

## ABSTRACT

Maximal strength is often viewed as an essential trait for firefighters, but may be challenging to measure in first responder populations. Dynamic strength tests can be time consuming and may not be appropriate for many trainees due to insufficient training history and increased risk of injury. The isometric midhigh pull (IMTP) could provide a valid strength measure, while also being an efficient test to conduct with first responder trainees who tend to have a wide range of fitness and ability levels. What would further validate the use of the IMTP in first responder populations is comparisons with job-specific tasks. **PURPOSE:** To determine predictive relationships between isometric strength and other general fitness measures in firefighter trainees. **METHODS:** Data from 47 firefighter trainees (41 men, 6 women) from one fire department were analyzed. General fitness tests included: two countermovement jump trials; two IMTP trials; 2-minute hand release push-ups; and the Yo-Yo Intermittent Recovery Test Level 1 (YYIRT1). Job-specific tests comprised: two drags with a 131.8-kg manikin over 40 m; two trials of a 10.67-m (35 feet) ladder extension; and a 5-lap tower climb wearing a 12.9-kg self-contained breathing apparatus while carrying a 24.9-kg, 30.5-m long hose pack. The best of the two trials for the countermovement jump, IMTP, manikin drag, and ladder extension were considered. Only one trial was completed for push-ups, the YYIRT1, and stair climb. Stepwise regression, controlling for sex (coded as 1 = male, 2 = female), derived relationships between the general and job-specific fitness tests ( $p < 0.05$ ), with a focus on the IMTP. **RESULTS:** Both the manikin drag and ladder extension were predicted by sex and the IMTP, with approximately 41% and 34% explained variance, respectively (Table 1). The predictive formula for the drag was:  $manikin\ drag\ time\ (s) = 85.256 + 9.814(Sex) - 0.016(IMTP)$ . For the ladder extension, the predictive formula was:  $ladder\ extension\ time\ (s) = 21.509 + 3.314(Sex) - 0.004(IMTP)$ . There were no significant predictive relationships for the stair climb. **CONCLUSIONS:** Casualty or body drags and ladder extensions are essential, physically demanding tasks performed by firefighters that can ensure the safety of the general population and property. The current results show the need for maximal strength in performing these tasks, with the IMTP being involved in significant predictive relationships for 40-m, 131.8-kg manikin drag and 10.67-m ladder extension times. Greater isometric strength could aid the faster performance of these job tasks in trainees. **PRACTICAL APPLICATIONS:** The IMTP could be used to predict performance in job-specific tasks such as manikin drags and ladder extension in firefighter trainees. This strength test has the added value of being low-fatiguing and relatively easy to perform regardless of individual training background, so the IMTP could have application for many first responders.

## INTRODUCTION

- Maximal strength is an essential trait for firefighters. In professional firefighters, a 5RM bench press correlated with time to complete a 65.6-m hose pull, 80-kg victim drag over 30 m, stair climb with a 22-kg hose pack, and 30.3-m equipment hoist with a 16-kg load ( $r = -0.39$  to  $0.80$ ) (8). Civilians who completed a 29-kg ladder lifting simulation had a 1RM shoulder press of ~53 kg, while this who could not had a 1RM shoulder press of ~25 kg (9). Civilians who could perform a 42-kg ladder lowering simulation had a 1RM seated pull of ~79 kg, while those who could not had a 1RM seated pull of ~48 kg (9).
- Maximal strength testing could be valuable for practitioners working with firefighters, especially if a test could predict the ability to perform certain tasks. RM tests (i.e., bench press, squat, deadlift) may not be appropriate for all people (e.g., those with limited training experience). An ideal strength test would be easy to administer on large groups, time efficient, limits fatigue, and safe to perform regardless of age, sex, and skill (3).
- An example would be the isometric midhigh pull (IMTP). The IMTP relates to maximal strength measured by RM tests (6), and also results in minimal fatigue or margin for technical error when compared to traditional strength tests (1). Establishing relationships between the IMTP relative to firefighter job tasks could highlight the value of this metric.
- The purpose of this study was to determine predictive relationships between isometric strength and other general fitness measures with job-specific tasks in firefighter trainees.

