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Firefighters Versus Law Enforcement Officers: A Comparison of Cardiovascular Disease Risk

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Abstract

International Journal of Exercise Science 18(6): 659-671, 2025. https://doi.org/10.70252/WHUP7091 Firefighters (FFs) and law enforcement officers (LEOs) have heightened cardiovascular disease (CVD), with data suggesting that ≈45% of on-duty FF fatalities are related to CVD, while LEOs have a 1.7 times higher CVD prevalence than the general public. This study compared CVD risk biomarkers, fitness, and body composition between FFs and LEOs. Ninety-eight career, structural male FFs (age = 35.1±9.6 yrs; weight = 94.3±15.4 kg; height = 178.4±13.2 cm) and seventy-three career LEOs (age = 41.4±9.0 yrs; weight = 92.3±16.8 kg; height = 179.6±8.1 cm) from local departments were studied. Participants completed a maximal cardiopulmonary exercise test (CPXT), where VO_{2max} was estimated from the Foster equation. Fasted blood was collected to assess CVD risk biomarkers. Dual-energy X-ray absorptiometry assessed body composition, and waist and hip measures were taken. Analyses with and without women participants were conducted to assess differences in CVD risk biomarkers, fitness, and body composition between the FFs and LEOs. Effect sizes were calculated and reported as Cohen's *d*. Univariate general linear model (GLM) analysis of covariance (ANCOVA) were conducted to account for age as a covariate, wherein partial Eta squared (η_p^2) values were used to assess effect size for the GLM statistics. FFs had higher ($p<0.05$) CPXT exercise times (FFs: 10.9±1.6 min; LEOs: 10.3±2.0 min; d=0.366) compared to LEOs. FFs also had higher ($p<0.05$) advanced oxidation protein products (FFs: 134.8±90.1 µM; LEOs: 106.8±67.6 µM; d=0.342), blood cortisol (FFs: 14.2±5.0 µg/dL; LEOs: 12.5±5.6 µg/dL; d=0.325), and waist-to-hip ratios (FF: 0.95±0.06; LEO: 0.89±0.08; d=0.792). These findings suggest that while FFs demonstrated greater CPXT time-to-exhaustion, they also expressed higher stress and CVD risk biomarkers concentrations than LEOs. These data suggest that occupation-specific characteristics and stressors may play a role in the CVD risk profile of first responders.

Keywords: First responders, physiological stress, oxidative stress, inflammation, obesity

Introduction

Cardiovascular disease remains the leading cause of death worldwide, taking an estimated 17.9 million lives each year.[1] The National Institute for Occupational Safety and Health has previously identified first responder groups, such as firefighters (FFs) and law enforcement officers (LEOs), as occupations that appear to be at a greater risk of CVD.[2] Indeed, previous investigations have found that sudden cardiac death accounted for 45-50% of on-duty fatalities among career structural FFs,[3,4] while CVD prevalence among LEOs was 1.7 times higher than age-matched controls.[5] While traditional risk factors, such as obesity and hypertension, have been identified as predictive measures of CVD risk for FFs and LEOs, recent work has demonstrated that non-conventional biomarkers may offer more comprehensive insight into CVD risk.[6,7] However, to our knowledge, studies comparing FF to LEO in terms of physiological stress, oxidative stress, and inflammatory biomarkers indicative of CVR risk as a more comprehensive assessment has not been published. This information is necessary to better understand differences in occupational disease risk and to help further understand the relationship between stress and CVD markers.

FFs and LEOs regularly perform physically demanding tasks as part of their day-to-day operations, such as lifting and dragging heavy objects, casualty rescue, and responding to emergency scenarios, exposing them to repeated bouts of acute stress.[8-10] In response to stress, the sympathetic-adreno-medullar (SAM) axis and the hypothalamic-pituitary-adrenal (HPA) axis are activated, stimulating the release of catecholamines and cortisol to help the body meet demands.[11] However, chronic activation of the SAM and HPA axis leads to many adverse effects, such as high levels of oxidative stress and inflammation. Oxidative stress and inflammation biomarkers, such as advanced oxidation protein products (AOPP) and C-reactive proteins (CRP), have been shown to promote atherosclerosis, a major contributor to the development of CVD have been identified as potential predictors of CVD risk among FFs[6,7,12] and LEOs.[13] However, data comparing both occupational groups concerning these biomarkers are lacking.

