Journal of Exercise Physiologyonline

October 2018
Volume 21 Number 5

Official Research Journal of the American Society of Exercise Physiologists

ISSN 1097-9751

JEPonline

Specified Training to Improve Functional Fitness and Reduce Injury and Lost Workdays in Active Duty Firefighters

Adam C. La Reau, Maria L. Urso, Brice Long

O2X, Boston, MA, USA

ABSTRACT

La Reau AC, Urso ML, Long B. Specified Training to Improve Functional Fitness and Reduce Injury and Lost Workdays in Active Duty Firefighters. **JEPonline** 2018;21(5):49-57. Musculoskeletal injuries are common in active duty firefighters. These injuries have significant medical and operational effects including increased prevalence of cardiovascular disease and excessive costs related to treatment and disability. The purpose of this study was to determine the impact of a comprehensive health, wellness, and safety initiative on overall fitness and injury prevalence in active duty firefighters. This retrospective analysis, collected data from firefighters (N=148) who participated in O2X training programs between September 2016 and March 2017. The training consisted of an initial lead-in week that included 40 hrs of lectures and supervised physical training followed by a periodized, tactical exercise training program. Demographics and performance scores from a battery of tests known as Key Performance Indicators (KPIs) were collected at baseline and at the end of each 16-wk program. The number of injuries contributing to paid time off, sick calls, salary and overtime costs, incidence of musculoskeletal injury, and incidence of disease were evaluated. KPIs improved in more than 89% of the population, depending on the fitness outcome. Overall cost savings was $6.3 million. The most impactful changes included a 19% reduction in monthly injuries and paid time off, 39% reduction in monthly sick calls, 33.3% reduction in costs related to Cardiac disease, 23.4% reduction in Cancer-related costs, and a 20% reduction in neck injury costs. These data demonstrate that the five principles of improvement established and reinforced by O2X are effective in instilling sustainable gains, functional fitness, and reducing injury in fire department personnel.

Key Words: Disease, Functional Fitness, Tactical Athlete, Firefighter

INTRODUCTION

Physical fitness training that is appropriate for the demands of the tactical environment is imperative for survival and mission success (7). Military, police, and fire personnel are considered tactical athletes due to the strength, agility, speed, and endurance required to perform their jobs and succeed despite harsh or dangerous conditions (9). While many of these personnel have long periods of sedentary and passive activity, they are often required to instantly shift to hostile environments where maximal physical exertion is required. The ability for a tactical athlete to perform various physical responsibilities will determine the operational effectiveness of an individual and, in some cases, the entire unit. As such, physical training programs must include exercises that are designed to improve strength, endurance, and agility in a manner that translates to improvements in functional performance while reducing incidence of injury (8,15). Currently, the rates of musculoskeletal injury, chronic illness, and mental health issues, are on the rise in tactical populations (1-3). Sub-standard physical performance has become a significant risk factor for attrition, career development, and work-related injury.

Among tactical populations, there has been significant growth in the popularity of programs such as CrossFit and High-intensity Interval Training (HIIT) (7). However, a limitation is that these programs were originally designed for civilian personnel who are not faced with the same occupational, physical, and mental demands as tactical athletes. While short-term measures of physical fitness may improve with these civilian-based programs, mission specificity and integration are neglected. Consequently, training may not be practical or sustainable and injury remains a significant risk factor.

As the evidence in the performance-literature has demonstrated for decades, an effective training program needs to incorporate overload and specificity, but also be sustainable (10,11). For this reason, O2X developed a specialized 16-wk program for tactical athletes. The evidence-based, physical training regimen incorporates movements that tactical athletes require in their daily tasks. The program targets aerobic capacity, anaerobic power, flexibility, and muscular strength and endurance.

At the same time, the program provides instruction on how to obtain the appropriate body composition for gender, age and occupational tasks. Others before us have used training programs to train cadets and military personnel, but a consistent limitation is a plateau in gains early in the program with no evidence of sustainable changes, injury reduction, or long-term cost savings (4,5,14,16). Therefore, the purpose of this work was to retrospectively investigate the impact of a periodized 16-wk functional training program on a cohort of fire department personnel to identify the magnitude of performance gains, health-related measures, and over the long-term, injury prevalence and department cost savings.

