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Field-Based Fitness Tests Predict Completion of a Firefighter Recruit Academy

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Abstract

Recruitment of firefighters is, in part, hindered due to attrition from fire academies. This study explored initial fitness differences between those who graduated (GRAD) or were released (REL) from the academy. During the first week of the academy, recruits (N = 407; GRAD = 354, REL = 53; 26.6 ± 7.2 yrs; 177.6 ± 8.6 cm; 87.9 ± 17.2 kg) completed an assessment battery including: body composition using skinfold calipers to estimate percent body fat (BF) and fat-free mass (FFM); shoulder mobility via Apley's scratch test (APLEY); aerobic fitness (VO_{2peak}) and heart rate recovery (HRR_{1min}) estimated from the five-minute Forestry step test; muscular strength via the sum of right and left handgrip (SHG); and muscular endurance via a paced two-minute push-up test (PU). A t-test identified age differences between GRAD and REL, followed by separate ANCOVAs for each fitness measure, and logistic regression to identify the ability of fitness measures to predict academy outcome. GRAD had a lower age and BF and a higher FFM, VO_{2peak}, SHG, and PU, but did not differ in APLEY or HRR_{1min}. The full model predicting release was significant; age, BF, and FFM were significant predictors. These results provide pre-fire academy preparation guidance for optimizing the potential for successful academy completion.

Keywords: firefighter; training academy; attrition; pre-employment screen; occupational health; fitness

1. Introduction

Recruitment of structural firefighters (FFs) has been a challenge in the United States over the past decade [1]. Despite a slight decline in the total number of FFs, the 2020 United States Department Profile released by the National Fire Protection Association (NFPA) indicated that the total number of career fire departments across the country has been increasing while volunteer departments have been decreasing [1]. Accordingly, the United States Department of Labor has projected that 27,100 FF positions need to be filled each year until 2034 [2]. To address this need, FF recruit training academies are called upon to develop and prepare prospective FFs.

Recruit training academies are commonly employed by major-metropolitan career departments to formally prepare recruits for the rigors of the FF profession. This typically entails a 40 h per week training process, lasting several weeks to months, to develop physical, mental, and technical FF-specific competencies [3]. While each department may specify its own requirements, applicants are usually required to pass a pre-employment

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medical evaluation and physical ability test, the standard for which in the United States is the Candidate Physical Ability Test (CPAT). However, attrition from the recruit academy remains an issue with downstream department staffing and economic consequences [4]. From 2007 to 2009, Griffin et al. [4] reported an attrition of 11.2 to 47.4% from the Tucson Fire Department recruit academy. More recently, Lockie et al. [5] reported an average attrition rate of 16% across 13 recruit academy classes from 2020 to 2022, using archival data from an unspecified department. The authors also demonstrated significant differences in physical fitness between those who graduated or were released from the academy, with physical fitness levels upon entry to the academy being predictive of release. To this point, little work has been done beyond these investigations to investigate factors related to successful recruit academy graduation.

Physical fitness is critical to both health [6–8] and performance [5,9–19] in FFs, owing to the rigorous and spontaneous multisystem load inherent to the profession. Accordingly, the Fire Service Joint Labor Management Wellness Fitness Initiative (WFI) was established, creating guidelines for standardized fitness testing of FFs in the subcomponents of physical fitness including body composition, aerobic fitness, mobility, power, and muscular strength and endurance [20] (pp. 37–39). Many of these tests are commonly found in FF literature, likely due to their field-based nature, making for easily accessible measures with the capacity to test multiple individuals simultaneously. Lockie et al. [5] examined the Occupational Physical Ability Test (OPAT) in recruits and this test battery included job-specific activities (e.g., farmer's carry, 10-repetition maximum deadlift, etc.). However, the potential consideration for the OPAT is the time and equipment resources required for this battery which may impact implementation in resource-limited departments or when testing large groups. Therefore, while field-based assessments of physical fitness may offer a high-utility framework to build a pre-employment physical fitness screen, there is a gap in understanding how they relate to recruit academy success.

Therefore, the purpose of this study was to explore the differences in common field-based measures of physical fitness between those who graduated and those who were released from the FF recruit academy. An additional purpose was to explore whether these physical fitness measures are predictive of FF recruit academy outcome. Based upon the previous outcome-related literature on FF academy recruits and the injury- and performance-related literature on active-duty FFs, we hypothesize that recruits who graduated will generally have higher levels of physical fitness than those who were released, and that these measures of physical fitness will be predictive of recruit academy outcome.

