Blood Pressure in Firefighters, Police Officers, and Other Emergency Responders

Stefanos N. Kales1,2, Antonios J. Tsismenakis1,3, Chunbai Zhang1 and Elpidoforos S. Soteriades1,4

Elevated blood pressure is a major risk factor for cardiovascular morbidity and mortality. Increased risk begins in the prehypertensive range and increases further with higher pressures. The strenuous duties of emergency responders (firefighters, police officers, and emergency medical services (EMS) personnel) can interact with their personal risk profiles, including elevated blood pressure, to precipitate acute cardiovascular events. Approximately three-quarters of emergency responders have prehypertension or hypertension, a proportion which is expected to increase, based on the obesity epidemic. Elevated blood pressure is also inadequately controlled in these professionals and strongly linked to cardiovascular disease morbidity and mortality. Notably, the majority of incident cardiovascular disease events occur in responders who are initially prehypertensive or only mildly hypertensive and whose average premorbid blood pressures are in the range in which many physicians would hesitate to prescribe medications (140–146/88–92).

Laws mandating public benefits for emergency responders with cardiovascular disease provide an additional rationale for aggressively controlling their blood pressure. This review provides a background on emergency responders, summarizes occupational risk factors for hypertension and the metabolic syndrome, their prevalence of elevated blood pressure, and evidence linking hypertension with adverse outcomes in these professions. Next, discrepancies between relatively outdated medical standards for emergency responders and current, evidence-based guidelines for blood pressure management in the general public are highlighted. Finally, a workplace-oriented approach for blood pressure control among emergency responders is proposed, based on the seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure.

The review aims to provide the most comprehensive and balanced review of the “state of the science” on all three groups of emergency responders with respect to hypertension. To date, however, significantly more cardiovascular research has been focused on firefighters than on police officers. Although such investigations are more limited regarding EMS personnel. Thus, the balance of information provided in our review reflects the relative amount of science available on each group, as opposed to any intentional emphasis by the authors.

EMERGENCY RESPONDERS

In this review, the term “emergency responders” refers to firefighters, police officers, and EMS personnel. Together, these professions employ about 2.1 million persons, or almost 1.5% of the US workforce.4–6 Although the three categories of
occupational risk factors to cardiovascular disease. Among police officers, the relative risk of on-duty cardiovascular events is 10–100 times higher than nonemergency duty.13–15 Some of the occupational risk factors for cardiovascular disease are summarized in Table 1.

Irregular physical exertion
It is widely accepted that the lack of regular physical exercise leads to increased risk for both excess weight gain and cardiovascular disease. In addition, sedentary persons are at increased risk for acute cardiovascular events during activities requiring considerable physical exertion.10,11,13–15

Unhealthy diet and shift work
Shift work disrupts normal sleep and dietary patterns.24,29,30 Emergency responders commonly perform two 24-hour shifts per week or staggered rotating shifts.24,31 Moreover, many spend their days off working second jobs or overtime and may thereby experience chronic sleep deprivation. In addition,
whether these effects are longstanding or relatively short-lived has yet to be clearly elucidated.

### Noise exposure
Alarms, sirens, vehicle engines, and mechanized rescue equipment typically produce 8-h time-weighted average noise exposures in the 63–85 dBA range. Individual recorded exposures are very high in firefighters, who have consistently been documented to experience intermittent exposures over 90 dBA (the federal permissible exposure limit for an 8-h time-weighted average). The highest exposures reported exceed 100 dBA. In a 2002 meta-analysis by van Kempen et al., it was estimated that, for each five decibel increase in occupational noise exposure, there is an increase of 0.51 mm Hg in systolic blood pressure. As a result of siren noise, there is a general agreement that the hemodynamic effects of intermittent occupational noise, such as that experienced by emergency responders, persist during active exposure. However, whether these effects are longstanding or relatively short-lived has yet to be clearly elucidated.

