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Evaluation of a fitness intervention for new firefighters: injury reduction and economic benefits

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ABSTRACT

Background Firefighting is a hazardous profession and firefighters suffer workplace injury at a higher rate than most US workers. Decreased physical fitness is associated with injury in firefighters. A physical fitness intervention was implemented among Tucson Fire Department recruit firefighters with the goals of decreasing injury and compensation claims frequency and costs during the recruit academy, and over the subsequent probationary year.

Methods Department injury records were analysed and described by body part, injury type and mechanism of injury. Injury and workers' compensation claims outcomes from the recruit academy initiation through the 12-month probationary period for the intervention recruit class were compared with controls from three historical classes.

Results The majority of injuries were sprains and strains (65.4%), the most common mechanism of injury was acute overexertion (67.9%) and the lower extremity was the most commonly affected body region (61.7%). The intervention class experienced significantly fewer injuries overall and during the probationary year ($p=0.009$), filed fewer claims ($p=0.028$) and experienced claims cost savings of approximately US\$33 000 (2013) from avoided injury and reduced claims costs. The estimated costs for programme implementation were \$32 192 leading to a 1-year return on investment of 2.4%.

Conclusions We observed reductions in injury occurrence and compensation costs among Probationary Firefighter Fitness (PFF-Fit) programme participants compared with historical controls. The initiation of the PFF-Fit programme has demonstrated promise in reducing injury and claims costs; however, continued research is needed to better understand the programme's potential effectiveness with additional recruit classes and carryover effects into the recruit's career injury potential.

BACKGROUND AND INTRODUCTION

Firefighting is a hazardous profession that often requires strenuous work in dynamic and unpredictable environments. Firefighters and emergency medical services employees have been shown to be at higher risk of non-fatal injury than most other US workers.^{1–3} In 2012, the 1.1 million career and volunteer firefighters in the US suffered an estimated 69 400 injuries, a rate of 6.1 injuries per 100 firefighters.^{4 5}

On-duty exercise has been promoted as one way to improve measures of health and fitness among firefighters,^{6–8} and research has demonstrated the potential positive impact of improved fitness on injury. Poplin *et al*⁹ found that firefighters with lower levels of fitness ($VO_{2max} < 43$ mL/kg/min) were 2.2 times more likely to suffer occupational

injury as those with $VO_{2max} > 48$ mL/kg/min. Similarly, firefighters who exercise regularly on-duty were found to have nearly half the odds of suffering a non-exercise-related injury compared with those who do not regularly exercise on duty.¹⁰ Paradoxically, research has shown that nearly one-third of injuries reported among firefighters were the result of physical training or exercise,^{10 11} and that those who report exercising regularly on duty are over four times as likely to suffer exercise-related injury compared with firefighters who do not regularly exercise on duty.¹⁰ Therefore, while there is evidence that improving measures of health and fitness among firefighters has a positive effect on non-exercise-related injury, improved structure and management of on-duty physical exercise programmes for firefighters may be needed to mitigate the risk of exercise-related injury.

There are a limited number of studies examining the economic costs and benefits of fitness interventions for firefighters. Leffer and Grizzell¹² calculated a return on investment (ROI) for the Physician-Organized Wellness Regime using the cost savings of avoided injury as well as associated lost time and found that after 2 years, the programme saved US\$4.60 for every dollar invested. A recent economic evaluation of the Promoting Healthy Living: Assessing More Effects intervention revealed that workers' compensation claims and medical costs were significantly lower among two participating departments compared with two control departments, and that the team-based intervention had a beneficial ROI of US\$4.61 saved for every dollar invested in the programme.¹³ The third edition of the Wellness-Fitness Initiative, a comprehensive department-level health promotion programme developed by the International Association of Fire Fighters and the International Association of Fire Chiefs, included an evaluation of workers' compensation claims, lost workdays, costs per claim and total incurred costs in four Wellness-Fitness Initiative-participating departments and four non-participating departments, comparing the 7-year preimplementation period to the 7-year postperiod.⁷ The participating departments experienced a 5% increase in average claims costs and a 3% increase in total incurred costs compared with a 22% increase in average claims and a 58% increase in total incurred costs experienced by non-participating departments.⁷ Participating departments also experienced a 28% decrease in days lost from work, while non-participating departments saw a 55% increase over the study period.⁷

The Probationary Firefighter Fitness (PFF-Fit) programme was designed by researchers at the



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University of Arizona in partnership with the Tucson Fire Department (TFD), Tucson, Arizona, as part of a NIOSH-funded risk management intervention study, Risk Management Strategies to Prevent Injuries among Firefighters (SPIFi).¹⁴ Descending from one of the nine intervention control strategies, the PFF-Fit programme aimed at establishing a foundation of fitness behaviours among probationary firefighters to improve measures of health and fitness while reducing both exercise-related and non-exercise-related injuries.