2. Materials and Methods

2.1. Participants

In total, 407 FF recruits (352 males, 55 females) from the same major-metropolitan Midwest career fire department volunteered to participate in this longitudinal study (mean ± SD: age = 26.6 ± 7.2 yrs; height = 177.6 ± 8.6 cm; body mass = 87.9 ± 17.2 kg). Criteria for eligibility to participate in this study included that each participant was required to be free of musculoskeletal injury and medically cleared for full participation in their respective FF recruit academy cohort. Prior to data collection, written informed consent was obtained from each participant.

2.2. Procedures

As part of a larger longitudinal project, health and physical fitness data were collected from 11 separate cohorts of FF recruits. Data collection was performed during the first week of the 16-week FF recruit academy for each cohort of recruits, respectively. All recruits enrolled during the first week of the FF recruit academy completed testing. Data collection

included at least one cohort of recruits per year from 2017 to 2025, not including 2020 due to the COVID-19 pandemic. Cohort size varied from 18 to 50 recruits, largely influenced by department hiring needs. The researchers were not involved in the selection process for incoming recruits.

Health and fitness data were collected using field-based protocols well-established in FF literature [21,22] that are consistent with both the WFI [20] (pp. 82–102) and the American College of Sports Medicine (ACSM) [23] (pp. 66–110). All testing was completed on the same morning at approximately 0800, indoors at the training academy, with participants wearing their department-issued athletic clothing. Consistent with WFI guidelines, testing was completed in the following order: body composition, shoulder mobility, aerobic fitness, muscular strength, and muscular endurance.

2.2.1. Body Composition

Measures of body composition included height, body mass, body fat (BF, %) and fat-free mass (FFM, kg). Height was self-reported by each participant and recorded to the nearest 0.25 inch, then converted to centimeters. Body mass was measured via digital scale (Health-o-Meter Professional; Pelstar LLC., McCook, IL, USA) and recorded to the nearest 0.1 pound, then converted to kilograms. BF was estimated for each participant via skinfold assessment [20] (pp. 98–99). Skinfolds were measured to the nearest 1 mm from three sites (males: pectoral, triceps, and subscapular locations; females: triceps, suprailiac, and abdominal locations) using a Lange skinfold caliper (Beta Technology, Santa Cruz, CA, USA). Each site was measured twice from the right side of each participant's body, then averaged together. If the first two measures differed by 2 mm or greater, a third measurement was included. With these measures, body density was determined using the Jackson/Pollock method followed by the Siri equation to estimate BF. The combination of the Jackson/Pollock and Siri equations to estimate BF from skinfolds has been previously validated (r = 0.71–0.98, $p < 0.05$) [24]. FFM was then calculated for each participant based on their respective body mass and BF.

2.2.2. Shoulder Mobility

Shoulder mobility was assessed using the shoulder reach component of the WFI testing protocol, more commonly referred to as Apley's scratch test (APLEY, cm) [20,22] (p. 97). Each participant was asked to create a fist with both hands, enclosing each thumb inside each fist. They were then instructed to perform maximal shoulder extension, adduction, and internal rotation of one shoulder while simultaneously performing maximal shoulder flexion, abduction, and external rotation of the opposing shoulder. The shortest vertical distance between bony prominences was measured using a woven tape and measured to the nearest 1 mm. The same procedure was then repeated in the opposite direction, and the average of both directions was taken. When assuming the testing position, participants were required to move in one smooth and continuous motion. To maintain the reliability of the testing procedure, the same researcher (K.T.E.) measured each participant.

2.2.3. Aerobic Fitness

Aerobic fitness was assessed by estimating aerobic capacity (VO_{2peak}, $mL \cdot kg^{-1} \cdot min^{-1}$) and relative one-minute heart rate recovery (HRR_{1min}, %) based on heart rate data collected before and after the Forestry step test, a field-based assessment commonly used in the fire service [25] (pp. 1–9). The Forestry step test was selected as it allows for several participants to be tested simultaneously, and its predictive validity for estimating VO_{2peak} has been confirmed by previous research (r = 0.77, $p < 0.001$) [26]. During this test, participants were required to step onto and off of a 40 cm box to the beat of a metronome at a cadence of 90 beats per minute for five minutes. Polar T31i heart rate monitors (Polar Electro, Lake