Previous reports have suggested that FFs and LEOs may have similar occupational demands and operate in high-stress conditions.[14-17] For instance, Gonzalez et al [16] demonstrated that 27 firefighters performing fire suppressive tasks (i.e., live fire training evolutions and simulated fire ground tests) reached heart rate values of ≈93-97% age-predicted heart rate maximum ($APHR_{max}$), which is consistent with other reports demonstrating the intense cardiovascular demands of firefighting. Robinson and colleagues[17] found that among 8 specialist police tactical officers, completing an active shooter scenario reached ≈89% $APHR_{max,}$ with over 50% of the scenario being performed between ≈90-100% $APHR_{max}$. Gonzalez et al[14] reported elevations in salivary concentrations of α-amylase (sAA, 94%), secretory immunoglobulin a (42%), and cortisol (sCORT; 91%) post-live fire training evolutions. Similarly, Ramey et al[15] found that job demand was positively associated with an 88% increase in interleukin-1β in LEOs. While both occupational groups experience occupational scenarios contributing to heightened biomarkers of stress, it remained unclear if these groups have differing disease and premature mortality risks depending on the specific occupational stressors faced. Therefore, this study aimed to compare CVD risk biomarkers, fitness, and body composition metrics between career FFs and LEOs to better understand the differences in occupational disease risk between these groups.

Methods

Participants

Retrospective data for ninety-eight career, structural FFs (n = 98, 97 = men, 1 women; age = 5.1±9.6 yrs; weight = 94.3±15.4 kg; height = 178.4±13.2 cm) and seventy-three career LEOs (n = 73, 66 men, 7 women; age = 41.4±9.0 yrs; weight = 92.3±16.8 kg; height = 179.6±8.1 cm) from local fire and police departments were used for this analysis. The participants provided written informed consent before completing a series of general health and lifestyle history questionnaires that screen for any signs, symptoms, and diagnosis of cardiometabolic and blood diseases/disorders. Data collection occurred during the spring of 2023 as part of the annual clinical testing in which the fire and police departments participated. This study was carried out in full accordance with the declaration of Helsinki as well as the ethical standards of the *International Journal of Exercise Science*.[18] All experimental procedures subsequently described were approved by the Institutional Review Board of Texas A&M University (IRB2023-0957D).

Protocol

The subsequent procedures have been previously described[6,7] and are part of a large annual clinical testing battery conducted with local first responders. Briefly, each participant completed two testing days, including a bio-sample collection and a laboratory testing day. The bio-sample collection day was conducted at the respective local fire or police departments and allowed for high-volume collection of blood and salivary bio-samples. Then, the laboratory testing day consisted of assessments for resting hemodynamics (i.e., resting heart rate and resting systolic and diastolic blood pressure), anthropometrics (i.e., waist and hip circumferences, height, body mass, and body mass index [BMI]), body composition via a dual-energy x-ray absorptiometry scan (DEXA; Hologic Horizon A, Marlborough, MA), muscular strength (i.e., hand grip strength), muscular endurance (i.e., push-ups), flexibility (i.e., sit-and-reach), and a maximal cardiopulmonary exercise test (CPXT), where VO_{2max} was estimated from the Foster equation using time-to-exhaustion (TTE) [19]. All resting hemodynamic and anthropometric assessments followed standard American College of Sports Medicine and World Health Organization procedures.[20-22] The CPXT was completed on a standard TM65 treadmill with a 12-lead electrocardiogram system (Quinton Q Stress System, Cardiac Science Corporation, Bothell, WA]) and utilized the Bruce protocol.

Following standard phlebotomy procedures, ≈8.5 mL of fasted (>12 hours; overnight) blood was collected from the antecubital fossa into 2 × 8.5 mL serum separation tubes (SST) and 1 × 4 mL K2 EDTA tube (Becton, Dickinson and Company, Franklin Lakes, New Jersey) [22]. Immediately after collection, the bio-samples were allowed to rest, clot at room temperature (≈30 minutes), and then transported to a Biosafety Level 2 (BSL-2) laboratory (within 1 hour of collection). Then, the bio-samples were centrifuged for 15 minutes at 2500 rpm at 4°C. One SST was immediately sent on ice to a commercial laboratory (Clinical Pathology Labs Inc., Austin, TX) for analysis of total cholesterol (TC), triglycerides (TAG), high-density lipoprotein cholesterol (HDL-c), low-density lipoprotein cholesterol (LDL-c), glucose, and hemoglobin-A1c (HbA1c). The second SST had serum aliquoted and stored at −80°C and later analyzed for insulin, AOPP, cortisol, and CRP concentrations. The insulin, AOPPs, cortisol, and CRP concentrations were analyzed in duplicate using commercially available enzyme-linked immunosorbent assay (ELISA) kits: insulin (ALPCO, Salem, NH), AOPPs (Cell Biolabs, San Diego, CA), blood cortisol (EagleBio, Amherst, NH), and CRP (R&D systems, Inc. Minneapolis, MN) following the manufacturer instructions. Absorbance was detected via a BioTek colorimetric plate reader (Winooski, VT). Homeostatic Model Assessment for Insulin Resistance was calculated by fasting glucose concentrations (mg/dL) × fasting insulin concentrations (μU/mL)/405.