The PFF-Fit programme was implemented over an approximately 17-month period. TFD Peer Fitness Trainers (PFT)—firefighters with American Council of Exercise certifications—designed and conducted functional fitness training 3 days per week at the 2012 recruit academy (RA). These functional workouts consisted of strength, cardiovascular and flexibility training that integrated movement found in emergency response (eg, abdominal training including hose pulling or upper body and core training integrating axe swings) to mimic the job-specific tasks found in firefighting and reduce the risk of injury. PFTs were then assigned as peer mentors to probationary firefighters during the 12-month probationary year, where they were available for instation and/or electronic (eg, phone, email and text) exercise and nutrition consultation. The PFTs also conducted periodic instation fitness assessments with their probationary firefighter, with the intent of motivating the probationary firefighters to maintain the same level of fitness they reached over the course of the RA, address questions and concerns, and assure that ‘bad habits’ did not become engrained in exercise routines. Finally, the PFF-Fit programme included a nutrition intervention; a registered dietician provided the 2012 recruit class with information and guidance during the RA. More details about the PFF-Fit programme can be found on the project website (http://spifi.publichealth.arizona.edu/Health_Fitness/PFF_Fit).

The objective of this study was to evaluate the injury outcomes as well as the ROI of the PFF-Fit programme, comparing the cohort in the pilot intervention with historical controls from previous TFD firefighter recruit classes. The hypotheses are: (1) because of the improved physical training management and structure, the 2012 recruit class will experience decreased injury (both exercise-related and non-exercise-related) compared with the historical controls and (2) the PFF-Fit programme will have a positive ROI from the cost savings of avoided injuries.

MATERIALS AND METHODS

The current study uses data from recruit and probationary commissioned personnel of TFD. The TFD is a medium-sized metropolitan department that operates 22 fire stations and employs nearly 600 career fire fighters; the overall department population has been described previously.^{9–11} Fire recruits participate in an 8 h/day, 5 day/week training for a period of 21–22 weeks at the City of Tucson’s Public Safety Academy. Successful graduates of the RA are then assigned to a station and shift where they work 24 h shifts on a rotating three-shift schedule and complete their training as probationary firefighters for a period of 12–14 months, at which time they are considered incumbent firefighters. Reasons for not completing the RA include failure to meet minimum performance standards on written tests and evaluations of practical skills, as well as injury that requires the recruit to miss more than 24 cumulative hours of physical training and/or drilling time. Data for four recent classes of the TFD RA were used: the 2007, 2008 and 2009 classes served as historical controls and the 2012 class received the PFF-Fit intervention (there were no recruit classes

conducted from 2010 to 2011). The University of Arizona’s Institutional Review Board approved all study procedures.

TFD injury surveillance reports were used to measure injury frequency and describe the injury characteristics, including (1) the part of the body affected; (2) the nature of or physical characteristics of the injury and (3) the mechanism of injury. Workers’ compensation claims data were used to measure claims costs. TFD records on-the-job injuries if the incident meets the Occupational Safety and Health Administration’s injury reporting requirements (29 CFR, 1904.7), or if the injury has the potential to progress and require a workers’ compensation claim. Medical events such as heat exhaustion, stress and cardiac events (eg, stroke, heart attack) were excluded from the injury analysis, although none of the subjects suffered a cardiac event. Injury and claims rates were estimated for the RA using the total number of recruits, and for the probationary year using the number of recruits who successfully completed the probationary year.

The costs of the PFF-Fit intervention, primarily personnel time, were estimated based on time spent by TFD and other personnel implementing the intervention. Costs incurred by University of Arizona researchers for programme development and research-specific tasks (eg, consenting study subjects) are excluded. TFD has adopted many of the Wellness Fitness Initiative standards and protocols, and the department maintains a cadre of trained and certified PFTs who provide a variety of services to TFD personnel.⁷ Costs of beginning and maintaining a PFT programme are not estimated here.

Data analysis was completed using Stata V.11 (College Station, Texas, USA 2009). Frequency data, including recruit drop-out status and gender, were analysed using Fisher’s exact test. An ordinary least-squares (OLS) regression analysis was used to analyse age. Workers’ compensation claims data were adjusted to constant 2013 dollars using the Consumer Price Index.¹⁵ For all statistical tests including regression models, workers’ compensation claims costs were transformed using the natural log after adding US\$1 to zero cost claims. Descriptive statistics (eg, mean, median, maximum) were calculated on the non-log transformed claims data. Injury frequency and workers’ compensation claims frequency were analysed using Poisson regression, and claims costs were analysed using OLS. All regression models were adjusted for intraclass correlation (ie, models were clustered on recruit class) using generalised estimated equations. All tests compared differences between the controls (2007, 2008 and 2009 classes) and the intervention class (2012). Statistical significance was defined as a *p* value <0.05.

RESULTS

The study population is described in [table 1](#). A total of 109 recruits participated in the four recruit classes and 77.1% of all recruits successfully completed the RA and the probationary year. Drop-out status and gender differed significantly by recruit class. Notably, less than half of the 2007 recruit class completed the probationary year, compared with 77%–85% of other classes.

