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ABSTRACT

Firefighter trainees require numerous fitness capacities (e.g., muscular strength, power, and endurance, anaerobic and aerobic fitness) to be admitted to, and complete, a training academy and effectively perform their job. Performance in certain fitness tests could be used to predict trainee potential for academy success. This information could be used to design training programs for trainees that may have specific limitations. **PURPOSE:** To investigate the impact of fitness test performance on trainee ability to graduate an academy using ordinal logistic generalized linear models. **METHODS:** Retrospective analysis was conducted on trainee data ($N=686$) from one fire department. Trainees completed a department-specific occupational physical ability test (OPAT) that included: Illinois agility test (IAT); push-ups; pull-ups; leg tucks; estimated maximal aerobic capacity ($\dot{V}O_{2max}$) derived from the 20-m multistage fitness test; backwards overhead 4.54-kg medicine ball throw (BOMBT); 10-repetition maximum deadlift; and 91.44-m farmer's carry with 18-kg kettlebells. Data were recorded in raw scores, in addition to scaled scores based on internal department scoring. Tests were scored from 0-100, with a maximum total OPAT score of 800. Trainees were split into graduated (completed academy; $n=576$) or released (did not complete academy; $n=110$) groups. Data were analyzed via ordinal logistic generalized linear models, with significance set at $p < 0.05$. Raw and scaled scores were investigated separately, with odds ratios (OR) and confidence intervals (CI) produced. **RESULTS:** For the raw scores, there was a significant difference in the odds of graduating relative to IAT performance (OR=1.357; CI=1.047-1.760; $p=0.021$), BOMBT distance (OR=0.744; CI=0.628-0.882; $p<0.001$), and $\dot{V}O_{2max}$ (OR=0.907; CI=0.862-0.954; $p<0.001$) in firefighter trainees. A faster IAT, further BOMBT, and greater $\dot{V}O_{2max}$ increased the likelihood of graduation. For the scaled scores, there was a significant difference in the odds of graduating relative to the points attained for the BOMBT (OR=0.985; CI=0.972-0.999; $p=0.032$), deadlift (OR=0.982; CI=0.968-0.995; $p=0.008$), and total OPAT (OR=0.994; CI=0.988-1.000; $p=0.047$). More points increased graduation likelihood. **CONCLUSIONS:** The results reinforced the importance of overall fitness for firefighter trainees relative to academy graduation. Change-of-direction speed (IAT), total-body power (BOMBT), aerobic fitness ($\dot{V}O_{2max}$), lower-body strength (deadlift), and the combination of different facets of fitness (total OPAT points) significantly impacted the odds for a trainee to graduate from the fire academy. The largest impact seemed to be for the IAT; for every unit decrease in time (i.e., a faster IAT), there was a 36% better chance of a trainee graduating from the academy. However, different scoring systems may yield different results if used as cut-scores. **PRACTICAL APPLICATIONS:** Logistic generalized linear models could use fitness test data to identify a trainee's odds of graduating academy. Although it may be expected that a firefighter trainee requires multiple fitness components to be successful in their training, the current results highlight how specific tests could identify limitations in trainee fitness that could impact their ability to successfully graduate. Furthermore, the data suggested change-of-direction speed, total-body power, lower-body strength, and aerobic fitness could enhance a trainee's likelihood of graduation.