METHODS

Subjects

For physical fitness outcomes, the data were retrospectively analyzed from 148 firefighters (100% male, mean body mass 190.2 ± 24.6 lbs) who completed baseline Key Performance Indicator (KPI) testing and the 16-wk training program. For 24 hrs before each testing session, the subjects were encouraged to refrain from high intensity physical activity and

consuming excessive caffeine or alcohol. All subjects provided consent to collect the performance measures. The data were de-identified prior to analysis by an outside consultant.

For health economic outcome measures, data from 900 active duty firefighters who participated in the O2X training course between May 2015 and December 2017 were analyzed retrospectively.

Physical Fitness Testing

Testing of KPIs was performed at weeks 1 (baseline), 8, and 16. KPIs included Bodyweight Squats, Push-ups, Pull-ups, Plank, and a 1.5-mile run (or 1K row) test. The subjects were tested at the same time of day and wore their own fitness clothing. The order of tests went from non-fatiguing (bodyweight), to strength, to endurance. There was a 2-min rest between each strength test, and a 10-min rest allowed before the endurance test. In addition to the time or number of repetitions, subjects were scored on a 5 point scale (0 to 4), based on the number of repetitions completed or time taken to complete the run. The benefit of the scoring matrix is that it serves as an indicator for a firefighter's likelihood of injury (Table 1).

Table 1. Key Performance Indicators, Scores, and Likelihood of Injury (17, 18)

Score	Plank (max)	Pull Ups (max)	Push Ups (1 min)	Bodyweight Squats (1 min)	Run (1.5 miles)	
4 Points	>4:00	>19	>70	>62	<9:00	Outstanding
3 Points	3:05	15	56	54	10:05	Excellent
2 Points	2:13	10	41	46	11:02	Good
1 Point	1:00	5	30	33	12:32	Standard
0 Points	<1:00	<5	<30	<33	>12:32	Below Standard

Shaded area = increased likelihood of injury

Bodyweight

Body weight was collected on a standard scale before any physical testing to ensure that hydration status did not affect body weight measures. The subjects removed shoes and were weighed in their shirt and shorts. They were asked to wear the same (or similar) clothing at the 16-wk follow-up measure.

Upper-Body Strength and Endurance Test

The push-up test was used to assess upper body push strength and endurance. The subjects were scored on the maximum number of full repetitions completed in 1 min. The subjects were permitted to pause in the upright position, but could not rest the chest on the floor. Once any part of the body touched the floor (aside from hands and feet), the test was terminated.

Lower Body Strength and Endurance Test
Body weight squats were used to assess lower body strength and endurance. A full squat required that the subject lower to a seated position with the thighs parallel and then return to the starting position in a single, explosive motion. The subjects were scored on the number of repetitions completed in 1 min.

Upper Body Strength Test
The pull-up test was used to assess subject's upper body pull strength. The subjects began in a 'dead hang' position on a bar, to avoid the use of an explosive start motion. With palms facing out, the subjects pulled their body upwards until their chin was over the bar. Once the chin had cleared the bar, subjects lowered themselves back to the start position with arms extended. Kipping and swinging were not permitted. The subjects were scored on the number of repetitions completed in 1 min, or when they fatigued and lost contact with the bar.

Core Strength and Endurance Test
The plank was performed until fatigue, with the subjects' score being the maximum amount of time that they were able to hold the plank. Fatigue/test failure was documented when the hips began to drop or if they were raised into the air.

Aerobic Endurance Test
After a 10-min rest, the subjects completed the 1.5-mile run test. The test took place outdoors on a marked course with little to no incline. The time to complete a distance of 1.5 miles was recorded in minutes and seconds.

O2X Training Program
As part of the O2X curriculum, the subjects were encouraged to participate in a physical training program for 90 min, 4 $d \cdot wk^{-1}$ for 16 wks. The exercise program was a comprehensive, full-body, program that incorporated a warm-up, endurance training, strength training, and a cool-down/recovery period. The program followed O2X's prepare, sweat, and recover training methods. The subjects continually increased their training load over the course of the 16-wk program. To keep the subjects engaged, O2X designed and deployed a mobile app that was used by all subjects. The mobile app was installed on the subject's personal mobile device and incorporated daily coaching according to the O2X eat, sweat, and thrive principle.