Injury and workers’ compensation claims

Overall, the majority of injuries took place during the RA (58%); however, 24/41 (59%) of injuries experienced by the 2008 class occurred during the probationary year ([table 2](#)). The body parts most frequently affected during the RA and probationary year included the lower extremity, torso and upper extremity. Injuries to the back during the probationary year accounted for 14.7% of injuries, compared with only

Table 1 Study population

| | Control classes | | | Total controls | Intervention | Total |
|------------------------------|-----------------|------------|------------|----------------|--------------|------------|
| | 2007 | 2008 | 2009 | | 2012 | |
| Starting class size, n | 19 | 40 | 18 | 77 | 32 | 109 |
| RA drop-outs | | | | | | |
| Injury, n (%) | 1 (5.3) | 0 | 1 (5.6) | 2 (2.6) | 1 (3.1) | 3 (2.8) |
| Other, n (%) | 8 (42.1) | 5 (12.5) | 1 (5.6) | 14 (18.2) | 4 (12.5) | 18 (16.5) |
| Prob. year drop-out, n (%) | 1 (5.3) | 1 (2.5) | 2 (11.1) | 4 (5.2) | 0 | 4 (3.7) |
| Successful completion, n (%) | 9 (47.4) | 34 (85.0) | 14 (77.8) | 57 (74.0) | 27 (84.4) | 84 (77.1)* |
| Age, mean (SD)† | 25.3 (3.4) | 28.2 (5.8) | 29.3 (6.1) | 28.0 (5.7) | 28.4 (5.1) | 27.5 (5.3) |
| Female, n (%) | 3 (15.8) | 0 | 2 (11.1) | 5 (6.5) | 1 (3.1) | 4 (3.7)‡ |

*Successful completion differed significantly by year, $p=0.013$.

†Age at time of pre-employment physical. These data are missing for many recruits who failed to complete the RA. 2007: $n=10$; 2008: $n=36$; 2009: $n=16$; 2012, $n=28$ ($p=0.41$).

‡Total does not equal column totals: one female participated in the 2007 and 2009 RAs; another female participated in the 2009 and 2012 RAs. These are treated as independent observations for the statistical tests ($p=0.025$).

RA, recruit academy.

4.3% in the RA. Overall, the majority of injuries during the RA and probationary year were sprains/strains for both the controls and the intervention group (53/81, 65.4%), and the mechanism of acute overexertion was most common for both controls (44/67, 65.7%) and intervention group (11/14, 78.6%). The overall injury rate for the 2012 class during the probationary year was 3/27 (0.11) compared with 31/57 (0.54) for the controls. Similarly, the 2012 class experienced an exercise-related injury rate of 1/27 (0.04) during the probationary year, compared with 6/57 (0.11) experienced by the controls (table 2).

A total of 55 claims were filed by members of the control classes, for a total incurred cost of US\$95 582, and 13 claims were filed by the 2012 class for a total incurred cost of US\$6679 (table 3). One workers' compensation claims case in 2009 remained open at the time of analysis. TFD's third-party payer reported that US\$3782 had been paid to date and an additional US\$1218 was held in reserve to cover any future costs. For the purposes of this analysis, the paid and reserved amounts were used to estimate the total cost of US\$5000 for the open claim. All other claims, including those for the 2012 recruit class, were closed at the time of analysis. Results of the Poisson regression models (table 4) show that claims and injury frequency significantly differed for the probationary year and for overall injuries, but not for injuries occurring during the RA or for exercise-related injuries. Compared with controls, the difference in the log count of overall injuries, injuries during the probationary year and claims frequency were significantly lower among the intervention group. The linear regression model showed that workers' compensation claims costs were 13% lower than controls (table 4).

The 2012 recruits experienced a 30% reduction in claims frequency compared with the control classes and a reduction of US\$1224 in average cost per claim. If the intervention class experienced the same claims rate as controls (0.71), they would have filed 22.72 claims over the study period at a mean cost per claim of US\$1737, for a total cost of US\$39 465. The actual costs accrued by the 2012 class were US\$6679, which results in an estimated savings of US\$32 786. Similarly, the mean claims costs per recruit were US\$208 for the intervention group, compared with US\$1241 for the controls, a difference of US\$1033. For 32 total recruits, this yields a decrease of US\$33 056 in claims costs, comparing interventions with controls. The estimated savings in claims costs is, therefore, approximately US\$33 000.