Success, NY, USA) were worn by each participant to record heart rate values immediately following the five-minute step test (HR_0) and one minute later (HR_{1min}). Submaximal assessments of HRR_{1min} have demonstrated statistically equivalent reliability compared to maximal protocols (CV = 25.7 vs. 14.7%, $p = 0.10$) [27]. Due to training academy equipment changes between the years of data collection, step heights varied from 40 to 48 cm. As such, the following equation was used to estimate VO_{2peak} while accounting for biological sex, age (years), and step height (cm) [28] (pp. 111–115):

$$VO_{2peak} = 1.12 - 0.0073 \times \text{age} \cdot \frac{131.5 \cdot (7.9 + 0.539 \cdot \text{step height})}{HR_0 + (10 \text{ for male}; 0 \text{ for female}) - 72}$$

Normalizing HRR_{1min} to age is commonly performed due to profound age-related cardiovascular adaptations, though reliability and validity have not been outlined [29]. Thus, to account for differences in participant age, HRR_{1min} (%) was calculated relative to each participant's age-predicted maximal heart rate using the following equation [30]:

$$HRR_{1min} = \frac{HR_0 - HR_{1min}}{208 - (0.7 \cdot \text{age})}$$

2.2.4. Muscular Strength

Muscular strength was assessed via the sum of right and left handgrip (SHG, kg) using a Jamar hydraulic dynamometer (Lafayette Instrument Company, Lafayette, IN, USA). Per the protocol recommended within the WFI [20] (p. 102), each participant's peak handgrip was measured in a standing position with their elbow flexed to 90 degrees and wrist in a neutral position. Each participant was instructed to squeeze the dynamometer as hard as possible, and the peak force value was recorded by the researcher to the nearest 1 lb. Two trials were completed bilaterally, then the highest value for each hand was summed and converted to kilograms.

2.2.5. Muscular Endurance

Muscular endurance was assessed via the number of push-ups (PU, #) completed during a paced two-minute test. Per the protocol recommended within the WFI [20] (pp. 92–93), participants were instructed to complete repetitions at a cadence of 80 bpm (i.e., one full repetition every two beats). Participants were required to maintain their hands shoulder-width apart and feet together throughout the test, while a full range of motion was ensured by instructing participants to lower their body toward the floor until their chin touched a five-inch prop placed on the floor beneath the participant. Participants were instructed to continue performing repetitions until volitional termination, inability to maintain the cadence of 80 bpm, or the maximum test time of two minutes (i.e., 80 repetitions) was achieved.

2.3. Statistical Analyses

At the conclusion of the recruit academy for each cohort, academy outcome data was obtained for each participant, and recruits were divided into graduated (GRAD, $n = 354$) and released (REL, $n = 53$).

Before performing statistical analyses, the distribution of each variable was examined for normality and confirmed visually by inspecting univariate QQ-plots. A Chi-Square test was used to examine for differences in gender distribution between GRAD and REL. Independent *t*-tests were used to examine for differences in age, height, and body mass between GRAD and REL. Next, seven separate analysis-of-covariance (ANCOVA) tests were performed to examine for differences between GRAD and REL for each of the measures of physical fitness while controlling for participant age. Logistic regression analysis was then

used to determine the collective significance of age and each measure of physical fitness in predicting recruit academy release. Prior to constructing the logistic regression model, a correlation matrix was used for age and each measure of physical fitness to confirm no collinearity among the measures. REL was coded as the reference category. Overall model significance and fit were determined using a Likelihood Ratio test and the Hosmer–Lemeshow test for Goodness-of-Fit, then Wald Chi-Square tests were used to evaluate the significance of each predictor. Standard error (SE), odds ratio (OR), and 95% confidence intervals (95% CIs) were obtained for each predictor. An alpha of 0.05 determined statistical significance for all analyses.

Effect size (Cohen's *d*) was calculated for the age, height, and body mass comparisons between GRAD and REL and interpreted with the following criteria [31]: small ($d < 0.50$), medium ($0.50 \leq d < 0.80$), large ($d \geq 0.80$). Partial eta squared (η_p^2) effect sizes were calculated for the fitness comparisons between GRAD and REL and were interpreted with the following criteria [31]: small ($\eta_p^2 < 0.06$), medium ($0.06 \leq \eta_p^2 < 0.14$), large ($\eta_p^2 \geq 0.14$). All statistical analyses were conducted using R Statistical Software (v4.4.1; R Core Team, 2025) [32] with the car [33] and effect size [34] packages.

