the "up" position (hands under the shoulders, back straight, head up, with the toes serving as the pivot point). In this study, a 10-cm yoga block was positioned beneath the participant's chest to ensure the required push-up depth. The maximum number of push-ups completed without resting was recorded as the final score. The test was terminated if participants were unable to maintain proper technique or displayed excessive strain within two consecutive repetitions (Bajić et al., 2023). The last fully completed repetition was counted as the final score. The outcome measure was presented as single repetitions.

Flexibility

Lower back and hip joint flexibility were measured using a sit and reach box with the foot plate set at 23 cm. After a brief warm-up and stretching, participants were instructed to sit barefoot with their feet flat against the flexometer (Baseline USA). They then slowly bent their trunk forward and extended their hands as far as possible in a controlled motion, holding the final position for 2 seconds. Two measurements were taken, and the best from the two trials, measured in cm, was used for data analysis (Pawlak et al., 2015; Bajić et al., 2023).

Functional Movement Screening (FMS)

Previously described in the literature (Cook et al., 2006), the FMS required participants to perform seven movement patterns (deep squat, hurdle step, in-line lunge, shoulder mobility, active straight leg raise, trunk stability push up, and rotary stability) with five of the movements (hurdle step, in-line lunge, shoulder mobility, active straight leg raise, and rotary stability) performed on both the left and right side. Each movement was scored on a scale of 0 to 3 points where: '0' meant the participant experienced pain during the movement; '1' meant the participant could complete the movement poorly but without pain; '2' meant the participant could complete the movement pattern but with compensatory movements; and '3' meant the participant completed the movement correctly and without compensatory movements or pain (Cook et al., 2006). For movements performed on the left and right side, the lowest score (left or right) was the final score for that movement. The final overall FMS score, summed from each of the seven movements ranged from 0 to 21 points (Cook et al., 2006).

Occupational Fitness Assessment

To replicate and evaluate occupational physical performance, a specific simulated fire ground test was administered. Following feedback from the firefighters informing this study, four tests were selected based on their occurrence on the fire ground and in consideration of equipment accessibility. Each task was accomplished, in succession, with all but the stair climb completed as quickly as possible at a maximal effort. The time taken for each task and the total test duration were recorded using a handheld stopwatch (Sportline, USA) (Pawlak et al., 2015).

The occupational fitness assessment was composed of the following tasks: stair climb, hose drag, equipment carry, and rescue drag. Throughout all tasks, the participants wore long pants (sweat suit), t-shirt, a hard hat with chin strap, work gloves and footwear with no open heel or toe. In addition, for each task, participants wore a 24kg vest to simulate the weight of a self-contained breathing apparatus (SCBA). For the stair climb task, an additional 12 kg (two x 6 kg weights) was carried to simulate carrying a high-rise pack (hose bundle). To provide a standardized approach and consistency in application, before beginning the testing process, an explanation and demonstration of each task were provided (International Association of Fire Fighters, 2007). All participants were able to choose whether to walk or run during all tasks and from one task to another, noting that the fastest time for the last three tasks and overall were being collected.

Stair Climb

The essential task of ascending stairs in full protective gear while carrying a high-rise pack (hose bundle) was simulated in the first task. Firefighters were required to carry two 6 kg weights on their shoulders to simulate the weight of a high-rise pack (hose bundle). Before the event, participants had a 20 second warm-up on the StepMill (Life Fitness PowerMill Stair Climber) at a rate of 50 steps per minute. For the test, the firefighters were required to walk on the StepMill at a rate of 60 steps per minute for a maximum 3 minutes. After 3 minutes, the test ceased and the two 6kg weights were removed from their shoulders. The participant then walked or ran within the established walkway approximately 26 m to the next task (International Association of Fire Fighters, 2007).