Costs of the intervention

The costs of the PFF-Fit programme included personnel costs and materials costs and are detailed in table 5. The TFD Safety and Health Captain invested approximately 15% of his time (6 h/week) for a period of 6 months, including the RA, and approximately 2.5% (1 h/week) during the probationary year, which cost TFD approximately US\$12 267.84 in wages and benefits for his time. Four PFTs were assigned to the RA: one PFT was assigned to the Academy as part of the training staff and dedicated an estimated 5 h/week to PFT duties, two visiting PFTs conducted functional fitness workouts 3 days/week (Monday, Wednesday and Friday) and one visiting PFT participated once a month for long-distance runs (>1.5 miles) on Thursdays. Wages and benefits costs for the PFT who served on the training staff are estimated to be US\$2611.00. These costs were paid out of the department's training budget and represent costs for this PFT's time, as this PFT was taken out of his/her normal duty rotation for 20 weeks of the RA and dedicated this portion of his time to the PFF-Fit programme. The overtime wages and benefits costs for visiting PFTs are estimated to total US\$9792.50. These PFTs completed their regular department duties during the RA and were paid overtime for their participation in the PFF-Fit programme. During the probationary year, PFT mentors completed up to four instation visits with their assigned probationary firefighters. An estimated US\$6708.96 in personnel costs was incurred for these instation visits. A nutritionist spent 11 h in meetings and preparing materials and presentations, then provided a 1 h presentation and spent another hour reviewing health records for the 2012 recruit class at a total cost of US\$661.90. Materials costs, beyond those that are normally incurred for the RA, were minimal. TFD produced fitness logs for each of the 32 members of the 2012 recruit class at an estimated cost of US\$150. An estimated total of US\$32 192.20 was invested in the PFF-Fit programme implementation. Other personnel costs for programme implementation (eg, time spent by Station Captains, probationary firefighters) were minimal, as their involvement rarely exceeded what was expected in their normal job tasks; these costs are excluded.

ROI of the intervention

The costs of the programme totalled US\$32 192.20, while the benefits totalled approximately US\$33 000 saved in workers' compensation claim costs, yielding a 1-year ROI, defined as (cost reduction-programme costs)/programme costs \times 100, of 2.4% (table 6).

Table 2 Distribution of injury by body part, injury type and mechanism of injury for controls (2007, 2008 and 2009) and the intervention class (2012)

| | 2007 | | 2008 | | 2009 | | Total controls | | 2012 | | Total | |
|------------------------------|--------------|-------------|--------------|--------------|--------------|-------------|----------------|--------------|--------------|-------------|---------------|---------------|
| | RA n=13 | PY n=2 | RA n=17 | PY n=24 | RA n=6 | PY n=5 | RA n=36 | PY n=31 | RA n=11 | PY n=3 | RA n=47 | PY n=34 |
| Body part | | | | | | | | | | | | |
| Lower extremity | 12 (92.3) | 2 (100) | 13 (76.4) | 8 (33.3) | 3 (50) | 2 (40) | 28 (77.8) | 12 (38.7) | 9 (81.8) | 1 (33.3) | 37 (78.7) | 13 (38.2) |
| Upper extremity | 0 | 0 | 2 (11.8) | 6 (25) | 0 | 1 (20) | 2 (5.6) | 7 (22.6) | 1 (9.1) | 2 (66.6) | 3 (6.4) | 9 (26.5) |
| Back/spine | 0 | 0 | 0 | 4 (16.7) | 1 (16.7) | 1 (20) | 1 (2.8) | 5 (16.1) | 1 (9.1) | 0 | 2 (4.3) | 5 (14.7) |
| Head/face/neck | 0 | 0 | 0 | 2 (8.3) | 0 | 1 (20) | 0 | 3 (9.7) | 0 | 0 | 0 | 3 (8.8) |
| Torso | 1 (7.7) | 0 | 2 (11.8) | 4 (16.7) | 2 (33.3) | 0 | 5 (13.9) | 4 (12.9) | 0 | 0 | 5 (10.6) | 4 (11.8) |
| Injury type | | | | | | | | | | | | |
| Sprain/strain | 12 (92.3) | 2 (100) | 11 (64.7) | 13 (54.2) | 3 (50) | 2 (40) | 26 (72.2) | 17 (54.8) | 8 (72.7) | 2 (66.6) | 34 (72.3) | 19 (55.9) |
| Contusion/laceration | 0 | 0 | 3 (17.6) | 6 (25) | 1 (16.7) | 1 (20) | 4 (11.1) | 7 (22.6) | 1 (9.1) | 0 | 5 (10.6) | 7 (20.6) |
| Fracture/dislocation | 0 | 0 | 0 | 1 (4.2) | 1 (16.7) | 1 (20) | 1 (2.8) | 2 (6.5) | 1 (9.1) | 1 (33.3) | 2 (4.3) | 3 (8.8) |
| Burn | 0 | 0 | 1 (5.9) | 1 (4.2) | 0 | 1 (20) | 1 (2.8) | 2 (6.5) | 0 | 0 | 1 (2.1) | 2 (5.9) |
| Other* | 1 (7.7) | 0 | 2 (11.7) | 3 (12.5) | 1 (16.7) | 0 | 4 (11.1) | 3 (9.7) | 1 (9.1) | 0 | 5 (10.6) | 3 (8.8) |
| Mechanism of injury | | | | | | | | | | | | |
| Acute overexertion | 11 (84.6) | 2 (50) | 7 (41.2) | 17 (70.8) | 4 (66.7) | 3 (60) | 22 (61.1) | 22 (71.0) | 9 (81.8) | 2 (66.6) | 31 (66) | 24 (70.6) |
| Cutting, piercing | 0 | 0 | 0 | 3 (12.5) | 0 | 1 (20) | 0 | 4 (12.9) | 0 | 0 | 0 | 4 (11.8) |
| Struck by/caught between | 0 | 0 | 5 (29.4) | 0 | 1 (16.7) | 0 | 6 (16.7) | 0 | 1 (9.1) | 1 (33.3) | 7 (14.9) | 1 (2.9) |
| Fall | 1 (7.7) | 0 | 0 | 0 | 0 | 0 | 1 (2.8) | 0 | 0 | 0 | 1 (2.1) | 0 |
| Other† | 1 (7.7) | 0 | 5 (29.4) | 4 (16.7) | 1 (16.7) | 1 (20) | 7 (19.4) | 5 (16.1) | 1 (9.1) | 0 | 8 (17.0) | 5 (14.7) |
| Injury rate | 13/19 (0.68) | 2/10 (0.20) | 17/40 (0.43) | 24/34 (0.71) | 6/18 (0.33) | 5/14 (0.36) | 36/77 (0.47) | 31/57 (0.54) | 11/32 (0.34) | 3/27 (0.11) | 47/109 (0.43) | 34/109 (0.31) |
| Exercise-related injury rate | 5/19 (0.26) | 0 | 6/40 (0.15) | 6/34 (0.18) | 3/18 (0.17) | 0 | 14/77 (0.18) | 6/57 (0.11) | 8/32 (0.25) | 1/27 (0.04) | 22/109 (0.20) | 7/109 (0.06) |
| Total | 15/19 (0.79) | | 41/40 (1.03) | | 11/18 (0.61) | | 67/77 (0.87) | | 14/32 (0.44) | | 81/109 (0.74) | |