3. Results

3.1. Descriptive Statistics and Group Comparisons

Descriptive results for GRAD and REL are presented in Table 1. Physical fitness and ANCOVA results are presented in Table 2. The distribution of males and females was not different between GRAD and REL. Compared to REL, GRAD was significantly younger and taller but did not differ in body mass. After controlling for age, significant differences were found between GRAD and REL for each measure of physical fitness except APLEY and HRR_{1min}. Specifically, GRAD had lower BF and higher FFM, VO_{2peak}, SHG, and PU.

Table 1. Descriptive results for graduated (GRAD) and released (REL) firefighter recruits.

Measure [1]	GRAD (n = 354)	REL (n = 53)	Test Statistics [2]		
Sex	311 Male/43 Female	41 Male/12 Female	$\chi^2 = 3.49$	$p = 0.062$	-
Age (yrs) *	25.8 ± 6.8	32.11 ± 7.6	$t = 5.71$	$p < 0.001$	$d = 0.87$
Height (cm) *	178.1 ± 8.4	174.10 ± 9.2	$t = 2.98$	$p = 0.004$	$d = 0.46$
Body mass (kg)	87.5 ± 17.1	90.76 ± 17.9	$t = 1.26$	$p = 0.211$	$d = 0.19$

[1] Descriptive results are presented as mean ± SD. [2] Test statistics are results of Chi-Square and independent *t*-tests. * Denotes statistically significant difference between groups ($p < 0.05$).

Table 2. Physical fitness results for graduated (GRAD) and released (REL) firefighter recruits.

Measure [1]	GRAD (n = 354)	REL (n = 53)	Test Statistics [2]		
BF (%) *	18.6 ± 6.7	24.4 ± 5.7	$F = 22.74$	$p < 0.001$	$\eta_p^2 = 0.05$
FFM (kg) *	70.7 ± 11.8	68.4 ± 12.7	$F = 6.85$	$p = 0.009$	$\eta_p^2 = 0.02$
APLEY (cm)	16.7 ± 8.8	20.0 ± 7.5	$F = 0.02$	$p = 0.897$	$\eta_p^2 < 0.01$
VO_{2peak} ($mL \cdot kg^{-1} \cdot min^{-1}$) *	42.2 ± 7.8	37.1 ± 7.1	$F = 5.33$	$p = 0.021$	$\eta_p^2 = 0.01$
HRR_{1min} (%)	21.2 ± 6.1	19.1 ± 5.3	$F = 1.15$	$p = 0.284$	$\eta_p^2 < 0.01$
SHG (kg) *	101.7 ± 23.3	96.6 ± 24.0	$F = 3.98$	$p = 0.047$	$\eta_p^2 = 0.01$
PU (#) *	31.7 ± 11.4	25.3 ± 9.0	$F = 12.18$	$p < 0.001$	$\eta_p^2 = 0.03$

[1] Fitness results are presented as mean ± SD; BF = body fat; FFM = fat-free mass; APLEY = Apley's scratch test; VO_{2peak} = estimated aerobic capacity; HRR_{1min} = heart rate recovery; SHG = sum handgrip; PU = push-ups. [2] Test statistics are results of ANCOVA tests controlling for age. * Denotes statistically significant difference between groups ($p < 0.05$).

3.2. Logistic Regression Analysis

Results for the logistic regression model and each individual physical fitness predictor are presented in Table 3. The full model to predict the odds of being released from the recruit academy was statistically significant (X^2_8 = 69.40, p < 0.001) and had a good fit (X^2_8 = 7.25, p = 0.509). Age (OR = 1.088, p < 0.001), BF (OR = 1.097, p = 0.003), and FFM (OR = 0.959, p = 0.014) were the only significant predictors within the model. These results suggest that after controlling for their respective remaining variables, each 1-year increase in age corresponds with a 3.7% to 14.2% increase in the odds of release, each 1% increase in BF corresponds with a 3.3% to 17.0% increase in the odds of release, and each 1 kg increase in FFM corresponds with a 0.9% to 7.4% decrease in the odds of release.

Table 3. Results for the logistic regression model predicting release from the firefighter recruit academy.