The saliva samples were obtained from a passive drool collection method previously used [14] and subsequently analyzed for concentrations of sAA and sCORT. Participants were asked to mouth rise with water (≈10 minutes) before providing the saliva sample. After collection, the saliva samples were transferred to a BSL-2 laboratory for storage at −80°C and later analyzed. Before analysis, the samples were thawed and centrifuged for 15 minutes at 1500 rpm at 4°C. Then, samples were analyzed in duplicate for sAA and sCORT concentrations using commercially available ELISA kits (Salimetrics, PA). Absorbance was detected via a BioTek plate reader (Winooski, VT). An automated washer was used to wash assays (BioTek, Winooski, VT). The intra-assay and inter-assay coefficients of variation were <10% for all assays.

Statistical Analysis

All statistical procedures were performed with the IBM® Version 30 SPSS® statistical analysis software (IBM Corp., Armonk, NY, USA). Data are reported as means ± standard deviations (SD). The Shapiro-Wilk Test was used to assess normality. We did analysis with and without women participants (which was ran excluding women participants due to a low sample size [n=8]) using independent sample T-tests or non-parametric Mann-Whitney U tests (if normality was violated) to assess differences in CVD risk biomarkers, fitness, and body composition between the FFs and LEOs. Effect sizes were calculated and reported as Cohen's d (i.e., small [0.2-0.5], medium [0.5-0.8], large [>0.8]). In addition, we used a univariate general linear model (GLM) analysis of covariance (ANCOVA) to account for age as a covariate, for the demographic, blood biomarker, anthropometric and body composition, and fitness parameter data. The α-level (type I error) was set at a p-level probability of 0.05 or less. Partial Eta squared (η_p^2) values were used to assess effect size, where values of 0.01 (small effect), 0.06 (medium effect), and 0.14 (large effect), were reported for the GLM statistics.

Results

Regarding the demographic data (Table 1), statistically significant differences were noted for age ($t(161)=-4.292$, $p<0.001$), resting heart rate ($t(148)=2.569$, $p=0.011$), and resting systolic blood pressure ($U=3759.5$, $p=0.019$) when including women within the analysis. These differences remained when excluding the women from the analysis. When accounting for age as a covariate, the occupational groups differed only for resting diastolic blood pressure ($p=0.038$, $\eta_p^2=0.028$)

with age having an effect on resting systolic blood pressure (p=0.006, η_p^2=0.049), but not difference between the occupational groups.

Table 1. Demographic Data

		Including Women				Excluding Women				GLM Univariate ANCOVA*		
Variable	Occ	*n*	Mean	p-Value	d	*n*	Mean	p-Value	d	Source	p-Value	η_p^2
Age	FFs	*98*	35.2 ± 9.6	<0.001	-0.667	*97*	35.2 ± 9.7	<0.001	-0.685	Age	-	-
(yrs)	LEOs	*73*	41.4 ± 9.0			*66*	41.7 ± 9.1			Occ	-	-
Height	FFs	*98*	178.4 ± 13.2	0.516	-0.102	*97*	178.4 ± 13.3	0.130	-0.212	Age	0.611	0.002
(cm)	LEOs	*67*	179.6 ± 8.1			*61*	180.8 ± 7.0			Occ	0.282	0.007
Weight	FFs	*98*	94.3 ± 15.4	0.381	0.124	*97*	94.4 ± 15.4	0.700	0.063	Age	0.327	0.006
(kg)	LEOs	*67*	92.3 ± 16.8			*61*	93.4 ± 16.2			Occ	0.506	0.003
Body Mass Index	FFs	*98*	31.0 ± 18.0	0.393	0.169	*97*	31.1 ± 18.0	0.292	0.173	Age	0.499	0.003
(kg/m^2)	LEOs	*67*	28.6 ± 4.8			*61*	28.6 ± 4.6			Occ	0.425	0.004
Resting Heart Rate	FFs	*97*	82.3 ± 12.5	0.013	0.390	*96*	82.0 ± 12.4	0.011	0.437	Age	0.080	0.021
(bpm)	LEOs	*60*	77.0 ± 15.0			*54*	76.4 ± 13.7			Occ	0.056	0.025
Systolic Blood Pressure	FFs	*98*	121.1 ± 6.6	0.019	-0.360	*97*	121.2 ± 6.6	0.032	-0.341	Age	0.006	0.049
(mmHg)	LEOs	*63*	123.9 ± 9.5			*57*	123.9 ± 9.6			Occ	0.239	0.009
Diastolic Blood Pressure	FFs	*98*	77.4 ± 5.0	0.271	0.178	*97*	77.5 ± 5.0	0.178	0.215	Age	0.051	0.051
(mmHg)	LEOs	*63*	76.5 ± 5.2			*57*	76.4 ± 5.3			Occ	0.038	0.028