To increase adherence to the program, O2X allowed training sessions to take place at a time convenient for the subject. This aspect of the program ensured that once the 16-wk data collection period was over, the subjects would have integrated the program into their daily routine at a time that was convenient for them. Each session consisted of three segments: Prepare, Sweat, and Recover. In the prepare segment, pillar activation, chain activation, and anatomical alignment exercises were used. In the Sweat segment, exercises involved movements that would enhance triple extension speed, lower body push-pull movements, upper body push-pull movements, and horizontal and vertical conditioning movements that stressed the aerobic and anaerobic energy systems. The Recover segment consisted of foam rolling and static stretching.

The comprehensive program targeted specific energy systems and functional skills that target the rigors of the firefighter. For example, a 15 to 20 min conditioning obstacle course was

constructed of movements and exercises that stressed the aerobic and anaerobic energy systems and mirrored the routine activities of a firefighter.

Statistical Analyses

A one-way analysis of variance (ANOVA) was used to test for differences in markers of physical fitness across the 16-wk training program. Statistical significance was defined as $P<0.05$ for all the tests. Statistical analyses were performed using a statistical software package (SPSS, version 18, SPSS Inc, Chicago). All values are presented as mean ± SD.

RESULTS

Body Weight

Mean body weight did not show a statistically significant change during the course of the 16-wk program. However, ~40% of the new recruits set a goal to increase lean body mass and gain weight during the course of the program. When examining individual scores, those who intended to lose weight decreased their body weight between 1 and 9 lbs over the course of 16 wks.

Fitness Test Outcomes

Specific data for each test are included in Table 2. In sum, by week 16, 96% of the participants improved their push-up score, 99% improved their total squats, 91% improved the number of pull-ups completed, and 89% increased plank duration. When grouped by baseline score, statistical improvements were significant ($P<0.05$).

Aerobic Endurance Test

At baseline, the average time taken to run 1.5 miles was 11 min and 55 sec. Mean run time at the end of the 16-wk training program was 11 min and 13 sec. Seventy-nine percent of the subjects decreased their overall run time. This decrease was considered statistically significant ($P<0.05$).

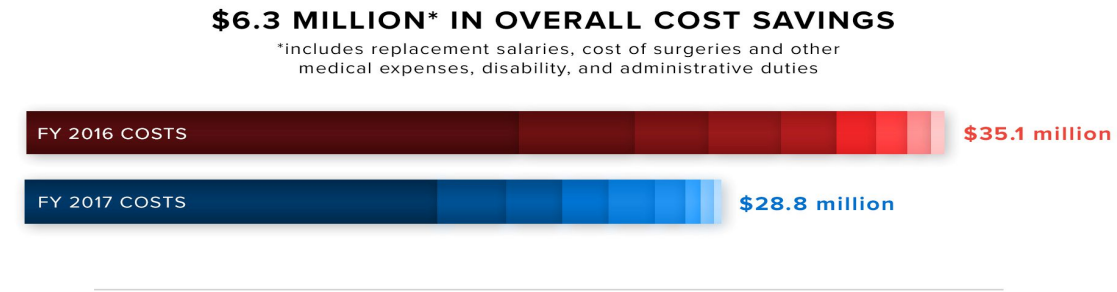
Table 2. Fitness Test Outcomes at Baseline, 8- and 16- Wks (mean ± SD).

	Plank (max)	Pull Ups (max)	Push Ups (1 min)	Bodyweight Squats (1 min)	Run (1.5 miles) Mm:ss
Baseline	2:06 ± 1:08	10.1 ± 6.5	47.8 ± 16.2	49.1 ± 9.8	11:59 ± 42
Week 8	2:44 ± 1:16	12.3 ± 7.0	56.5 ± 14.5	58.8 ± 10.0	11:03 ± 30
Week 16	2:55 ± 1:21	13.7 ± 6.8	65.7 ± 14.5	66.7 ± 8.6	11:13 ± 32

Health Economic and Injury Outcomes

Overall cost savings that based on records collected from departments participating in the O2X training program was $6.3 million dollars. The most impactful changes included a 19% reduction in monthly injuries and paid time off, a 39% reduction in monthly sick calls, a 33.3% reduction in costs related to Cardiac disease, a 23.4% reduction in costs related to Cancer, and a 20% reduction in costs related to Neck injuries. Specific data are included in Figure 1.

$4.7 M cost savings can be broken into two components: (a) total injuries; and (b) sick call. Assuming an annual salary of $130 k per FF ($356/day), there was a 9% decrease in total injuries over the previous fiscal year (942 to 857) and a 28 day average down time which comes out to $848 k savings. There was also a 39% drop in sick calls (11,838 to 7,262). Assuming at least one day per sick call there was a $1.63 M savings. In addition to these cost savings, there was also replacement and overtime that has to be taken into account. We assumed 66% of the injuries and sick days required replacement and overtime at 150% rate - this savings totaled $2.3 M in savings.