Hose Drag

Pulling an uncharged hose line from the fire truck to the fire and navigating it around obstacles while staying in one place served as the basis for the second component of the occupational fitness assessment. During this task, the fire-fighters grasped an automatic nozzle attached to a 60 m hose (4 x 15 m hoses connected with 52 mm fire hose couplings). The participant placed the hose line over the shoulder or across the chest, and then dragged the hose 23 m to a prepositioned object, made a 90° turn around the object and continued additional 8 m. These distances were selected based on space availability at the testing site. The firefighter then stopped, passed the finish line, dropped to at least one knee, and pulled the hose line until three of four connected hoses were across the finish line. During the hose pull, the firefighter had to keep at least one knee in contact with the ground and behind the finish line. The firefighters then walked or ran approximately 25 m to a simulated tool storage cabinet for the next task (International Association of Fire Fighters, 2007).

Equipment Carry

The purpose of this task was to replicate the tasks of retrieving power tools from a fire truck, transporting them to the emergency site, and then returning the equipment to the fire truck. During this task, the firefighter took two dumbbells, one weighing 16 kg (simulating a rescue circular saw) and the other weighing 14 kg (simulating a chain saw), one at a time, from a 1-meter-tall shelf which simulated the tool cabinet, and placed them on the ground. The participant then picked up both dumbbells, one in each hand, and, carrying them, walked as fast as possible around an object 23 m away before returning to the starting point. Upon returning to the simulated tool cabinet, the firefighters placed both dumbbells on the ground, then picked up each dumbbell one at a time, and placed them back at the shelf. The firefighters then walked or ran approximately 3 m to the starting point for rescue drag event (International Association of Fire Fighters, 2007).

Rescue Drag

The purpose of this task was to simulate removal of an injured person from a fire scene. During this event, the firefighters dragged sleds with 75 kg weights (hand loops were on the belt for them to grip) a distance of 9 m to a marked line, made a 180° turn, and returned the 9 m distance to the starting line. The firefighters were permitted to lower the hand loops to the ground to adjust their grip. The entire sled had to be dragged past the marked lines. This task concluded the occupational fitness assessment.

Training Interventions

Participants partook in an 8-week unsupervised home training intervention. The training program consisted of three home workouts per week for approximately 30 minutes per exercise session. In addition, participants were suggested to perform individual FMS corrective exercises for 2–3 days per week (days without programmed training).

The exercise program included an initial warm-up routine, main conditioning session and a cool down. Full body exercises, focused on fundamental movement patterns, were used as the primary training mode for the training intervention. Exercise dose consisted of performing 8–12 repetitions per exercise for 2–3 sets with a recovery period of 30–60 seconds. Each subject was instructed to use dumbbells if they had them at home or a water bottle or some item of similar weight (prescribed in the training program) found in the household. Participants were provided with modifications to each exercise which were made to accommodate potential variations in the subjects' fitness levels (Pawlak et al., 2015). The exercises included in the training program targeted the primary muscles of the chest, back, legs, shoulders, and torso and major movement patterns of push, pull, and lift. Body-weight exercises (e.g., push-ups, body squats, and lunges) mixed with dumbbell exercises were the focus of the training intervention. Moreover, participants also received corrective exercises, derived from individual FMS scores, and were suggested to complete the exercises on the rest days (days without programmed training). Each participant received a demonstration of every exercise to ensure the correct exercise technique was performed to minimize injury risk. Each participant was also able to access the FMS exercise application so that they could review videos of each corrective exercise over the 8-week period. Finally, the participants were asked to maintain their current physical activity levels (sports and recreational activities) throughout the duration of the study. During the second assessment, following the 8-week program, each participant was asked to rate, on a visual analogue scale from 0 (no exercise) – 100 (full compliance and completion of every session) how well they stuck to the program (a % of how much of the program they completed).

Statistics

Statistical analyses were performed using the JASP statistical software (Version 0.18.3). Descriptive data (mean, standard deviation, minimum, and maximum) were determined. The normality of data distribution was evaluated using the Shapiro-Wilk test. An independent sample t-test was used to compare potential differences in baseline data between the firefighters who completed the intervention and those who started but did not complete the intervention. Where data were not normally distributed, a Mann-Whitney test was performed. To test the effects of the intervention (i.e., difference between the baseline and post-treatment measurements) a paired sample t-test was used. For the variables that violated the normality of distribution a Wilcoxon signed-rank order was used. A Pearson's Correlation analysis was employed to investigate relationships between exercise compliance and training program performance outcomes. Alpha levels were set at 0.05 a priori.