Data are expressed as means ± standard deviations. Because of inconsistency in sample volumes and missing testing parameters, the sample sizes differ for each measure. FFs = Firefighters; LEOs = Law Enforement Officers; Occ = Occupation. Age was ran as a covariate with the general linear model (GLM) univariate ANCOVA analysis; * denotes that the ANCOVA was ran excluding women.

Regarding the blood and salivary biomarkers (Table 2), no statistically significant differences were found for concentrations of glucose (t(169)=-1.288, p=0.199), HDL-c (U=3929, p=0.271), LDL-c (U=3055, p=0.136), TAG (U=3779, p=0.527), TC (t(169)=0.482, p=0.630), HbA1c (U=1246.5, p=0.827), sAA (U=2488.5, p=0.589), sCORT (U=2569.5, p=0.595), and CRP (U=2468, p=0.613). When excluding the women and accounting for age as a covariate, no differences between the occupational groups were noted for the following blood and saliva biomarkers concentrations: glucose, HDL-c, LDL-c, TAG, TC, HbA1c, sAA, sCORT, and CRP. Age did have an effect on glucose concentrations (p=0.020, η_p^2=0.033). Furthermore, AOPP (U=2060, p=0.001), fasting insulin (U=2047, p=0.015), and blood cortisol (U=2380, p=0.037) concentrations were different between the occupational groups, wherein the FFs demonstrated higher AOPP (FFs: 134.8±90.1 µM; LEOs: 106.8±67.6 µM), insulin (FFs: 4.4±2.8 µIU/mL; LEOs: 3.3±2.4 µIU/mL), and cortisol (FFs: 14.2±5.0; LEOs: 12.5±5.6 µg/dL) concentrations than the LEOs (see Figure 1). When excluding the women from the analysis, AOPP and fasting insulin remained statistically different between the occupational groups. However, when accounting for age as a covariate, only fasting insulin remained different between the occupational groups with no effect of age on this biomarker (p=0.274, η_p^2=0.009).

Table 2. Blood and Saliva Biomarkers

		Including Women				Excluding Women				GLM Univariate ANCOVA*		
Variable	Occ	*n*	Mean	p-Value	d	*n*	Mean	p-Value	d	Source	p-Value	η_p^2
Glucose	FFs	*98*	89.3 ± 10.0	0.280	-0.203	*97*	89.4 ± 10.0	0.165	-0.222	Age	0.020	0.033
(mg/dL)	LEOs	*73*	103.6 ± 107.7			*66*	105.5 ± 113.1			Occ	0.559	0.002
High-Density Lipoprotein	FFs	*98*	49.0 ± 11.8	0.271	-0.248	*97*	48.7 ± 11.2	0.629	-0.118	Age	0.929	0.000
(mg/dL)	LEOs	*73*	52.7 ± 17.8			*66*	50.2 ± 15.4			Occ	0.469	0.003
Low-Density Lipoprotein	FFs	*98*	124.1 ± 31.4	0.136	0.204	*97*	123.9 ± 31.5	0.256	0.159	Age	0.172	0.012
(mg/dL)	LEOs	*72*	117.7 ± 31.6			*65*	118.9 ± 31.4			Occ	0.167	0.012
Triglycerides	FFs	*98*	118.9 ± 74.3	0.527	-0.042	*97*	119.3 ± 74.6	0.463	-0.072	Age	0.116	0.015
(mg/dL)	LEOs	*73*	122.1 ± 78.4			*66*	124.8 ± 81.3			Occ	0.937	0.000
Total Cholesterol	FFs	*98*	195.1 ± 34.6	0.559	0.075	*97*	194.6 ± 34.4	0.601	0.084	Age	0.050	0.024
(mg/dL)	LEOs	*73*	192.6 ± 32.2			*66*	191.8 ± 32.5			Occ	0.259	0.008
Hemoglobin-A1c	FFs	*97*	5.4 ± 0.3	0.827	-0.052	*96*	5.4 ± 0.3	0.986	-0.019	Age	0.023	0.044
(%)	LEOs	*25*	5.5 ± 0.3			*23*	5.5 ± 0.3			Occ	0.656	0.002
†α-Amylase	FFs	*75*	61.4 ± 46.4	0.589	0.189	*74*	62.0 ± 46.5	0.328	0.270	Age	0.528	0.003
U/mL	LEOs	*70*	53.6 ± 34.5			*63*	51.0 ± 32.7			Occ	0.093	0.021
†Cortisol	FFs	*74*	0.3 ± 0.2	0.595	-0.202	*73*	0.3 ± 0.2	0.446	-0.239	Age	0.120	0.018
(μg/dL)	LEOs	*66*	0.3 ± 0.2			*60*	0.4 ± 0.2			Occ	0.059	0.027
C-Reactive Protein	FFs	*88*	1409.4 ± 1204.4	0.613	-0.032	*87*	1420.8 ± 1206.6	0.413	0.052	Age	0.288	0.008
(ng/dL)	LEOs	*59*	1449.7 ± 1387.6			*53*	1355.6 ± 1298.7			Occ	0.558	0.003