Overall Model [1]	X^2	*df*	*p*			
LR Test	69.40	8	<0.001			
HL Test	7.25	8	0.509			
Predictor [2]	X^2	*p*	**SE**	**β**	**OR**	**95% CI**
Intercept	<0.01	0.992	3.401	−0.024	0.976	0.009–113.669
Age (yrs) *	11.71	<0.001	0.025	0.084	1.088	1.037–1.142
BF (%) *	8.60	0.003	0.032	0.093	1.097	1.033–1.170
FFM (kg) *	6.01	0.014	0.017	−0.042	0.959	0.926–0.991
APLEY (cm)	0.58	0.444	0.022	0.017	1.017	0.974–1.062
VO_{2peak} (mL·kg^{-1}·min^{-1})	2.33	0.127	0.032	−0.049	0.953	0.893–1.011
HRR_{1min} (%)	3.50	0.061	0.031	−0.058	0.943	0.886–1.002
SHG (kg)	<0.01	0.957	0.008	−0.001	1.000	0.983–1.016
PU (#)	1.14	0.285	0.020	−0.021	0.979	0.942–1.017

[1] LR = Likelihood Ratio; HL = Hosmer–Lemeshow Goodness-of-Fit. [2] BF = Body fat; FFM = fat-free mass; APLEY = Apley's scratch test; VO_{2peak} = estimated aerobic capacity; HRR_{1min} = heart rate recovery; SHG = sum handgrip; PU = push-ups. * Denotes statistically significant model or predictor (p < 0.05).

4. Discussion

The purpose of the current study was to explore initial differences in physical fitness between firefighter academy recruits who graduated (GRAD) or were released (REL), and which of these factors of physical fitness are predictive of recruit academy outcome. The current study used physical fitness measures consistent with the WFI for greater applicability within the North American fire service [20].

4.1. GRAD Versus REL

Previous research indicates that age is closely related to physical fitness in the fire service [21,35]. Therefore, as there were significant age differences between GRAD and REL, subsequent analyses included age as a covariate for more meaningful comparisons of physical fitness.

GRAD had better physical fitness than REL in all measures except APLEY and HRR_{1min}. These results are generally consistent with previous work by Lockie et al. [5], where they found GRAD to have higher levels of physical fitness than REL in all measures, though they did not examine body composition or shoulder mobility.

4.1.1. Body Composition

Body composition is a critical component of FF health [6] and performance [9–12]; however, there is limited available recruit academy normative data to use as a comparison for the current recruits. GRAD (18.6%) had a BF almost 6% lower than REL (24.4%), yet the effect size was small (η^2_p = 0.05), suggesting that much of the variance in BF can be

attributed to age. Recently published normative data in active-duty FFs by Tinsley et al. [36] suggests that GRAD ranks between the 20th and 30th percentiles, while REL ranks between the 50th and 60th percentiles. Furthermore, GRAD (70.7 kg) had a higher FFM than REL (68.4 kg), yet the effect size for this comparison was also quite small ($\eta_p^2 = 0.02$). According to the same reference values by Tinsley et al. [36], this suggests that GRAD ranks between the 40th and 50th percentiles, while REL ranks between the 30th and 40th percentiles. These placements are supported by Bond et al. [6], who reported that across a 20-year career, active-duty FFs ranged in BF from 19.5% to 21.1%, and FFM from 74.4 kg to 75.7 kg. Thus, GRAD is more comparable to active-duty FFs in terms of BF, while both GRAD and REL have lower FFM.

Body composition can reflect the ability to perform FF tasks [9–12], as a lower BF for a given level of FFM reflects a decrease in unnecessary energy expenditure. In a recent study by Ras [37], a BF cut-point of 22.1% demonstrated high specificity in determining failure of a physical abilities test in active-duty FFs. This aligns with the results of the current study. Furthermore, simulated FF task completion times have been consistently correlated with BF (r = 0.30–0.56) [10,16,17] and lean mass ($r = -0.69$) [38]. Norris et al. [12] further demonstrated that BF is a significant predictor of work efficiency (i.e., a function of air usage and task completion time) in FFs. Marciniak et al. [9] later found that there is a strong relationship (r = 0.76) between BF and the amount of time that active-duty FFs spend above 90% maximum heart rate during simulated fire suppression. Upon task completion, body composition may also play a role in recovery, which is likely a key to successfully completing a recruit academy that demands 5 days per week for 16 consecutive weeks. Cornell et al. [39] demonstrated this in FF recruits, where parasympathetic nervous system (PSNS) recovery, necessary for returning heart rate to baseline following high-intensity activity, was slower in those with higher BF ($r = -0.31$). Schmitz et al. [40] later demonstrated a potential relationship between neuromuscular recovery and body composition in active-duty FFs, where those with elevated BF showed diminished ability to perform repeated lower-extremity contractions. Thus, a more optimal body composition may allow for faster completion of FF tasks with a lower heart rate and increased air tank efficiency during fire suppression, followed by a quicker return to baseline for repeated tasks.