*Includes injury types, medical, eye, electrical injury and missing.

†Includes injuries with a mechanism of thermal effect, transportation-related, unspecified and missing.
PY, probationary year; RA, recruit academy.

Table 3 Workers' compensation (WC) claim frequency, costs and estimated rate in the recruit academy (RA), probationary year and over the total study period

| | Control classes | | | Total controls | Intervention 2012 | Total |
|--------------------|-----------------|--------------|---------------|----------------|----------------------|---------------|
| | 2007 | 2008 | 2009 | | | |
| RA (n) | 13 | 17 | 6 | 36 | 11 | 47 |
| WC claim (n) | 13 | 17 | 6 | 36 | 10 | 46 |
| (US\$) Mean (SD) | 1255 (1946) | 1194 (1053) | 6806 (10 492) | 2152 (4689) | 453 (412) | 1783 (4199) |
| (US\$) Median | 783 | 1073 | 3313 | 867 | 363 | 782 |
| (US\$) Range | 64–7637 | 87–3825 | 376–27 769 | 64–27 769 | 78–1546 | 64–27 769 |
| Prob. year (n) | 2 | 24 | 5 | 31 | 3 | 34 |
| WC claim (n) | 0 | 15 | 4 | 19 | 3 | 22 |
| (US\$) Mean (SD) | – | 736 (835) | 1761 (2774) | 952 (1418) | 710 (298) | 919 (1318) |
| (US\$) Median | – | 451 | 508 | 451 | 683 | 555 |
| (US\$) Range | – | 0–2899 | 136–5896 | 0–5896 | 427–1022 | 0–5896 |
| Total (n) | 15 | 41 | 11 | 67 | 14 | 81 |
| WC claim (n) | 13 | 32 | 10 | 55 | 13 | 68 |
| (US\$) Mean (SD) | 1255 (1946) | 979 (970) | 4788 (8396) | 1737 (3905) | 513 (393) | 1503 (3543) |
| (US\$) Median | 783 | 801 | 1258 | 815 | 427 | 729 |
| (US\$) Range | 64–7637 | 0–3826 | 136–27 769 | 0–27 769 | 78–1546 | 0–27 769 |
| Total* | 16 331 | 31 360 | 47 890 | 95 582 | 6679 | 102 262 |
| US\$/recruit | 859 | 784 | 2660 | 1241 | 208 | 938 |
| Claims rate, n (%) | 13/19 (0.68) | 32/40 (0.80) | 10/18 (0.56) | 55/77 (0.71) | 13/32 (0.41) | 68/109 (0.62) |

*Totals may not agree due to rounding.