INTRODUCTION

- Most firefighter trainees in the USA complete the Candidate Physical Ability Test (CPAT), which measures the ability to perform demanding job tasks (stair climb, hose drag, equipment carry, ladder raise and extension, forcible entry, search, rescue drag, and ceiling breach and pull), in the hiring process (1). Trainees require sufficient muscular strength, power, and endurance, anaerobic and aerobic fitness to successfully complete the CPAT and be admitted to a training academy (4,5).
- Performance in certain fitness tests could predict trainee potential for academy success. Lockie et al. (2) used receiver operating curves (ROC) and the resulting area under the curve (AUC) to investigate the predictive capabilities of a department-specific Occupational Physical Ability Test (OPAT; raw and scaled scores) in firefighter trainees. The OPAT included the Illinois agility test (IAT), metronome push-ups, pull-ups, leg tucks, estimated maximal aerobic capacity ($\dot{V}O_{2max}$) derived from the 20-m multistage fitness test, 4.54-kg (10-lb) backwards overhead medicine ball throw (BOMBT), 10-repetition maximum (10RM) deadlift, and a 91.44-m (100-yard) farmer's carry with 18-kg (40-lb) kettlebells. Push-up repetitions (AUC = 0.754), BOMBT points (AUC = 0.727), and total OPAT points (AUC = 0.709) had fair accuracy for predicting graduation. However, other statistical approaches may produce different results which could impact what specific limitations may be identified in trainees and how physical training is implemented.
- The purpose of this study was to investigate the impact of fitness test performance on trainee ability to graduate an academy using ordinal logistic generalized linear models.

METHODS

- Retrospective analysis was conducted on trainee data ($N = 686$) from one fire department (age: 32.53 ± 6.05 years). Apart from age, other demographic information (sex, height, and body mass) were not provided to the researchers. Some of variables may not be recorded by a department and provided to third-parties to avoid any suggestion of preferential hiring based on factors such as height, body mass, and sex, because of the assumption that they are not job-related [31, 32].
- Trainees completed a department-specific occupational physical ability test (OPAT) that included: the IAT; metronome push-ups; pull-ups; leg tucks; estimated $\dot{V}O_{2max}$ derived from the 20-m multistage fitness test; BOMBT with a 4.54-kg medicine ball; 10RM deadlift; and 91.44-m farmer's carry with 18-kg kettlebells (2). Data were recorded in raw scores, in addition to scaled scores based on internal department scoring (2). Tests were scored from 0-100, with a maximum total OPAT score of 800.
- Based on data provided by the fire department, trainees were identified as those who graduated (completed academy requirements; $n = 576$) or were released (did not complete academy and were released at any stage during their academy; $n = 110$). Data were analyzed via ordinal logistic generalized linear models, with significance set at $p < 0.05$. Raw and scaled scores were investigated separately, with odds ratios (OR) and 95% confidence intervals (CI) produced.

RESULTS

- Descriptive data for the raw and scaled scores for the graduated and separated trainees is shown in Table 1. For the raw scores (Table 2), there was a significant difference in the odds of graduating relative to IAT performance, BOMBT distance, and estimated $\dot{V}O_{2max}$ in firefighter trainees. A faster IAT, further BOMBT, and greater estimated $\dot{V}O_{2max}$ increased the likelihood of graduation.
- For the scaled scores (Table 3), there was a significant difference in the odds of graduating relative to the points attained for the BOMBT, 10RM deadlift, and total OPAT. More points in the BOMBT and 10RM deadlift events and the total OPAT increased graduation likelihood.

Table 1. Raw score descriptive data (mean \pm SD) for age and OPAT performance (raw and scaled scores for IAT, push-ups, pull-ups, BOMBT, estimated $\dot{V}O_{2max}$, 10RM deadlift, farmer's carry, and total OPAT points) for firefighter trainees who graduated or were released from academy training.

	Graduated (n = 576)		Released (n = 110)	
	Raw	Scaled (points)	Raw	Scaled (points)
Age (years)	32.16 \pm 6.77	–	36.61 \pm 11.55	–
IAT (s)	18.07 \pm 1.22	26.23 \pm 36.59	18.77 \pm 1.05	7.77 \pm 22.52
Push-ups (no.)	67.40 \pm 22.73	49.89 \pm 41.88	56.12 \pm 22.42	32.51 \pm 39.60
Pull-ups (no.)	12.39 \pm 6.19	68.22 \pm 29.96	8.96 \pm 6.02	51.55 \pm 36.03
BOMBT (m)	9.62 \pm 1.65	77.15 \pm 13.28	8.49 \pm 1.92	64.59 \pm 26.27
Leg Tuck (no.)	13.57 \pm 7.30	72.55 \pm 30.02	9.66 \pm 6.81	55.61 \pm 37.29
Estimated $\dot{V}O_{2max}$ (ml·kg ⁻¹ ·min ⁻¹)	47.10 \pm 5.99	50.86 \pm 37.12	42.75 \pm 5.16	24.03 \pm 33.48
10RM Deadlift (kg)	145.88 \pm 20.37	90.56 \pm 13.00	134.62 \pm 24.52	78.23 \pm 24.55
Farmer's Carry (s)	27.34 \pm 4.55	72.53 \pm 23.10	28.65 \pm 3.87	66.22 \pm 25.82
Total OPAT	–	510.00 \pm 143.97	–	379.97 \pm 140.71