4.1.2. Shoulder Mobility

Shoulder mobility is an important factor of physical fitness for FFs due to the abundance of overhead job demands [41]. For example, in their attempt to classify FF job demands by body region, Taylor et al. [42] determined that the majority biased the upper body. Therefore, while shoulder injuries are not the most common type of musculoskeletal injury in FFs, they do account for roughly 13% of on-duty musculoskeletal injuries [43]. Despite this, available evidence suggests that shoulder mobility may not be predictive of injury on its own [44]. However, Butler et al. [7] did demonstrate that overall mobility, indicated by an FMS™ score of $\leq$14, could predict musculoskeletal injury in FF recruits. Furthermore, Harbison et al. [13] demonstrated that FMS™ shoulder mobility, a test with similar methodology to the Apley's scratch test, was significantly negatively correlated ($r = -0.45$) with simulated FF task completion times in career FFs. It is occupationally relevant to note that shoulder mobility decreases by up to 29% when donning personal protective gear [45], amplifying the need for adequate baseline mobility. Specific to FFs, much of the available data on shoulder mobility uses the categorical FMS™ scoring system, which bases each participant's score on their respective hand length, rather than the WFI-supported methodology of quantifying the distance between fists. This presents challenges for making normative comparisons and represents a need for further normative

data to be published, as job demands are absolute rather than relative to FF anthropometrics. Therefore, despite no differences between GRAD and REL in shoulder mobility after controlling for age, consideration for this aspect of physical fitness may still be relevant from a performance perspective.

4.1.3. Aerobic Fitness

Aerobic fitness is a key component of FF health [8] and performance [12]. While VO_{2peak} is representative of metabolic efficiency from an oxygen delivery and cellular respiration perspective, HRR_{1min} aligns better with PSNS recovery [46]. GRAD had significantly higher levels of VO_{2peak} (42.2 vs. 37.1 $mL \cdot kg^{-1} \cdot min^{-1}$) compared to REL but did not differ in HRR_{1min} (21.2 vs. 19.1%). This may support GRAD being more metabolically efficient than REL, despite similar capacity for recovery, though the effect size for VO_{2peak} was small ($\eta_p^2 = 0.01$). Lockie et al. [5] reported recruits who graduated from the recruit academy had a mean estimated VO_{2peak} of 47.7 $mL \cdot kg^{-1} \cdot min^{-1}$, while those who were released had a mean of 42.9 $mL \cdot kg^{-1} \cdot min^{-1}$. These values are higher than the results of the current study, where GRAD had a lower VO_{2peak} than their group of released recruits. Compared to recent age-independent normative values published from a large cohort of active-duty FFs [36], both GRAD and REL rank above the 70th percentile. However, the NFPA recommends that all individuals in the fire service meet or exceed the 50th percentile for VO_{2peak} based on age and sex [47]. For the mean age of the current recruits (26.6 yrs), this is a VO_{2peak} of 47.6 $mL \cdot kg^{-1} \cdot min^{-1}$ for males and 37.5 $mL \cdot kg^{-1} \cdot min^{-1}$ for females, which again suggests that both GRAD and REL entered the recruit academy with sub-optimal VO_{2peak}.

For HRR_{1min}, most available normative data are within general populations, including risk-based cut-off values rather than percentile or categorical ranking. Vivekananthan et al. [48] reports that an HRR_{1min} of less than 12 beats indicates elevated cardiovascular disease risk; however, both GRAD and REL far exceeded this value. Recent work by Brau et al. [21] included age-based percentile ranks for HRR_{1min} which would suggest that GRAD is positioned within the 70th percentile, while REL is positioned within the 50th percentile.

Metabolic efficiency and autonomic recovery are critical to the sustained and successive performance of job demands in FFs. Metabolic efficiency can be inferred from VO_{2peak}, as it represents the ability for the body to extract oxygen from the air, deliver it to target tissues, and utilize it for energy relative to the individual's overall body mass. Practically, this represents the individual's ability to safely achieve and sustain high levels of workload [9], while minimizing air tank consumption [12,49]. Following high-intensity workloads, there is a necessary component of recovery that allows for the safe and effective repeated exposure that is critical to the FF job [50]. HRR_{1min} is reflective of this quick recovery ability as the initial descent toward cardiovascular and autonomic nervous system baseline can be largely attributed to the degree of PSNS reactivation following intense activity [46]. Therefore, upon entering the recruit academy, GRAD demonstrated higher metabolic efficiency than REL as well as greater, but not significant, autonomic recovery.