DISCUSSION

The current study evaluated the injury outcomes as well as the costs and financial benefits of the PFF-Fit programme, comparing the intervention class with historical controls from three previous TFD firefighter recruit classes. The majority of injuries for the recruits in the current study were sprains/strains with a mechanism of acute overexertion, similar to the findings of a descriptive study of injury in TFD for the period 2004–2009.¹¹ However, exercise-related injuries accounted for only 29/109 (26.6%) of all injuries for the recruits in the current study, compared with 32.9% that occurred during physical exercise for the overall TFD population.¹¹ We observed significantly lower injury and workers' compensation claim frequency and a statistically significant difference in claims cost was detected in the regression analysis. We also observed decreases in injuries occurring during the RA and for exercise-related injuries, but were not able to demonstrate statistical significance possibly because of sample size. Programme benefits outweighed costs, yielding a positive 2.4% return on the investment for the PFF-Fit programme. While this ROI is lower than what has been reported in other health intervention studies in the fire service,^{12–13} we observed important decreases in costs.

The PFF-Fit programme represented an important change for TFD, with the emphasis on functional fitness and mentoring through the probationary year. Previous research has shown that nearly a third of all on-duty injuries in the fire service are related to exercise,^{10–11} findings that are confirmed in the current study. This is perhaps a function of the time personnel dedicate to this activity, but it points to the need for improved structure and management of exercise. One potential long-term benefit of the PFF-Fit programme is that it engrains good fitness behaviours and promotes the structure and management of exercise in new personnel.

The hypothesis for the study was that participants in the PFF-Fit programme would experience decreased injury (both exercise-related and non-exercise-related) compared with the historical control classes, and that cost savings of avoided injuries would lead to a positive ROI for the PFF-Fit programme. Measures of health and fitness were evaluated in a previous study (including BMI, blood pressure, blood lipids, timed runs, push-ups, sit and reach, etc) and found there was no pattern of improved health and fitness outcomes for the intervention class at baseline or at the end of the recruit academies.¹⁶ This makes it unlikely that health and fitness levels are responsible for the

Table 4 Results of regression models, comparing the frequency and cost of claims in the intervention class to historical controls

| | Coefficient | SE β | 95% CI | p Value |
|-----------------------------------|-------------|------------|-----------------|---------|
| Injury freq.—during RA | –0.52 | 0.42 | –1.34 to 0.30 | 0.212 |
| Injury freq.—probationary year | –1.43 | 0.60 | –2.61 to –0.25 | 0.018 |
| Injury—overall | –0.89 | 0.34 | –1.55 to –0.22 | 0.009 |
| Exercise-related injury (overall) | –0.23 | 0.51 | –1.22 to 0.77 | 0.658 |
| Claims frequency | –0.79 | 0.36 | –1.50 to –0.088 | 0.028 |
| Claims cost* | –0.14 | 0.058 | –0.26 to –0.026 | 0.016 |

*Costs compared using linear GEE model with gamma distribution and log link, clustered on recruit class.

All other outcomes (injury and claims frequency) compared using Poisson GEE model, clustered on recruit class.

$(e^{\beta} - 1) \times 100 = 13\%$ reduction in claims costs, comparing intervention group to controls.

GEE, generalised estimated equations; RA, recruit academy.

Table 5 Summary of costs of the PFF-Fit programme, presented in 2013 (US dollars)

| Programme supervision | No. of personnel | Hours/week | No. of weeks | Total hours | Hourly wages | Benefits* | Overhead costs† | Total costs‡ | Cost type |
|---|------------------|-------------|---------------|-------------|---------------|-----------|---|-----------------------|---|
| Safety and Health Captain | 1 | 6 | 26 | 156 | 37.57 | 12.02 | 9.39 | 9200.88 | Personnel |
| | 1 | 1 | 52 | 52 | 37.57 | 12.02 | 9.39 | 3066.96 | Personnel |
| RA | No. of personnel | Hours/week | No. of weeks | Total hours | Hourly wages§ | Benefits | Overhead costs | Total costs | Cost type |
| RA PFT | 1 | 5 | 20 | 100 | 16.63 | 5.32 | 4.16 | 2611.00 | Personnel |
| Visiting PFT—M/W/F workouts | 2 | 6 | 20 | 240 | 24.95 | 7.98 | 6.24 | 9400.80 | Overtime |
| Visiting PFT—once monthly run day | 1 | 2 | 5 | 10 | 24.95 | 7.98 | 6.24 | 391.70 | Overtime |
| Probationary year | No. of personnel | Hours/visit | No. of visits | Total hours | Hourly wages§ | Benefits | Overhead costs | Total costs | Cost category |
| PFT—station visits with probationary firefighters | 27 | 2 | 4 | 8 | 19.78 | 6.33 | 4.95 | 6708.96 | Personnel |
| Personnel—other | No. of personnel | Prep. hours | Interv. hours | Total hours | Hourly rate | Mileage | Benefits and overhead | Total costs¶ | Cost category |
| Nutritionist | 1 | 11 | 2 | 13 | 50.00 | 11.90 | n/a | 661.90 | Contractor |
| Programme materials | | | | | | | | Binders US\$150.00 | Materials |
| Total programme costs | | | | | | | 21 587.80 9792.50 661.90 150.00 US\$32 192.20 | | Personnel Overtime Contractor Materials Total |

*TFD calculates benefits as 32% of the hourly wage rate.