Table 2. Results from the ordinal logistic generalized linear models for raw score OPAT performance (IAT, push-ups, pull-ups, BOMBT, estimated $\dot{V}O_{2max}$, 10RM deadlift, and farmer's carry) for firefighter trainees. * Significant ($p < 0.05$) difference in odds of graduating.

	Estimates	Standard Error	p value	OR	95% CI
IAT	0.305	0.133	0.021	1.357*	1.047-1.760
Push-ups	-0.008	0.007	0.262	0.992	0.979-1.006
Pull-ups	0.042	0.032	0.187	1.043	0.980-1.111
BOMBT	-0.295	0.086	<0.001	0.744*	0.628-0.882
Leg Tuck	-0.011	0.024	0.638	0.989	0.942-1.037
Estimated $\dot{V}O_{2max}$	-0.098	0.026	<0.001	0.907*	0.862-0.952
10RM Deadlift	-0.011	0.006	0.092	0.989	0.977-1.002
Farmer's Carry	-0.064	0.038	0.095	0.938	0.871-1.010

Table 3. Results from the ordinal logistic generalized linear models for scaled score OPAT performance (IAT, push-ups, pull-ups, BOMBT, estimated $\dot{V}O_{2max}$, 10RM deadlift, farmer's carry, and total OPAT) for firefighter trainees. * Significant ($p < 0.05$) difference in odds of graduating.

	Estimates	Standard Error	p value	OR	95% CI
IAT	-0.006	0.005	0.236	0.994	0.984-1.004
Push-ups	0.003	0.005	0.533	1.003	0.994-1.012
Pull-ups	0.008	0.006	0.161	1.008	0.997-1.020
BOMBT	-0.015	0.007	0.032	0.985*	0.972-0.999
Leg Tuck	0.005	0.005	0.334	1.005	0.995-1.015
Estimated $\dot{V}O_{2max}$	-0.008	0.005	0.082	0.992	0.984-1.001
10RM Deadlift	-0.019	0.007	0.008	0.982*	0.968-0.995
Farmer's Carry	0.010	0.006	0.089	1.010	0.999-1.021
Total OPAT	-0.006	0.003	0.047	0.994*	0.988-1.000

CONCLUSIONS

- The results reinforced the importance of overall fitness for firefighter trainees relative to academy graduation (2). Change-of-direction speed (IAT), total-body power (BOMBT), aerobic fitness ($\dot{V}O_{2max}$), lower-body strength (10RM deadlift), and the combination of fitness components (total OPAT points) significantly impacted the odds for a trainee to graduate from the fire academy.
- The largest impact seemed to be for the IAT; for every unit decrease in time (i.e., a faster IAT), there was a 36% better chance of a trainee graduating from the academy. A faster IAT requires superior lower-body strength, power, and movement technique (3), all of which could benefit a firefighter trainee in their job tasks. However, different scoring systems may yield different results if used as cut-scores, so this requires specific analysis by the practitioner.

PRACTICAL APPLICATIONS

- Logistic generalized linear models could use fitness test data to identify a trainee's odds of graduating academy. Although it may be expected that a firefighter trainee requires multiple fitness components to be successful in their training (2,4,5), the current results highlight how specific tests (e.g., IAT) could identify limitations in trainee fitness that could impact their ability to successfully graduate their respective fire training academy.
- The data from this study suggested superior change-of-direction speed, total-body power, lower-body strength, and aerobic fitness could enhance a trainee's likelihood of graduation.

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