Data are expressed as means ± standard deviations. Because of inconsistency in sample volumes and sample quality, the sample sizes differ for each measure. FFs = Firefighters; LEOs = Law Enforement Officers; Occ = Occupation. Age was ran as a covariate with the general linear model (GLM) univariate ANCOVA analysis; * denotes that the ANCOVA was ran excluding women. † denotes the salivary bio-samples.

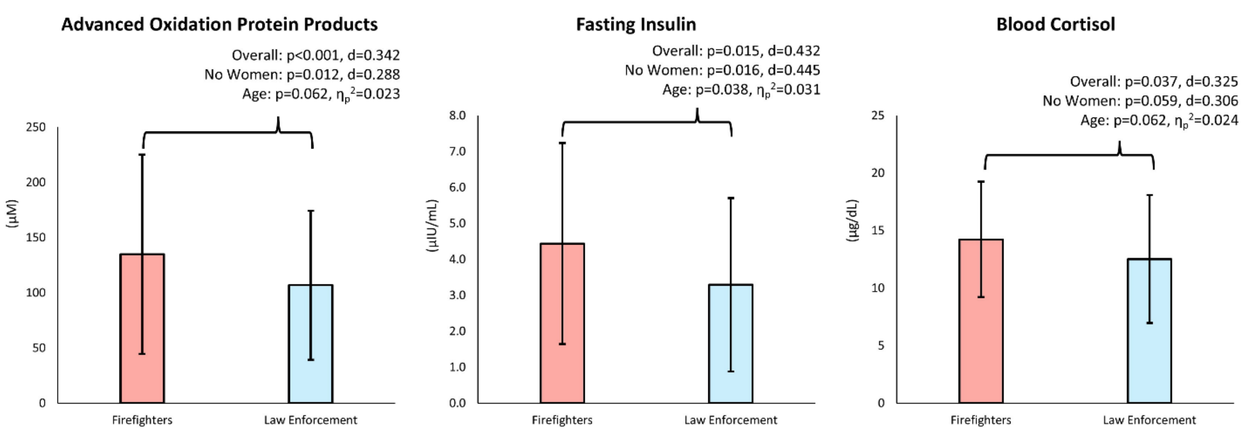

Figure 1. Biomarker results. Data are presented as means ± SD. The "age" statistics denote the effect for occupational difference when account for age as the covariate.

Regarding the anthropometrics and body composition parameters, no statistically significant differences were found (Table 3) for fat mass (U=3424, p=0.640), lean mass (t(163)=0.581, p=0.562), android fat distribution (t(163)=-1.1561, p=0.120), gynoid fat distribution (t(163)=-1.047, p=0.297), and waist circumference (U=3356, p=0.193). However, statistically significant differences were found for hip circumferences (U=4292, p<0.001) and waist-to-hip ratio (t(157)=4.857, p<0.001). When excluding the women from the analysis, these differences between the occupational groups were maintained. It is important to note that the 7 women averaged waist-to-hip ratios of 0.73±0.87, which would classify them at low risk of abdominal obesity, while the men are considered to be abdominally obese (i.e., ≥0.90). When accounting for age as a covariate, there were difference between the occupational groups for hip circumferences and waist-to-hip ratios, whereas age had an effect on fat mass (p=0.041, η_p^2=0.027), android fat distribution (p<0.001, η_p^2=0.080), waist circumference (p<0.001, η_p^2=0.081), and waist-to-hip ratios (p<0.001, η_p^2=0.079).