Effect sizes were calculated using Cohen's d and interpreted as follows: d < 0.2 (trivial), d = 0.2–0.5 (small), d = 0.5–0.8 (moderate), d = 0.8–1.2 (large), and d > 1.2 (very large) (Sullivan & Feinn, 2012).

RESULTS

Table 1 shows the results from the baseline measurements for 14 firefighters who started the intervention. Few variables violated the normality of data distribution. However, out of 14, only 5 (35.7%) participants completed the intervention. While only their data were used for further analyses, their baseline data were compared to the nine participants who only completed the assessment at baseline. No significant differences were found between the groups (p = 0.138–0.973).

Table 1. *Descriptive Statistics for Baseline Measurements, n = 14*

Variables	Mean	SD	Minimum	Maximum	Shapiro-Wilk p
Systolic BP (mmHg)	132.71	14.16	115	166	0.249
Diastolic BP (mmHg)	80.00	10.28	66	107	0.156
Height (cm)	181.71	5.28	171	193	0.972
Body Mass (kg)	101.16	18.41	78.1	133.2	0.224
BMI (kg/m^2)	30.71	6.00	23.1	42.5	0.213
Body Fat (%)	26.26	9.41	13.1	42.3	0.556
Grip – Left (kg)	59.64	8.52	45	74	0.895
Grip – Right (kg)	60.43	7.20	45	68	0.123
Grip Total (kg)	120.07	14.85	90	141	0.839
Vertical Jump (cm)	33.99	7.27	20.4	45.9	0.795
Push Up (repetitions)	17.93	9.24	4	30	0.059
FMS (points)	13.36	2.71	8	18	0.793
Est. VO_{2max} (mL/kg/min)	45.25	6.40	38.6	61.7	0.043
Flexibility (cm)	25.82	8.81	10	37	0.054
Stairs – Time (secs)	139.69	49.38	44	180	0.008
Stairs – HR (b.p.m.)	183.85	13.36	157	201	0.393
Hose Drag (secs)	108.95	26.79	80.46	177.05	0.03
Equipment Carry (secs)	71.55	26.46	51.43	153.92	< .001
Sled drag (secs)	42.21	21.41	24.73	111.35	< .001
Final Time (secs)	362.22	101.64	217.6	622.32	0.147

Note. mmHg = millimetres of mercury; VO_{2max} = volume of oxygen consumed; b.p.m. = beats per minute.

Considering the results of the paired sample t-tests for differences between baseline and post-intervention data in firefighters who completed the intervention (Table 2), significant differences occurred in right-hand grip strength ($t(4) = -3.416$, $p = 0.027$) and FMS ($t(4) = -7.203$, $p = 0.002$). While not significant, systolic blood pressure ($t(4) = 2.696$, $p = 0.054$), body fat ($t(4) = 2.288$, $p = 0.084$), and total hand grip strength ($t(4) = -2.398$, $p = 0.075$) were trending towards significance. The effect sizes in these variables also suggest that there may be considerable effect in these variables, which could be further observed in Figure 1.

Table 2. *Descriptive Data for Baseline and Post-Intervention with Paired Sample T-Test, n = 5*

