Body Composition and Fitness in Structural Firefighters: Differences According to Injury Status and Anatomical Location

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ABSTRACT

The job demands of firefighting often place the firefighter at risk of injury. However, firefighters may often continue working with an existing injury. How existing injuries could affect job performance may be extrapolated from fitness test performance. **PURPOSE:** To analyze differences in body composition and fitness between currently injured (self-reported) and uninjured structural firefighters. **METHODS:** Retrospective analysis was conducted on data collected from 270 firefighters (258 men, 12 women) as part of a health and wellness program within one fire department. Firefighters voluntarily participated within the program. Body composition metrics included: height; body mass; body mass index (BMI); body fat percentage (BF%); fat mass (FM); lean body mass; and waist:hip ratio. Fitness data included: flexibility measured using novel equipment (trunk flexion, left rotation, right rotation, trunk extension, shoulder flexion, left lateral flexion, right lateral flexion); grip strength; absolute and relative predicted one-repetition maximum (1RM) leg press; 90-second crunches; 120-second push-ups; and estimated maximal aerobic capacity ($\dot{V}O_{2max}$). Firefighters self-reported if they were, or were not, injured. Number of current injuries, and their anatomical location, were used to place them in groups: uninjured (UNINJ; *n*=208); upper-body injury (UBI; *n*=11); lower-body injury (LBI; *n*=19); back injury (BI; *n*=12); and more than one (multiple) injuries (MULT; *n*=20). A series of univariate ANOVAS, with sex and age as covariates, compared the groups in body composition and fitness ($p<0.05$) with a *post hoc* Bonferroni adjustment for multiple comparisons. **RESULTS:** The MULT group was older ($p=0.005$), heavier ($p=0.001$), and had a greater BMI ($p=0.006$) than the UNINJ group, and greater BF% ($p\leq0.039$) and FM ($p\leq0.025$) than the UNI and LBI groups. The BI group had poorer trunk extension compared to the UBI, LBI, and MULT groups ($p\leq0.033$), poorer left lateral flexion compared to the UNINJ and MULT groups ($p\leq0.039$), and performed fewer crunches than the UNINJ group ($p=0.004$). The LBI, BI, and MULT groups had a lower absolute and relative 1RM leg press compared to the UNINJ group ($p\leq0.026$). The LBI and MULT groups had a lower $\dot{V}O_{2max}$ compared to the UNINJ group ($p\leq0.007$). **CONCLUSIONS:** The data indicated the presence of injuries can impact select fitness test performance in firefighters. Firefighters with more than one injury tended to have poorer body composition, and lesser strength and $\dot{V}O_{2max}$. The BI group was limited with trunk extension and flexion actions. The LBI group had lower-body strength limitations. Poorer fitness test performance due to an injury could indicate limitations in job tasks that require certain qualities (e.g., firefighters in the LBI, BI, and MULT groups may struggle with maximal lifting tasks). Firefighters with an injury may also reduce any exercise they do, which could have a downstream effect of poorer body composition and fitness and increase their risk of future injury. **PRACTICAL APPLICATIONS:** Although poorer performance in the fitness tests could be the result of the current injury, these data highlight certain qualities that could be developed to prevent specific injuries in firefighters. It should be noted that all firefighters from the program were still working. Training staff should assist firefighters with current injuries to complete adapted exercise programs so that negative impacts to job performance are reduced.

INTRODUCTION

- Firefighting is a physically challenging profession. Numerous occupational tasks can place great demands on firefighters, including extinguishing fires, load carriage (e.g., personal protective equipment, self-contained breathing apparatus, equipment, hose bundles), hose pulls/hoists, ladder raises, forcible entries, stair climbs, crawl/search and rescues, and salvages (4,6).
- These job demands can often place the firefighter at risk of injury. Commonly injured areas of structural firefighters include the knee and ankle, hand and fingers, trunk (back and spine), neck, and shoulders (1). Firefighters may also experience injuries at multiple body sites.
- Firefighters often continue to work while they are injured, due to the consequences of not working (e.g., financial losses, belief that they are letting their fellow firefighters down, judgment of fellow firefighters and command staff in the department/station) (5). Although working injured can display character traits of perseverance and strength, this can also lead to a decline in job performance, aggravation of a current injury, and increased probability of another injury.
- The effects of how existing injuries could affect firefighting job performance could be extrapolated from how an individual performs in fitness tests. For example, strength limitations could affect how a firefighter performs a casualty drag (2).
- The purpose of this study was to analyze differences in body composition and fitness between uninjured structural firefighters and firefighters who self-reported a current injury/injuries.