Table 3. Body Composition Parameters

		Including Women				Excluding Women				GLM Univariate ANCOVA*		
Variable	Occ	*n*	Mean	p-Value	d	*n*	Mean	p-Value	d	Source	p-Value	η_p^2
Fat Mass	FFs	*98*	23.6 ± 8.5	0.640	-0.045	*97*	23.6 ± 8.5	0.862	0.002	Age	0.041	0.027
(kg)	LEOs	*67*	23.9 ± 7.7			*61*	23.6 ± 7.6			Occ	0.522	0.003
Lean Mass	FFs	*98*	72.0 ± 9.9	0.562	0.092	*97*	72.2 ± 9.9	0.714	-0.060	Age	0.466	0.003
(kg)	LEOs	*67*	71.1 ± 11.0			*61*	72.7 ± 9.5			Occ	0.569	0.002
Android Fat Distribution	FFs	*98*	27.7 ± 7.1	0.120	-0.247	*97*	27.7 ± 7.1	0.253	-0.188	Age	<0.001	0.080
(%)	LEOs	*67*	29.4 ± 6.7			*61*	29.0 ± 6.6			Occ	0.980	0.000
Gynoid Fat Distribution	FFs	*98*	25.5 ± 4.6	0.297	-0.166	*97*	25.5 ± 4.6	0.874	0.026	Age	0.186	0.011
(%)	LEOs	*67*	26.4 ± 6.8			*61*	25.3 ± 6.0			Occ	0.580	0.002
Hip	FFs	*98*	97.8 ± 11.6	<0.001	-0.725	*97*	97.9 ± 11.6	<0.001	-0.683	Age	0.159	0.013
(cm)	LEOs	*61*	105.5 ± 8.7			*55*	105.1 ± 8.1			Occ	0.001	0.074
Waist	FFs	*98*	93.1 ± 11.5	0.193	-0.113	*97*	93.3 ± 11.4	0.090	-0.184	Age	<0.001	0.081
(cm)	LEOs	*61*	94.4 ± 10.5			*55*	95.3 ± 10.1			Occ	0.990	0.000
Waist-to-Hip Ratio	FFs	*98*	0.95 ± 0.06	<0.001	0.792	*97*	0.95 ± 0.06	<0.001	0.675	Age	<0.001	0.079
	LEOs	*61*	0.90 ± 0.08			*55*	0.91 ± 0.08			Occ	<0.001	0.145

Data are expressed as means ± standard deviations. Because of inconsistency in sample volumes and missing testing parameters, the sample sizes differ for each measure. FFs = Firefighters; LEOs = Law Enforement Officers; Occ = Occupation. Age was ran as a covariate with the general linear model (GLM) univariate ANCOVA analysis; * denotes that the ANCOVA was ran excluding women.

Regarding the fitness parameters (Table 4), no statistically significant differences were found for predicted VO_{2max} values (t(155)=1.864, p=0.064), push-ups (t(154)=0.329, p=0.743), and sit-and-reach (U=2933, p=0.843), which was maintained when excluding women from the analysis. Interestingly, when accounting for age as a covariate, there was a difference noted between the occupational groups for push-ups, wherein the FFs displayed higher average repetition than the LEOs. Furthermore, age had an effect on VO_{2max} values (p<0.001, η_p^2=0.151), push-ups (p<0.001, η_p^2=0.203), and sit-and-reach (p=0.046, η_p^2=0.026). However, there were statistically significant differences between the occupational groups for TTE on the CPXT (t(156)=2.240, p=0.027) and handgrip strength (U=2191, p=0.009; see Figure 2). The FFs expressed higher TTE on the CPXT (FFs: 11.0±1.6 min; LEOs: 10.3±2.0 min) and hand grip strength (FFs: 111.9±18.0 kg; LEOs: 103.3±22.5 kg) than the LEOs. However, these differences were not maintained when accounting for the exclusion of women from the analysis or age as a covariate. Age did have an effect on TTE on the CPXT (p<0.001, η_p^2=0.118) but not for handgrip strength (p=0.798, η_p^2=0.000).

Table 4. Fitness Parameters

		Including Women				Excluding Women				GLM Univariate ANCOVA*		
Variable	Occ	*n*	Mean	p-Value	d	*n*	Mean	p-Value	d	Source	p-Value	η_p^2
VO_{2max}	FFs	*97*	38.2 ± 6.6	0.064	0.306	*96*	38.3 ± 6.5	0.159	0.192	Age	<0.001	0.151
(ml/kg/min)	LEOs	*60*	36.2 ± 6.2			*54*	37.1 ± 5.6			Occ	0.697	0.001
Push-Ups	FFs	*96*	47.6 ± 15.3	0.743	0.054	*95*	47.6 ± 15.4	0.711	-0.063	Age	<0.001	0.203
(repetitions)	LEOs	*60*	46.7 ± 17.4			*54*	48.6 ± 17.2			Occ	0.033	0.031
Sit-and -Reach	FFs	*98*	15.3 ± 10.1	0.843	-0.016	*97*	15.3 ± 10.2	0.863	0.130	Age	0.046	0.026
(in)	LEOs	*61*	15.5 ± 11.0			*55*	14.2 ± 3.1			Occ	0.882	0.000

Data are expressed as means ± standard deviations. Because of inconsistency in sample volumes and missing testing parameters, the sample sizes differ for each measure. FFs = Firefighters; LEOs = Law Enforement Officers; Occ = Occupation. Age was ran as a covariate with the general linear model (GLM) univariate ANCOVA analysis; * denotes that the ANCOVA was ran excluding women.