4.1.4. Muscular Strength

Peak handgrip strength has been a consistently utilized metric in the fire service owing to its integral role in the completion of FF-specific tasks and strong relationship with FF performance [14,16–19]. Lindberg et al. [14] reported strong negative correlations between peak handgrip strength and time to complete hose pulling ($r = -0.73$) and victim rescue ($r = -0.79$) tasks. While Williams-Bell et al. [18] found that when predicting completion time for the CPAT using handgrip strength alone, it accounted for 47% of the variability in completion times. Furthermore, Lockie et al. [5] found differences in muscular strength be-

tween graduated and released recruits. Despite using a different methodology for strength testing, this is consistent with the current study where GRAD (101.7 kg) had significantly higher SHG than REL (96.6 kg), though, again, the small effect size (η_p^2 = 0.01) for this comparison suggests that much of the variability in SHG can be attributed to age rather than to academy outcome. Lockie et al. [5] assessed muscular strength using the 10-repetition maximum deadlift, while the current study used SHG. Despite similar results between studies, it is possible that each of these activities contributes differently to the overall FF job demands. There is also a difference in the physiological demands of submaximal and maximal assessments of strength, where maximal assessments require a larger neuromuscular contribution while primarily using the phosphagen energy system [51] (pp. 43–64). Thus, it is possible that the movement and physiological demands of the submaximal deadlift and SHG align with separate skills necessary to successfully complete the recruit academy.

When comparing the SHG of current recruits to normative data within the general population of a similar age bracket, both GRAD and REL score at approximately the 75th percentile [52]. However, Sanchez et al. [53] reported SHG in active-duty FFs with mean scores ranging from 125 to 127 kg. Therefore, both groups exhibit substantially lower SHG than active-duty FFs despite scoring well with respect to the general population. Though this is consistent with the previous literature [21], Ras [37] recently investigated handgrip in active-duty FFs using receiver-operating characteristic curves to determine cut-off points for passing a physical abilities test similar to the CPAT. They reported a peak single-hand handgrip of 78.2 kg had 85% sensitivity and 60% specificity for determining a passing time score. As all recruits are required to pass the CPAT prior to entry into the academy, this may suggest that active-duty FFs rely more heavily on their handgrip strength to successfully complete an FF-specific abilities test than the less experienced recruits. Additionally, personal protective equipment may also need consideration, as there is evidence suggesting that the donning of firefighter gloves reduces peak dominant handgrip strength by 33% [54]. Therefore, SHG is a critical element of FF performance and is relevant to success through a recruit academy, yet further exploration is needed to understand the specific grip-related needs of FF recruits.

4.1.5. Muscular Endurance

Muscular endurance is another commonly reported factor of physical fitness in FFs, with more available evidence supporting its connection to performance in FF recruits [5,15]. In their sample of incoming FF recruits, Chizewski et al. [15] reported an average of 42 PU, adding that PU accounted for 19% of the variability in completion times for an FF-specific physical performance test. Further, in their work investigating physical fitness and recruit academy outcome, Lockie et al. [5] reported higher PUs in both their graduated (67 repetitions) and released (56 repetitions) FF recruits. In the current study, GRAD (32 repetitions) performed significantly more repetitions than REL (25 repetitions), though this comparison also had a small effect size (η_p^2 = 0.03), and both performed substantially fewer repetitions than reported in each of the aforementioned studies. The current study utilized a 2 min paced methodology consistent with the WFI [20] (pp. 11–12). However, testing methodology varies significantly within the FF literature, including WFI-based [12,21], un-paced and untimed [23,35] (p. 101), and 60 s un-paced [15,37] methodologies. Furthermore, despite the un-paced and untimed methodology of the ACSM push-up assessment, compared to normative data in the general population, GRAD and REL rank within the "Very Good" and "Good" categories. Thus, comparisons in push-up ability must be made carefully with consideration for testing methodologies.