Variables	**Baseline**		**Post-Intervention**		**Paired Sample T-Test**	
	Mean	**SD**	**Mean**	**SD**	**Mean difference**	**Cohen's d**
Systolic BP (mmHg)	139.60	8.85	126.80	7.40	12.80	1.21
Diastolic BP (mmHg)	76.40	6.73	80.40	7.30	-4.00	-0.59
Body Mass (kg)	95.02	17.53	96.18	16.38	-1.16	-0.68
BMI (kg/m^2)	29.20	7.52	29.22	7.09	-0.02	-0.03
Body Fat (%)	22.08	11.55	21.34	11.52	0.74	1.02
Grip – Left (kg)	56.80	4.76	60.40	9.97	-3.60	-0.48
Grip – Right (kg)	59.40	5.46	66.40	9.10	-7.00*	-1.53
Grip Total (kg)	116.20	8.44	124.80	14.55	-8.60	-1.07
Vertical Jump (cm)	36.62	6.25	39.70	8.70	-3.08	-0.86
Push Up (repetitions)	20.20	7.66	24.00	7.58	-3.80	-0.84
FMS (points)	13.80	1.92	18.00	3.08	-4.20*	-3.22
Est. VO_{2max} (mL/kg/min)	47.33	8.95	45.45	8.78	1.88	0.59
Flexibility (cm)	26.90	7.93	28.80	6.26	-1.90	-0.65
Stairs – Time (secs)	156.00	53.67	159.00	46.96	-3.00	-0.45
Stairs – HR (b.p.m.)	176.80	17.81	176.40	25.59	0.40	0.01
Hose Drag (secs)	111.60	39.13	164.97	106.70	-53.36	-0.75
Equipment Carry (secs)	80.97	41.79	69.11	31.37	11.86	0.79
Sled drag (secs)	50.15	35.28	37.09	22.48	13.06	0.87
Final Time (secs)	400.82	126.99	375.81	121.93	25.02	0.70

Note. * = significantly different from baseline; mmHg = millimetres of mercury; VO_{2max} = volume of oxygen consumed; b.p.m. = beats per minute.

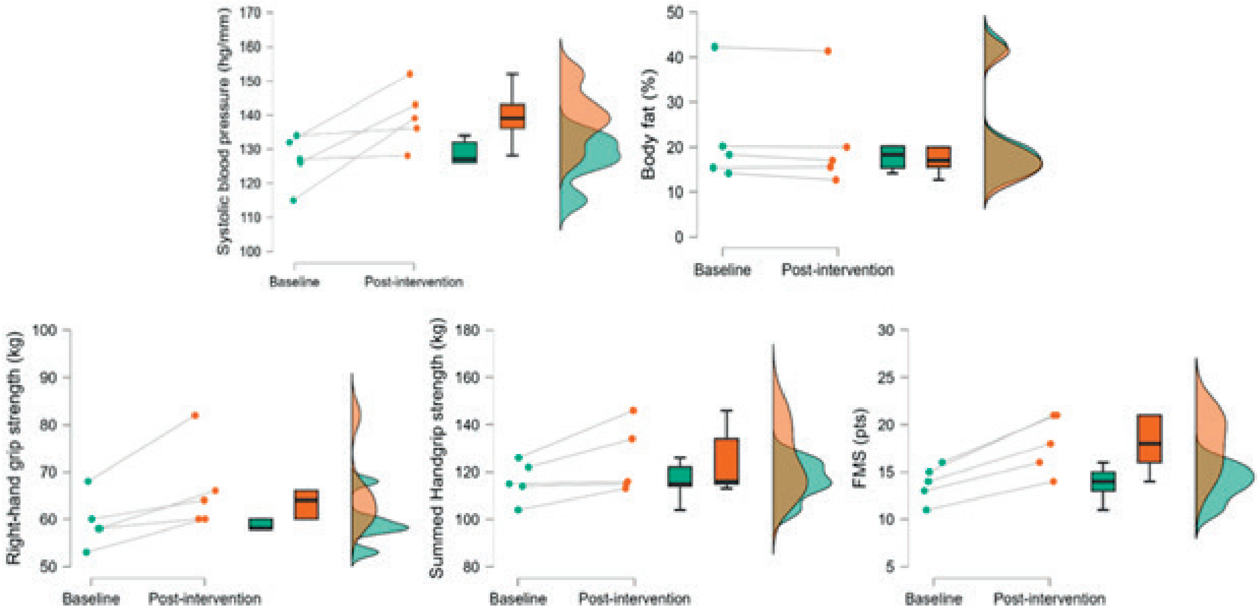

Figure 1. *Individual Data Trends per Outcome Measures of Note*

The adherence to the program was self-reported as 47%, ranging from 33 to 70%. There was no correlation between program adherence and obtained differences in hand grip (r = 0.81, p = 0.10), FMS (r = –0.67, p = 0.22), and systolic pressure (r = 0.13, p = 0.83).