	Salary and Overtime Costs	Cancer	Cardiac	Lung	Shoulder	Knee	Neck	Cervical	Administrative	Total
2016	$21.9M	$3.0M	$0.9M	$1.3M	$2.1M	$1.8M	$0.5M	$0.6M	$3.1M	$35.1M
2017	$17.2M	$2.3M	$0.6M	$1.3M	$2.0M	$1.8M	$0.4M	$0.5M	$2.8M	$28.8M

Figure 1. Department-Wide Injury- and Sickness- Related Costs.

DISCUSSION

Our retrospective review of pre- and post-fitness scores from 148 fire department new recruits who participated in a 16-wk progressive training program reveals that overall indices of physical fitness improved in more than 89% of the population, depending on the specific fitness outcome. More importantly, at 8 wks into the program while scores showed improvement, the improvements continued over the 16-wk period. Previous 16-wk training programs have shown that gains tend to taper-off at 8 wks, with little to no further improvements at the 16-wk mark (5). Additionally, while others before us have shown the short-term effects on reducing occupation-related injury and illness in firefighters, long-term outcomes have not been published (6,12).

In total, program benefits outweighed costs in >1,500 fire department personnel. This return on investment is higher than what has been reported in other health intervention studies in the fire service (6,12,13). O2X's emphasis on functional fitness and continued monitoring and support through the O2X Eat, Sweat, Thrive mobile App, contributed to the success of this program. The comprehensive O2X program, which targets bodyweight- and occupation-specific exercises, ensures specificity and sustainability. Previous research has identified that most injuries occur while attending to fire station duties, with lifting injuries occurring with the highest frequency and cost (6,19). With these data in mind, the foundation of the O2X training program is the needs of tactical athlete, specifically the firefighter.

This program incorporates exercises, at a rate of four times per week, which provides exposure to the movements, physiological stressors, and overall demands of the firefighter's job. This physiological approach of using a periodized training program induces developmental training effects. As a result, those who participate realize not only adaptive gains in strength and overall fitness, but there are also residual training effects that continue to maintain the fitness and health of the firefighter. Ultimately, the physical training program helps new recruits train to properly prepare for the tactical nature of their job, while helping veteran firefighters improve and maintain occupational-specific fitness.

Outside of the reduced injury and sick-costs realized as a result of the training program, the long-term benefit of the program is that it promotes the structure and management of a sustainable exercise program. Measures of health and fitness improved across all assessments in almost 90% of subjects. These changes are expected to maintain in a majority of the subjects based on the overall changes made to the 'firehouse lifestyle' following the O2X intervention. It is expected that these changes will contribute to sustainable behaviors among the fire department personnel, continue to contribute to the decline in injury rates, sick time, cancer incidence, and cardiovascular disease.

Limitations in the Study

Unlike many supervised exercise and nutritional training programs, the data in the present study are based on a cohort with diverse demographics. There was a wide range of body compositions, fitness outcomes, and strength characteristics among the subjects. Consequently, despite participating in similar training, the magnitude of improvement for many of the fitness scores varied and statistical differences were not documented. Additionally, it was not possible to collect individual subject data related to injury reduction and cost savings, which prevented a true analysis of the effect of the training program on individual cost savings.

CONCLUSIONS

We report improvements in overall fitness and reductions in injury occurrence and compensation costs among firefighters as a result of the O2X training program. The initiation of the O2X eat, sweat, and thrive philosophy and training has demonstrated extreme promise in reducing injury, illness, and claims costs over the long term. The importance of these data are that they demonstrate that the five principles of improvement for O2X are effective in instilling sustainable gains, functional fitness, and reducing injury in the fire department

personnel. These data are critical in establishing training programs that will contribute to sustained improvements in overall fitness and reductions in injury and illness.

ACKNOWLEDGMENTS

The authors would like to thank the volunteers who participated in the study, particularly the personnel and support staff of the Boston Fire Department. The authors declare that the tests conducted were in compliance with the current laws of the country in which they were performed.