4.2. Predicting Recruit Academy Outcome

The overall equation for predicting which recruits would be released from the academy based on initial physical fitness data was significant. However, the only significant individual predictors in this model were age, BF, and FFM. This suggests that after controlling for age and the remaining measures of physical fitness, measures of body composition may have higher relative importance with respect to graduating from a recruit academy. Importantly, regardless of their significance in this model, each of the seven included measures of fitness is important for completing job demands upon graduation from the academy, and warrants maintaining in the holistic consideration of an FF recruit's physical ability to successfully graduate from the academy. Lockie et al. [55] developed a similar equation to predict FF recruit academy outcome using a different battery of physical fitness assessments. While that equation included many of the same general aspects of fitness, it also included aspects of muscular power and agility while excluding measures of body composition. Thus, this study provides novel insight into the additional role of age and body composition in successfully graduating from a 16-week FF recruit academy, which further highlights the impact of initial fitness on longitudinal performance.

As each recruit academy candidate must already pass a pre-employment screening prior to entry, there may be value from a screening perspective in highlighting which recruit academy candidates may be at risk of release. These candidates could then be provided with specific programming to augment their physical fitness in the most necessary areas. While the five-test physical fitness assessment would be brief, if successfully implemented, it could positively contribute to the department in multiple ways. By optimizing the chances for FF recruits to successfully graduate, departments would likely see decreases in the cost of recruiting and training candidates. Further, a decreased attrition rate from the FF recruit academy would lead to an increase in workforce throughout the city, decreasing costs of overtime and mandatory shifts. Finally, by improving the health and performance of FF recruits prior to and during the recruit academy, the department may begin to see health and performance improvements.

4.3. Limitations and Future Directions

At the time of the current study, information related to the reason for release from the recruit academy was not available. Some potential reasons for release include medical issues or injury, academic performance, skill performance, or voluntary withdrawal. It is possible that the measures of physical fitness included in the current study have higher predictive value for certain reasons for release. Therefore, it may be important to consider the results of the current study as predictors of "all-cause" release from the recruit academy. Future work should continue to explore the impact of physical fitness on separate reasons for release.

Despite significant differences between GRAD and REL for BF, FFM, VO_{2peak}, SHG, and PU, each of the effect sizes for these comparisons was small. Furthermore, no alpha correction was performed to adjust for these multiple comparisons as the current study is largely exploratory. Therefore, caution should be taken when generalizing these results to other fire departments.

The current study was cross-sectional in design, with measures taken during the first week of the recruit academy. As the recruit academy is designed to holistically prepare recruits for active duty, it is possible that the rate of improvement in physical fitness is another factor in recruit academy outcome that the current study was unable to capture. Furthermore, the current study used measures of physical fitness that are representative of health and performance, with more specific tests of muscular power and agility being potentially more meaningful for recruit academy outcome. Yet, the results of the current

study align with those of previous investigations suggesting that while physical fitness may play a role in supporting the successful completion of an FF recruit academy, there are likely other significant contributors [56]. Thus, future work should explore the psychosocial and technical fire skills that may contribute to recruit academy success.

5. Conclusions

The results of the current study suggest that successful graduation from an FF recruit academy can be predicted by a small subset of field-based physical fitness factors known to be critical to the FF profession. After controlling for age, shoulder mobility (i.e., APLEY), aerobic fitness (i.e., VO_{2peak} and HRR_{1min}), and muscular strength and endurance (i.e., SHG and PU, respectively), body composition (i.e., BF and FFM) was found to be a modifiable physical fitness factor that significantly predicts recruit academy outcome. Further, to maximize the successful completion of a fire academy and, therefore, support the workforce needs of a department, future research should examine the potential for using these measures as tools for screening and/or preparatory work by candidates prior to entry into a fire academy.

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Abbreviations

The following abbreviations are used in this manuscript:

ACSM	American College of Sports Medicine
APLEY	Apley's scratch test
BF	Body fat
CI	Confidence interval
CPAT	Candidate Physical Ability Test
FF	Firefighter
FFM	Fat-free mass
FMS™	Functional Movement Screen
GRAD	Graduated recruits
HRR_{1min}	Relative one-minute heart rate recovery
HR_0	Heart rate immediately following the five-minute Forestry step test

HR_{1min}	Heart rate one minute following the five-minute Forestry step test
NFPA	National Fire Protection Association
OR	Odds ratio
PSNS	Parasympathetic nervous system
PU	Push-ups
REL	Released recruits
SE	Standard error
SHG	Sum handgrip
VO_{2peak}	Estimated aerobic capacity
WFI	Wellness-Fitness Initiative

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