DISCUSSION

The aim of this study was to assess whether an unsupervised home workout training program could enhance the physical fitness and occupational physical performance of volunteer firefighters in Serbia. The results from this study showed that right-hand grip strength and FMS measurements significantly improved after the intervention while systolic blood pressure and percentages of body fat trended towards improvements, whereas other tested variables did not change in either direction. Furthermore, the participants reported completing only around half (47%) of their unsupervised home exercise program sessions.

Only five participants attended the final assessment and, while there were some significant improvements in outcome measures, home exercise compliance rates were below 50%. The self-reported attendance rate of 47% may have influenced the study results due to potential reporting biases, such as over- or under-estimation of attendance. This low rate could reflect challenges like lack of motivation, external barriers (e.g., time constraints or health issues), or other unmeasured factors. Consequently, the findings should be interpreted cautiously, as limited adherence may impact the validity and generalizability of the outcomes. Future studies should explore strategies to improve attendance and minimize such biases. Potential reasons for low compliance rates include the absence of an exercise program supervisor and lack of equipment. Where low supervision may have resulted in a lack of motivation and encouragement, research regarding differences in supervised versus unsupervised home exercise sessions are conflicting. One of the biggest challenges in comparing exercise compliance is the limited diversity of study populations, as most research focuses on patients who have, or have had, a medical condition, for example, patients suffering intermittent claudication (Hageman et al., 2018) or diabetes (Dadgostar et al., 2016), stroke survivors (Olney et al., 2006), or following coronary bypass surgery (Stevens & Hanson, 1984). The results of these studies likewise vary, finding no differences in patients between supervised and un-supervised home exercise sessions (Stevens & Hanson, 1984), or improvements in supervised patients to a greater extent than unsupervised patients (Olney et al., 2006; Dadgostar et al., 2016) or no differences in some outcome measures (e.g., quality of life) but improvements in others (e.g., treadmill walking distance or time without pain) in favour of supervised patient sessions (Hageman et al., 2018). Considering these differences in outcomes, research does suggest that direct supervision by qualified professionals could enhance performance by offering motivational verbal support, increasing the competitiveness of the participants, aiding in goal setting, and guiding the progression of training loads effectively (Pawlak et al., 2015; Mazzetti et al., 2000; Hageman et al., 2018).

One study of exercise outcomes in the workplace in healthy adults who undertook a supervised program or an unsupervised exercise program found no differences in outcome measures (cardiovascular fitness, and both absolute and relative strength) (Hunter, 2024). However, in this program both groups completed their training in a gymnasium and as such had access to the required training equipment. Furthermore, research by Charleton (1994), found that when given access to a gymnasium, no significant variations in exercise adherence were observed between the supervised and unsupervised groups, although the supervised group frequency was slightly higher (14.33 sessions versus 12.50 sessions, respectively). Conversely, Mazzetti et al. (2000) found that one-on-one supervision by a trainer resulted in a greater training load and strength outcomes than an unsupervised program.

Unfortunately, providing participants an option of supervised sessions was not viable in this study of volunteer firefighters and, as such, consideration of participating in some exercise, as opposed to no exercise, is of value as exercise in general offers multiple health benefits. Furthermore, on meeting the recommended guidelines for health and fitness in healthy adults, the American College of Sports Medicine (ACSM) notes the use of both supervised training and unsupervised home exercise programs (Garber et al., 2011). As a final consideration, the use of home exercise programs does present with cost benefits in favour of the unsupervised home exercise program and, as such, may be more feasible to the organization. As such, given the amount of evidence, in this current study greater results (though greater compliance) may have occurred if the participants had been supervised and had access to suitable equipment. However, as this may not be possible with the given demographics (i.e., volunteer firefighters), an unsupervised home exercise presents itself as a cost effective and viable alternative as compared to no program.