METHODS

- Retrospective analysis was conducted on de-identified archival data from structural firefighters participating in a health and wellness program. This included 258 males (age = 42.45 ± 9.51 years; height = 1.80 ± 0.07 m; body mass = 90.61 ± 12.97 kg) and 12 females (age = 38.42 ± 11.72 years; height = 1.74 ± 0.08 m; body mass = 78.54 ± 11.48 kg).
- The body composition and fitness testing procedures were typical for this health and wellness program (3). Body composition data included: height; body mass; body mass index (BMI); body fat percentage; fat and lean body mass; and waist-to-hip ratio. Fitness data included: measures of flexibility (trunk flexion, left rotation, right rotation, trunk extension, shoulder flexion, left lateral flexion, right lateral flexion); combined grip strength for both hands; predicted one-repetition maximum (1RM) leg press; relative 1RM leg press; 90-second crunches; 2-minute cadence push-ups; and estimated maximal aerobic capacity ($\dot{V}O_{2max}$) measured via the Bruce protocol.
- Firefighters self-reported if they were, or were not, injured. Number of current injuries, and their anatomical location, were used to place them in groups: uninjured (UNINJ; *n* = 208); upper-body injury (UBI; *n* = 11); lower-body injury (LBI; *n* = 19); back injury (BI; *n* = 12); and more than one (multiple) injuries (MULT; *n* = 20). A series of univariate ANOVAS, with sex and age as covariates, compared the groups in body composition and fitness ($p < 0.05$) with a *post hoc* Bonferroni adjustment for multiple comparisons.

RESULTS

- The MULT group was older ($p = 0.005$), heavier ($p = 0.001$), and had a greater BMI ($p = 0.006$) than the UNINJ group; and greater body fat percentage ($p = 0.007$ and 0.039) and fat mass ($p = 0.001$ and 0.025) than the UNI and LBI groups, respectively (Table 1).
- Fitness data is displayed in Table 2. The BI group had poorer trunk extension compared to the UNI ($p = 0.011$), LBI ($p = 0.007$), and MULT ($p = 0.033$) groups, poorer left lateral flexion compared to the UNINJ ($p = 0.033$) and MULT groups ($p = 0.039$), and performed fewer crunches than the UNINJ group ($p = 0.004$).

Table 1. Descriptive data (mean ± SD) for age, height, body mass, and body composition (body mass index, body fat percentage, body fat, lean body mass, and waist-to-hip ratio) for uninjured firefighters, and firefighters who self-reported an upper-body injury (UBI), lower-body injury (LBI), back injury (BI), or multiple injuries (MULT).

	UNINJ (*n* = 208)	UBI (*n* = 11)	LBI (*n* = 19)	BI (*n* = 12)	MULT (*n* = 20)
Age (years)	41.29 ± 9.76	42.36 ± 862	44.21 ± 7.50	45.25 ± 7.71	48.80 ± 9.05*
Height (m)	1.80 ± 0.07	1.81 ± 0.0.06	1.79 ± 0.09	1.78 ± 0.08	1.81 ± 0.10
Body Mass (kg)	88.85 ± 12.54	89.97 ± 11.18	93.53 ± 15.99	89.32 ± 10.61	100.11 ± 14.78*
Body Mass Index (kg/m²)	27.48 ± 3.21	27.46 ± 2.92	29.24 ± 4.63	28.19 ± 3.60	30.60 ± 4.34*
Body Fat Percentage (%)	18.12 ± 5.89	18.97 ± 4.27	17.92 ± 7.23	20.77 ± 5.25	24.52 ± 6.99*ϕ
Body Fat (kg)	16.55 ± 7.25	17.35 ± 5.03	17.10 ± 8.73	18.82 ± 5.77	25.18 ± 9.49*ϕ
Lean Body Mass (kg)	72.51 ± 8.22	72.84 ± 7.59	76.65 ± 13.87	70.71 ± 7.35	75.17 ± 9.18
Wait-to-Hip Ratio	0.89 ± 0.07	0.89 ± 0.08	0.92 ± 0.08	0.90 ± 0.04	0.94 ± 0.10

* Significantly different from the UNINJ group. ϕ Significantly different from the LBI group.
¥ Significantly different from the MULT group.