Address for correspondence: O2X Human Performance, 1147 Hancock St. #223, Quincy, MA, 02169, Email: urso.maria@gmail.com

REFERENCES

1. Abt JP, Sell TC, Lovalekar MT, Keenan KA, Bozich AJ, Morgan JS, Kane SF, Benson PJ, Lephart SM. Injury epidemiology of U.S. Army Special Operations forces. ***Mil Med.*** 2014;179:1106-1112.

2. Brooks SK, Dunn R, Amlot R, Greenberg N, Rubin GJ. Social and occupational factors associated with psychological distress and disorder among disaster responders: A systematic review. ***BMC Psychol.*** 2016;4:18.

3. Brooks SK, Dunn R, Amlot R, Rubin GJ, Greenberg N. Social and occupational factors associated with psychological wellbeing among occupational groups affected by disaster: A systematic review. ***J Ment Health.*** 2017;1-12.

4. Cocke C, Dawes J, Orr RM. The use of 2 conditioning programs and the fitness characteristics of police academy cadets. ***J Athl Train.*** 51;887-896:2016.

5. Crawley AA, Sherman RA, Crawley WR, Cosio-Lima LM. Physical fitness of police academy cadets: Baseline characteristics and changes during a 16-week academy. ***J Strength Cond Res.*** 2016;30:1416-1424.

6. Griffin SC, Regan TL, Harber P, Lutz EA, Hu C, Peate WF, Burgess JL. Evaluation of a fitness intervention for new firefighters: Injury reduction and economic benefits. ***Inj Prev.*** 2016;22:181-188.

7. Haddock CK, Poston WS, Heinrich KM, Jahnke SA, Jitnarin N. The benefits of high-intensity functional training fitness programs for military personnel. ***Mil Med.*** 2016;181:e1508-e1514.

8. Hendrickson NR, Sharp MA, Alemany JA, Walker LA, Harman EA, Spiering BA, Hatfield DL, Yamamoto LM, Maresh CM, Kraemer WJ, Nindl BC. Combined resistance and endurance training improves physical capacity and performance on tactical occupational tasks. ***Eur J Appl Physiol.*** 2010;109:1197-1208.

9. Kechijian D, Rush S. Tactical physical preparation: The case for a movement-based approach. ***J Spec Oper Med.*** 2012;12:43-49.

10. Kraemer WJ, Duncan ND, Volek JS. Resistance training and elite athletes: Adaptations and program considerations. ***J Orthop Sports Phys Ther.*** 1998;28:110-119.

11. Kraemer WJ, Ratamess NA, French DN. Resistance training for health and performance. ***Curr Sports Med Rep.*** 2002;1:165-171.

12. Kuehl KS, Elliot DL, Goldberg L, Moe EL, Perrier E, Smith J. Economic benefit of the PHLAME wellness programme on firefighter injury. ***Occup Med (Lond).*** 2013;63: 203-209.

13. 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;52:336-339.

14. Liguori G, Krebsbach K, Schuna J, Jr. Decreases in maximal oxygen uptake among army reserve officers' training corps cadets following three months without mandatory physical training. ***Int J Exerc Sci.*** 2012;5:354-359.

15. Nindl BC, Alvar BA, J RD, Favre MW, Martin GJ, Sharp MA, Warr BJ, Stephenson MD, Kraemer WJ. Executive summary from the National Strength and Conditioning Association's second blue ribbon panel on military physical readiness: Military physical performance testing. ***J Strength Cond Res.*** 2015;29 Suppl 11:S216-220.

16. Rossomanno CI, Herrick JE, Kirk SM, Kirk EP. A 6-month supervised employer-based minimal exercise program for police officers improves fitness. ***J Strength Cond Res.*** 2012;26:2338-2344.

17. Teyhen DS, Shaffer SW, Butler RJ, Goffar SL, Kiesel KB, Rhon DI, Boyles RE, McMillian DJ, Williamson JN, Plisky PJ. Application of athletic movement tests that predict injury risk in a military population: Development of normative data. ***Mil Med.*** 2016;181:1324-1334.

18. Teyhen DS, Shaffer SW, Butler RJ, Goffar SL, Kiesel KB, Rhon DI, Williamson JN, Plisky PJ. What risk factors are associated with musculoskeletal injury in US army rangers? A Prospective Prognostic Study. ***Clin Orthop Relat Res.*** 2015;473:2948-2958.

19. Walton SM, Conrad KM, Furner SE, Samo DG. Cause, type, and workers' compensation costs of injury to fire fighters. ***Am J Ind Med.*** 2003;43:454-458.