Research suggests that training volume plays a pivotal role in determining the extent of physiological adaptations (Pawlak et al., 2015). Considering this, the training frequency and volume employed in this study were carefully chosen to accommodate the busy work schedules of volunteer firefighters, allowing for integration alongside their regular duties. Participants were advised to engage in 30-minute training sessions three times per week, a regimen specifically designed to minimize interference with their existing commitments. While potentially increasing compliance, through minimizing work interference, the training stimuli (both volume and intensity) were below those recommended by the ACSM of 30 minutes on five days per week (Garber et al., 2011) and as such may have likewise limited potential gains. Future research should investigate the feasibility of employing the ACSM guidelines on volunteer firefighter outcomes whilst concomitantly considering potential impacts on exercise compliance.

From a health perspective, CVD stands as the primary cause of mortality among firefighters, with obesity serving as a notable risk factor for cardiovascular ailments (National Fire Protection Association, 2024). Given the aforementioned health concerns of volunteer fighters, being of lower fitness and higher risk for CVD (Morris et al., 2022), findings of this study suggesting a trend towards improved outcomes in systolic blood pressure and body fat percentages are positive. Of note, these positive changes were made without changes to formal dietary habits. As such, research with a larger group should be conducted, if possible, to further examine and affirm findings that an unsupervised home exercise program may improve these health outcomes in a population of volunteer firefighters. The findings in this study also emphasize the potential benefits of implementing exercise programs within the fire service in general to improve overall fitness and manage blood pressure and body fat percentages. From a performance standpoint, the reduction in fat mass may contribute to enhanced overall completion times of certain participants in the occupational test. This supposition warrants consideration given that three of the final five participants in this study exhibited improved overall times in their occupational fitness assessment.

Enhancing muscular strength constitutes a vital fitness objective for firefighters, supported by research demonstrating a correlation between strength attributes and firefighter physical performance (Rhea et al., 2004; Lindberg et al., 2015). Physical strength is a fundamental component of general firefighting tasks with grip strength often included in these measures (Lindberg et al., 2015). The firefighters in this study had a mean grip strength akin to those found in other male firefighter populations (47 to 61 kg (Lindberg et al., 2015)). However, while there was a significant increase in right hand grip strength in this study, there was no significant increase in the occupational task outcomes assessed as part of this study. While contradicting the results of Lindberg et al. (2015), who found that grip strength was associated with performance on an occupational task simulation (i.e., carrying hose baskets upstairs, hose pulling, demolition at or after a fire, and a rescue drag), the findings of this study support work by Michaelides et al. (2011) which failed to find a relationship between grip strength and time to complete an 'ability test' based on a set of 6 simulated firefighting tasks (stair climb, rolled hose move and lift, sled drag, hose pull and hookup, rescue drag and charge hose advance). However, while occupational tasks were not found to improve in conjunction with the increases in right hand grip strength, grip strength is a known indicator of physical (Michaelides et al., 2011) and mental health (Kim, 2019) and as such, the increase in right hand grip strength is a positive outcome of this study.

Participants in this study were suggested to perform individual FMS corrective exercises for 2–3 days per week (days without programmed training). Movement assessments and preparticipation screenings have gained widespread acceptance among researchers and practitioners due to established correlations between individuals' movement patterns and their susceptibility to injury (Bock & Orr, 2015). The findings of this study indicate that an 8-week tailored corrective exercise regimen proved effective in enhancing scores on the

FMS. Of note, scores increased from a mean of 13.80 to 18.00 points (Table 2). Studies in tactical populations indicate that a score below 14 points on the FMS is associated with an increased risk of injury (Bock & Orr, 2015). As such, this increase from a score of below 14 points to well above 14 points is positive. Furthermore, the extent of the increase may further provide injury mitigation given that when wearing firefighter clothing, FMS performance decreases (Orr et al., 2019a). As such, offering customized corrective exercise programs targeting the improvement of dysfunction levels or the preservation/enhancement of function could potentially enhance firefighter readiness and mitigate the risk of injury (Bock & Orr, 2015).