†Overhead costs were estimated at an additional 25% of hourly wages.

‡Total costs=number of personnel×total hours×(hourly wages+benefits+overhead).

§TFD estimates the base hourly rate for the rank of firefighter to be US\$16.63; engineers/paramedics, US\$19.78; captains, US\$22.93. Overtime wage rates are 1.5 times base hourly. PFTs with the rank of firefighter were selected for assignment to the RA. The median overtime wage rate (engineers/paramedics) was used to estimate costs of the instation visits during the probationary year.

¶Nutritionist total cost=(total hours×hourly rate)+mileage.

TFD, Tucson Fire Department; PFF-Fit, Probationary Firefighter Fitness programme; PFT, peer fitness trainers; RA, recruit academy.

Table 6 Summary of estimated costs and benefits of the PFF-Fit programme (in US dollars)

| Programme costs | | Programme benefits | |
|---|---------------|---|------------|
| Personnel costs | US\$21 587.80 | WC claims | |
| Overtime costs | US\$9792.50 | ▶ Mean cost per claim: 1737×22.72—US\$6679×22.72 avoided claims | US\$32 786 |
| Dietician contractor | US\$661.90 | ▶ mean cost per recruit: –1033×32 recruits | US\$33 056 |
| Programme materials | US\$150.00 | | |
| Total estimated costs | US\$32 192.20 | Approximate total benefits | US\$33 000 |
| (Claims cost reduction—programme cost)/ programme cost (33 000–32 192)/32 192 | | Return on investment | 2.4% |

PFF-Fit, Probationary Firefighter Fitness programme; WC, workers' compensation.

reduction in injury experienced by the 2012 class. Unfortunately, we do not have data on other possible explanatory factors such as fitness behaviours outside of work, previous experience as a firefighter or military veteran, etc. The apparent success of the PFF-Fit programme may have been due, at least in part, to safer fitness training routines that put the 2012 class at lower risk for injury, regardless of their overall fitness levels.

The use of historical controls presents a challenge, as we do not have details on the training approach used in the RAs prior to 2012. We did not design the study to specifically measure the differences in training and the impact this may have had on injury, especially exercise-related injury. The anecdotal evidence from TFD indicates the training used prior to the PFF-Fit programme may have been more repetitive in nature, with injury prevention not a focal point of the training staff. Less than half of the 2007 class successfully completed the probationary year, but the majority of the recruits dropped out in the RA for reasons other than injury (eg, poor performance on exams or skill evaluations). We do not have recruiting data, but the poor retention numbers in the 2007 class might have been the result of recruiting a group of less qualified candidates. The PFF-Fit programme may be a worthwhile programme to reduce injury and claims costs but further research is needed to better understand the programme's potential effectiveness during the RA and probationary year, and potentially the carryover effects that reduce injury potential further in the firefighters' careers.

Another important consideration is that the PFF-Fit programme was not the only intervention taking place at TFD. The University of Arizona has been working with the department for 5 years, implementing a broad risk management intervention with a focus on injuries occurring on the fireground, during patient transport and during physical fitness training. This department-wide intervention could have reduced injuries at the RA even in the absence of the PFF-Fit programme. The current study is unable to parse out any potential effect that the risk management intervention may have had on the training environment at the 2012 RA or during the probationary year.

Another important limitation is that other analyses of workers' compensation claims data at TFD indicates that the overall department experienced a high number of injuries and claims in 2007, 2008 and 2009, and a marked decline in injury and claims frequency and costs in 2012, which may explain some of the reductions in injury and claims we observed.¹⁶ It may not be possible to separate the effects of the PFF-Fit programme from overall downward temporal trend in injury and claims during the study period. The current study relied on historical controls, which is rarely a definitive approach, and there was a multiyear gap during which TFD did not conduct RA classes in the years 2010–2011. Future research is needed to

overcome the challenges of using and interpreting historical data. Specifically, future studies should include the use of contemporary controls and the full characterisation of the training methods used preimplementation and postimplementation.

There is also the possibility that the 2012 recruit class, who knew they were being studied for health, fitness and injury outcomes, could have behaved differently than the historical controls, not because of the intervention but because of a perceived need to not report injury to help improve the study results. Given the fact that the 2012 recruit class reported injuries and claims in both the RA and the probationary year, we have no reason to suspect these biases affected the study results; however, the potential influence of these biases was not specifically tested in this study.

CONCLUSION

We observed reductions in injury frequency and compensation costs among PFF-Fit programme participants compared with historical controls. The PFF-Fit programme may be a worthwhile programme to reduce injury and claims costs but further research is needed to better understand the programme's potential effectiveness. Future research on this and other health and fitness interventions is needed with additional recruit classes and a longer follow-up time to evaluate potential carryover effects into the recruit's career injury potential.