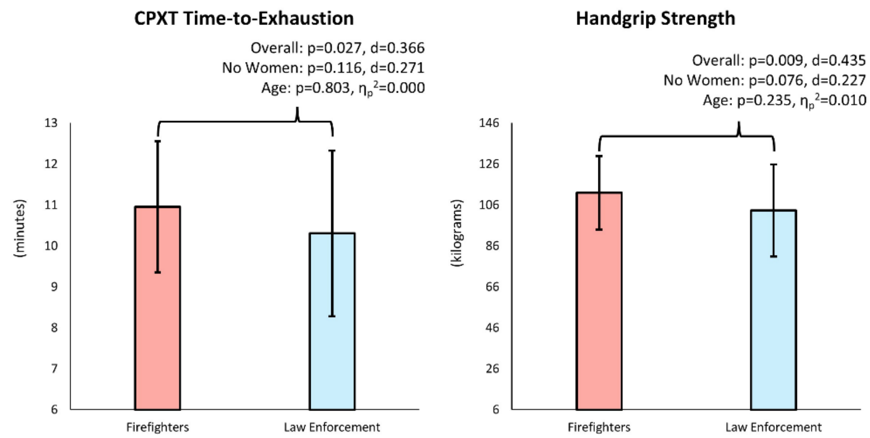

Figure 2. Fitness Parameters results; CPXT = cardiopulmonary test. * Denotes significant differences between groups. The "age" statistics denote the effect for occupational difference when account for age as the covariate.

Discussion

The present study aimed to examine if there are any differences in health and fitness-related CVD risk parameters between FFs and LEOs. The main findings of the present study demonstrate that although FFs express greater indices of physical fitness (i.e., TTE on the CPXT and hand grip strength), they express higher CVD risk and stress parameters (i.e., blood insulin, AOPP, and cortisol, as well as waist-to-hip ratios) than the LEOS. Interestingly, when we removed women from the analysis, the FFs still expressed higher concentrations of AOPP and insulin but were not different in their TTE on the CPXT. Further, when we accounted for age as a covariate, there were no differences in the fitness parameters or AOPP concentrations (p=0.062), but there was still a difference found for insulin. In addition, the FFs were younger than the LEOs (p<0.001), even when removing the women from the analysis. Taken together, these findings suggest that the FFs express higher indices of CVD risk, although they are younger and able to exercise for longer on the CPXT than the LEOs. Previous reports by McAllister and colleagues[6,7] have demonstrated that blood biomarkers, such as AOPP and CRP, are inversely related to fitness levels. Interestingly, these findings contradict the traditional notion that greater fitness is indicative of lower CVD risk.[23] To our knowledge, this is the first study to compare health and fitness parameters related to CVD risk among these two high-stress occupational groups, and further work is warranted to elucidate on the present study's findings – namely, to understand better the relationships between fitness and CVD risk among these personnel.