One concern of note arose from only 5 out of the initial 14 subjects being able to successfully complete the 3-minute stair climb test, a style of test common in this population (Lindberg et al., 2015). Furthermore, at the initial assessment, 6 out of 14 participants (43%) did not meet the NFPA VO_{2max} recommendation of 42 mL/kg/min. At the final assessment, 3 out of 5 participants (60%) remained below this recommendation. This is of concern considering that the ability to climb the stairs with equipment is a firefighter task requirement (Lockie et al., 2022) and that aerobic fitness, in general, is linked to the effective execution of occupational duties (Fyock-Martin et al., 2020) and cardiovascular health markers such as diastolic blood pressure, body fat, triglyceride levels, and low-density lipoprotein profiles.

Practical Implications for Volunteer Firefighters

The findings of this study offer several practical implications for the safety and security of volunteer firefighter profession. The observed improvements in right-hand grip strength and FMS scores directly relate to critical aspects of firefighter performance. Grip strength, as demonstrated in prior research, is integral to tasks such as carrying equipment, hose handling, and victim extrication during emergency scenarios. The enhancement in FMS scores is particularly significant, as it indicates the reduced risk of injury and improved movement efficiency, both of which are essential for firefighter readiness and operational safety.

The trend towards reduced body fat percentage and improved systolic blood pressure is equally promising from a health and operational perspective. Reduced fat mass and better cardiovascular markers are associated with enhanced endurance, agility, and the ability to manage physically demanding tasks, such as the 3-minute stair climb test, a crucial component of occupational fitness assessments in firefighting. These improvements can potentially increase the effectiveness of firefighting units during emergency responses, thereby improving both the safety of individuals and the overall security of the communities they serve.

Given the low compliance rates (47%) in this study, there is a need for targeted strategies to enhance adherence to exercise programs, such as integrating supervised sessions where feasible or providing motivational and logistical support for unsupervised training. While supervised training may not always be viable in volunteer firefighting settings due to logistical constraints, the results suggest that even unsupervised programs can yield health and fitness benefits, offering a cost-effective and practical solution for improving occupational fitness and safety among volunteer firefighters.

Future programs should consider the development of hybrid models that combine the elements of supervised and unsupervised training, potentially leveraging online platforms or peer-driven initiatives to maintain engagement and compliance. Such initiatives could optimize physical readiness and operational effectiveness within the firefighting workforce while addressing the unique safety and security challenges faced by this demographic.

This study has certain limitations. Firstly, the relatively small sample size diminishes statistical power, particularly evident with only 5 participants attending the second assessment, suggesting potential non-compliance with the prescribed program among the remaining 9 participants. Secondly, our ability to compare the results for certain variables, such as the 3-minute stair climb assessment, is limited due to the majority of participants (9 individuals) being unable to complete the test. This discrepancy implies that those unable to complete the test may have conserved energy for subsequent assessments, although intent cannot be conclusively determined. Additionally, as the program spanned 8 weeks and involved outdoor occupational assessments, weather variations could have impacted participant performance, albeit these tasks are typically conducted outdoors during emergencies. Furthermore, the long-term sustainability of the observed results remains uncertain due to the short duration of the intervention. It is unclear whether the improvements in physical fitness, grip strength, and FMS scores can be maintained over time without continued training or structured follow-up programs. This issue is particularly relevant for volunteer firefighters, as long-term maintenance of fitness and readiness is essential for their safety and effectiveness in emergency responses.

CONCLUSIONS

The outcomes of this study show that an unsupervised home exercise program for volunteer firefighters is of benefit, improving grip strength and movement scores and potentially improving blood pressure and percentages of body fat. However, compliance with the programs is suboptimal and is expected to have influenced optimal fitness and health outcomes. Noting the higher risk of poor fitness and CVD health in volunteer firefighters when compared to career fighters, and potential benefits of an unsupervised home exercise program, future research should investigate means of increased exercise compliance for these volunteer firefighter populations.

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