What is already known on the subject

- ▶ Among firefighters, higher levels of fitness are associated with decreased risk of non-exercise related injury but nearly a third of occupational injuries occur during physical training or exercise.
- ▶ Health and fitness interventions in the fire service have demonstrated reductions in injury and workers' compensation claims costs.

What this study adds

- ▶ We observed reductions in occupational injury and workers' compensation claims costs following implementation of the intervention and estimated a positive return on investment for the programme.
- ▶ Future research is needed on the potential benefits of the improved structure and management of physical fitness training for fire recruits.

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Contributors All authors contributed to the concept, design and execution of the study, and provided critical review of and final approval of the manuscript.

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REFERENCES

- Maguire BJ, Hunting KL, Guidotti TL, *et al.* Occupational injuries among emergency medical services personnel. *Prehosp Emerg Care* 2005;9:405–11.
- Reichard AA, Marsh SM, Moore PH. Fatal and nonfatal injuries among emergency medical technicians and paramedics. *Prehosp Emerg Care* 2011;15:511–17.
- US Department of Labor, Bureau of Labor Statistics. Workplace Injury and Illness Summary—2013. <http://www.bls.gov/news.release/osh.nr0.htm> (accessed Jun 2015).
- Karter MK, Stein GP. *US Fire Department Profile 2012*. Quincy, MA, USA: National Fire Protection Association, 2013.
- Karter MK, Molis JL. *US firefighter injuries 2012*. Quincy, MA, USA: National Fire Protection Association, 2013.
- Hilyer J, Weaver M, Gibbs J, *et al.* In-station physical training for firefighters. *Strength Cond J* 1999;21:60–4.
- International Association of Fire Fighters and International Association of Fire Chiefs. *The fire service joint labor management wellness-fitness initiative*. 3rd edn. Washington, DC: International Association of Fire Fighters, 2008.
- Poston WSC, Haddock CK, Jahnke SA, *et al.* An examination of the benefits of health promotion programs for the national fire service. *BMC Public Health* 2013;13:805.
- Poplin GS, Roe DJ, Peate W, *et al.* The association of aerobic fitness with injuries in the fire service. *Am J Epidemiol* 2014;179:149–55.
- Jahnke SA, Poston WS, Haddock CK, *et al.* Injury among a population based sample of career firefighters in the central USA. *Inj Prev* 2013;19:393–8.
- Poplin G, Harris R, Pollack K, *et al.* Beyond the fireground: injuries in the fire service. *Inj Prev* 2012;18:228–33.
- Leffer M, Grizzell T. Implementation of a physician-organized wellness regime (POWR) enforcing the 2007 NFPA standard 1582: injury rate reduction and associated cost savings. *J Occup Environ Med* 2010;52:336–9.
- Kuehl KS, Elliot DL, Goldberg L, *et al.* Economic benefit of the PHLAME wellness programme on firefighter injury. *Occup Med* 2013;63:203–9.
- Poplin GS, Pollack KM, Griffin S, *et al.* Establishing a proactive safety and health risk management system in the fire service. *BMC Public Health* 2015; 15:407.
- US Department of Labor, Bureau of Labor Statistics. Consumer Price Index, 2014. 2015. <http://www.bls.gov/cpi/> (accessed Jun 2015).
- Griffin SC. *Economic evaluation of injury and injury prevention interventions in the US fire service*. The University of Arizona. ProQuest Dissertations Publishing, 2014. Document ID 3634243.

Basketball team opposes its state's proposed gun bill

In Oklahoma, residents wishing to carry a firearm openly or concealed had been required to get a gun licence. It included a criminal and mental health background check and some firearms training. The state is now proposing that adults be permitted to openly carry guns without any training or background checks. This has led to disputes between supporters of expanded gun rights and the state's business community, including its basketball team. The team is among many university and law enforcement groups urging that the proposed bills be stopped.

Predicting when basketball injuries will happen?

A study that attempts to predict when National Basketball Association injuries will occur claims that resting the 20% of players above a certain risk threshold could avert 60% of injuries. Teams now know that they should not use their stars for long periods. The study used machine-learning methods to analyse 500 injuries from the last two seasons to isolate factors causing injuries. The least important factors were the number of games played in the last 14 days and the number of games on consecutive nights. Better indicators were a player's speed, usage and overall season workload.

The professional rugby injury surveillance project

A comprehensive injury surveillance project in UK professional rugby shows that the chance of a player sustaining a match or training injury has not appreciably changed since 2002. But there appear to be more severe injuries. Concussion remains the leading injury for the fourth consecutive season. This may be attributable to more powerful professional players, increasing frequency of contact, or both. This report was published in the *British J Sports Medicine*. Comment: in relation to an earlier posting, the study found no clear differences in the incidence, severity or injury burden between matches played on artificial turf and natural grass.