Physiological stress, oxidative stress, and inflammation have been implicated in the development and progression of CVD.[24] Biomarkers, such as AOPP, have been suggested to provide better insight in predicting CVD risk than conventional CVD risk biomarkers (e.g., blood lipids) among FFs.[6] In addition, our research group has found a similar relationship among LEOs.[13] Under conditions of chronic oxidative stress, AOPPs can form and are linked with tissue damage, inflammation, and endothelial dysfunction, and elevated concentrations of AOPP have been shown to be associated with other CVD risk factors (i.e., hypertension, dyslipidemia, etc.).[25] Furthermore, physiological stress biomarkers, such as cortisol (i.e., sCORT or blood cortisol), have been linked to CVD risk,[26] and, similarly to AOPP, under chronic stress conditions, cortisol can lead to endothelial dysfunction.[24] Therefore, it is likely that the repeated exposure to stress that first responders face can accelerate their CVD risk, especially when findings from Gonzalez et al[14] and Perroni et al,[27] wherein the exposure to tactical-specific conditions led to ≈91% and ≈57% increase in cortisol immediately post, respectively. It is plausible that these large increases, in a repeated fashion over time, can lead to chronic stress and subsequent increased CVD risk. Peculiarly, the FFs of the present study demonstrated higher AOPP concentrations (≈23.2%) than the LEOs, yet their TTE on the CPXT was significantly higher than that of the LEOS (≈6.5%). In addition, the FFs had higher blood cortisol (≈12.7%) and insulin (≈28.6%) concentrations than the LEOs, with insulin having been identified as an important previously identified CVD risk variable among these first responder populations [6]. These results suggest that while the FFs in this study were more fit they may have a greater CVD risk than LEOs. It is well established that FFs and LEOs face extreme demands and occupational conditions that augment their risk for CVD and premature mortality.[28] While there are some similarities among these occupational groups (i.e., disrupted sleep, high-exertional occupational activities, exposure to dangerous environments), firefighting and policing have distinct differences (i.e., FFs exposed to heat stress) that may play a substantial role in the development and progression of CVD. For instance, Wohlgemuth et al[29] noted that increased occupational heat exposure and thermoregulatory strain are the underlying physiological mechanistic link between stress/overexertion and on-duty deaths. It is plausible that the heat stress experienced among FFs may exacerbate their CVD risk regardless of their fitness levels. Moreover, LEOs face extremely psychologically demanding conditions that may be more sedentary (i.e., paperwork, long periods of surveillance on a suspect), which could explain their lower fitness levels than the FFs (i.e., they are less physically active during routine occupational tasks).[28,30] Importantly, while speculative, these stressors could warrant different strategies to mitigate CVD risk for each occupational group (i.e., thermoregulatory solutions for FFs and practices to improve mental acuity and cognitive function). Further research is needed to understand better the types of stressors these occupations face and how these stressors impact their risk of CVD.

The relationship between body composition and CVD risk is widely documented, with elevated body percentages, android fat distribution, and waist-to-hip ratios are linked to greater inflammation,[31,32] lower fitness,[33,34] and higher overall CVD risk.[35] In the present study FFs demonstrates higher waist-to-hip ratios than LEOs, which has been identified as a pragmatic parameter for first responders to assess and to consider monitoring routinely as it relates to CVD risk.[6] Strauss et al[36] found that lower waist circumferences related to higher cardiorespiratory fitness; yet, the FFs in the present study did not align with this finding.[36] It is worth noting that the LEOs did meet the World Health Organization recommendation for waist-to-hip ratios (i.e., 0.9 or less), while the FFs exceeded that threshold, indicating greater health risk. It is also important to note that both occupational groups are well below the firefighter standard for cardiorespiratory fitness (i.e., 42 ml/kg/min), which was previously suggested as to be a similar standard useable for LEOs when considering their occupational task demands.[28,37] Taken together, these data demonstrate that both occupational groups must strive to maintain adequate levels of cardiorespiratory fitness, which is critical for meeting the various occupational demands faced on duty.

The present study is not without limitations. First, the data included in this study are from a large longitudinal study and are a convenience sample. Therefore, the sampling for this study is non-probabilistic, and strict interpretations are not appropriate. All statistical tests should be interpreted descriptively and understood relative to the current study's sample. Second, the sample size differed between groups, and this is due to the number of FFs and LEOs who participated in the annual clinical testing. It is also worth noting that the annual clinical testing is not mandatory, and within the respective fire and police departments, the more fit/healthier personnel may tend to participate, creating a healthy worker effect.[38,39] Third, we did not assess other demographic factors, such as race/ethnicity and socioeconomic status. These factors, as well as years of experience within the occupation and age, may play an important role in assessing CVD risk, and future work should aim to include these demographic variables. Lastly our firefighter sample did not include females due to a limited number of volunteers. Future work should assess these relationships between sexes and occupational status.

These data demonstrate that while FFs demonstrated greater CPXT time-to-exhaustion, they also expressed greater concentrations of stress biomarkers and risk for CVD than LEOs. While still speculative, FFs and LEOs likely experience different disease etiology given the differing types of stress exposure (i.e., heat stress versus sedentary conditions). These data are important to understand the impact of occupational stress on disease risk and help identify ways to manage CVD risk or prevent premature mortality among these first responder groups. Future research is needed to elucidate the relationship between occupational stress and CVD risk fully. Taken together, the low cardiorespiratory fitness levels (i.e., VO_{2max}) noted in the present study underscore the importance of both occupations to improve their fitness. It is also important for these occupational groups to assess regularly and monitor CVD risk parameters, such as their waist-to-hip ratio. Lastly, there is a need to continue assessing stress responses around occupation-specific tasks and conditions. Considering the repeated stress exposures of these occupations, having a better understanding of how first responders respond to stressful conditions across their career span (i.e., considering age and years in service) and the influence their health and fitness profiles have on these responses may aid future exercise, stress management, and nutrition strategies to mitigate the risk of premature mortality.

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