- The LBI ($p = 0.006$ and 0.025), BI ($p = 0.001$ and 0.005), and MULT ($p = 0.026$ and 0.003) groups had a lower absolute and relative 1RM leg press, respectively, compared to the UNINJ group. The LBI ($p = 0.007$) and MULT ($p = 0.001$) groups had a lower $\dot{V}O_{2max}$ compared to the UNINJ group.

Table 2. Descriptive data (mean ± SD) for fitness (flexibility, grip strength, absolute and relative one-repetition maximum [1RM] leg press, crunches, push-ups, and estimated maximal aerobic capacity [VO_{2max}]) for uninjured firefighters, and firefighters who self-reported an upper-body injury (UBI), lower-body injury (LBI), back injury (BI), or multiple injuries (MULT).

	UNINJ (*n* = 208)	UBI (*n* = 11)	LBI (*n* = 19)	BI (*n* = 12)	MULT (*n* = 20)
Trunk Flexion (cm)	40.57 ± 9.77	43.82 ± 5.71	38.05 ± 10.66	33.50 ± 11.60	39.35 ± 9.75
Left Rotation (cm)	54.42 ± 9.77	54.55 ± 5.48	50.74 ± 9.41	49.33 ± 7.87	53.35 ± 10.12
Right Rotation (cm)	55.72 ± 9.19	56.00 ± 7.58	52.37 ± 10.70	51.50 ± 9.18	52.75 ± 6.74
Trunk Extension (cm)	43.00 ± 8.54	42.82 ± 8.78	44.26 ± 4.98	34.25 ± 4.18*ϕ¥	41.10 ± 8.73
Shoulder Flexion (cm)	52.57 ± 13.11	49.18 ± 19.84	50.11 ± 11.78	47.17 ± 13.31	52.40 ± 16.58
Left Lateral Flexion (cm)	25.94 ± 5.16	26.36 ± 5.61	24.63 ± 6.21	20.92 ± 3.80*¥	25.30 ± 4.80
Right Lateral Flexion (cm)	25.71 ± 4.96	26.45 ± 4.41	24.05 ± 5.57	22.00 ± 2.56	25.75 ± 4.45
Combined Grip Strength (kg)	104.12 ± 15.72	105.00 ± 14.87	106.32 ± 12.58	103.83 ± 15.64	98.60 ± 17.67
1RM Leg Press (kg)	394.75 ± 110.38	337.64 ± 137.62	298.49 ± 142.79*	254.96 ± 157.72*	272.59 ± 125.59*
Relative Leg Press (kg/kg)	4.52 ± 1.39	3.89 ± 1.74	3.41 ± 1.89*	2.92 ± 1.83*	2.83 ± 1.44*
Crunches (repetitions)	115.31 ± 40.84	99.73 ± 44.99	90.53 ± 52.46	64.82 ± 68.17*	80.68 ± 50.22
Push-ups (repetitions)	40.39 ± 14.95	29.82 ± 16.20	34.11 ± 19.84	26.08 ± 19.72	27.89 ± 18.99
Estimated VO_{2max} (ml/kg/min)	45.49 ± 8.83	42.60 ± 9.93	37.80 ± 10.82	41.18 ± 5.82*	34.78 ± 8.90*

* Significantly different from the UNINJ group. ϕ Significantly different from the LBI group.
¥ Significantly different from the MULT group.

CONCLUSIONS

- The data indicated the presence of injuries can impact select fitness test performance in firefighters. Firefighters with more than one injury tended to have poorer body composition, and lesser strength and $\dot{V}O_{2max}$. The BI group was limited with trunk extension and flexion actions. The LBI group had lower-body strength limitations.
- Poorer fitness test performance due to an injury could indicate limitations in job tasks that require certain qualities (e.g., firefighters in the LBI, BI, and MULT groups may find maximal lifting tasks difficult). Firefighters with a back injury will be limited with their range of motion.
- A further consideration is that firefighters with an injury may also reduce any exercise they do. Reduced exercise and physical activity which could have a downstream effect of poorer body composition and fitness, and increased injury and health risks (e.g., cardiovascular disease) (7).

PRACTICAL APPLICATIONS

- Although poorer performance in the fitness tests could be the result of the current injury, these data highlight certain qualities that could be developed to prevent specific injuries in firefighters.
- It should be noted that all firefighters from the program were still working. Training staff should assist firefighters with current injuries to complete adapted exercise programs so that negative impacts to job performance, and risk of future injury and poorer health outcomes, are reduced.

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