## METHODS

- Data from 47 firefighter trainees, including 41 men and 6 women, were analyzed. Age and height were not recorded in the datasets made available to the researchers.
- General fitness tests included: countermovement jump; IMTP; 2-minute hand release push-ups; and the Yo-Yo Intermittent Recovery Test Level 1 (YYIRT1).
- Job-specific tests included: casualty drag with a 131.8-kg manikin over 40 m; 10.67-m (35 feet) ladder extension; and a 5-lap tower climb wearing a 12.9-kg self-contained breathing apparatus while carrying a 24.9-kg, 30.5-m long hose pack.
- Stepwise regression, controlling for sex (coded as 1 = male, 2 = female), derived predictive relationships between the general and job-specific fitness tests ( $p < 0.05$ ). Sex was controlled for due to fitness test differences between men and women. The job-specific fitness tests (manikin drag, ladder extension, stair climb) were entered individually as dependent variables.

## RESULTS

- Descriptive data is shown in Table 1. Both the manikin drag and ladder extension were predicted by sex and the IMTP, with approximately 41% and 34% explained variance, respectively (Table 2). There were no significant predictive relationships for the stair climb.
- The predictive formula for the drag was:
 
$$Manikin\ drag\ time\ (s) = 85.256 + 9.814(Sex) - 0.016(IMTP).$$
- For the ladder extension, the predictive formula was:
 
$$Ladder\ extension\ time\ (s) = 21.509 + 3.314(Sex) - 0.004(IMTP).$$

**Table 1.** Descriptive data (mean ± SD) for body mass, and the general (countermovement jump, isometric midhigh pull, 2-minute hand release push-ups, and Yo-Yo Intermittent Recovery Test Level 1 [YYIRT1] distance) and job-specific fitness (40-m, 131.8-kg manikin drag, 10.67-m ladder extension, and stair climb) tests in firefighter trainees ( $N = 47$ ).

Variable	Mean ± SD
Body Mass (kg)	87.83 ± 12.29
Countermovement Jump (cm)	34.76 ± 7.48
Isometric Midhigh Pull (N)	2957.11 ± 421.28
Hand Release Push-ups (repetitions)	39.87 ± 8.83
YYIRT1 Distance (m)	573.62 ± 252.06
40-m, 131.8-kg Manikin Drag (s)	49.13 ± 13.45
10.67-m Ladder Extension (s)	12.84 ± 4.27
Stair Climb (min:s)	12:56 ± 1:52

**Table 2.** Significant stepwise linear regression analyses between drag a 40-m, 131.8-kg manikin drag and 10.67-m ladder extension with general fitness tests (countermovement jump, isometric midhigh pull [IMTP], 2-minute hand release push-ups; and the Yo-Yo Intermittent Recovery Test Level 1) in firefighter trainees ( $N = 47$ ).

Variables	$r$	$r^2$	Adjusted $r^2$	$F$	$p$
<b>40-m, 131.8-kg manikin drag</b>					
Sex	0.495	0.245	0.228	14.588	<0.001
IMTP	0.658	0.433	0.407	16.804	<0.001
<b>10.67-m ladder extension</b>					
Sex	0.495	0.245	0.227	13.919	<0.001
IMTP	0.607	0.369	0.339	12.262	<0.001

## CONCLUSIONS

- Casualty/body drags and ladder extensions are essential, demanding tasks performed by firefighters that can ensure the safety of the general population and property. The IMTP was involved in significant predictive relationships for 40-m, 131.8-kg manikin drag and 10.67-m ladder extension times. The strength of these relationships (34-41% explained variance), would suggest other factors are important for these tasks (e.g., technique). Nonetheless, greater isometric strength could aid the faster performance of these job tasks in trainees.
- Maximal strength is important for dragging tasks that require absolute load (7). In law enforcement recruits, greater isometric strength as measured by a leg/back dynamometer related to a faster 9.75-m drag with a 74.84-kg dummy ( $r = -0.66$ ) (4). In firefighter trainees, IMTP performance could indicate their ability to perform a 40-m, 131.8-kg manikin drag.
- Ladder manipulation can be a challenging task for trainees (5). Stevenson et al. (9) documented strength thresholds for ladder lifting and lowering tasks. Absolute strength would be important for efficiently manipulating the ladder.

## PRACTICAL APPLICATIONS

- The IMTP could be used to predict performance in job-specific tasks such as manikin drags and ladder extension in firefighter trainees. This strength test has the added value of being low-fatiguing and relatively easy to perform regardless of individual training background, so the IMTP could have application for many first responders.
- A limiting factor for fire departments using the IMPT could be cost, as specific equipment is required, as well as requiring trained personnel to administer the test and analyze the data. However, partnering with local universities with IMTP access could alleviate these issues (2).

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