### PTSD
Emergency responders are often exposed to significant psychological trauma, which, in susceptible persons, can progress to PTSD. Multiple studies have shown that patients suffering from PTSD have increased resting heart rates and a small (1–5 mm Hg) increase in diastolic blood pressure, compared to controls. They also display increased startle reaction, and increased heart rate and blood pressure reactivity when exposed to traumatic stimuli. Violanti et al. found that police officers with the highest PTSD symptom scores had three times the age-adjusted risk of metabolic syndrome when compared to colleagues in the lowest PTSD score category.

### Prevalence and Trends of Elevated Blood Pressure
The prevalence of prehypertension and hypertension in these professions is also a significant concern (Table 2). Approximately three-quarters of emergency responders have elevated blood pressure (prehypertension or hypertension). Mean resting systolic blood pressures in all three occupations have consistently been found in the prehypertensive or hypertensive range. As expected, older emergency responders have the highest average systolic blood pressure readings. Another very important factor affecting the prevalence of hypertension in emergency responders is obesity. Over

### Table 1 | Occupational risk factors for blood pressure elevation among emergency responders

| Risk factor | Comments |
|-------------|----------|
| Irregular physical exertion | Relative inactivity between emergencies, long sedentary periods, lack of formal exercise programs and fitness requirements at work. High prevalence of overweight and obesity. |
| Unhealthy diet and shift work | Expediency, convenience of "fast food" as a choice during work-time. Tradition of communal meals at fire stations rich in saturated fats and simple, refined carbohydrates. Sleep disruption and sleep deprivation, alarms and dispatches during on-duty sleep, overtime work and second jobs, which can promote insulin resistance and the metabolic syndrome. |
| Noise exposure | Alarms, sirens, vehicle engines, mechanized rescue equipment. |
| Posttraumatic stress disorder | Increased resting heart rate, diastolic blood pressure and vaso-reactivity to traumatic stimuli (increased "startle response"). |
| High job demand low decisional control | In the "Demand-Control" model of occupational stress, high demands and lower decisional latitude are associated with more stress. (Low demand and a high degree of control are associated with less stress.) |
75% of firefighters, police officers, and ambulance personnel are overweight or obese, by body mass index (BMI) criteria.19,64 Given the obesity epidemic66 and the close relationship between obesity and increasing blood pressure,65 we would expect the distribution of blood pressure among emergency responders to progressively shift to higher measurements over time. In the 1980s and early 1990s, the average veteran firefighter had a BMI of 25.4–26.7 kg/m².61,69 In 1996–97, the average veteran’s BMI had increased to almost 29 kg/m²;61,69 and, by 2001, it was 29.7 kg/m².64 Today, much younger firefighters and ambulance recruits (in their twenties) have an average BMI of 28.5 (unpublished observations). Moreover, in the latter younger cohort, the relationship between obesity and blood pressure elevation appears especially pronounced, with obese subjects having an almost sevenfold greater prevalence of hypertensive blood pressure readings as compared to normal weight subjects (16 and 2.4%, respectively, P = 0.004).

Furthermore, given the current 30–40% prevalence of obesity (BMI ≥30 kg/m²) in these populations, a significant number of obese responders have or is expected to develop obstructive sleep apnea.70 Obstructive sleep apnea is highly linked to hypertension in both cross-sectional and prospective studies.71–73 In fact, Peppard et al. found a dose–response increase in incident hypertension as the apnea–hypopnea index increased, with an almost threefold risk ratio for those with apnea–hypopnea index > 15.73

In addition, the prevalence of hypertension is expected to increase over time because the prevalence of prehypertension among emergency responders is also currently high as shown in Table 2. Individuals with blood pressure in the prehypertensive range are at increased risk for progression and development of hypertension.74

Table 2 | Prevalence of prehypertension and hypertension in emergency responders

| Population         | Mean age (± s.d.) | Prevalence of prehypertension (%) | Prevalence of hypertension (%) |
|--------------------|------------------|----------------------------------|-------------------------------|
| Career firefighters | 39 (±7)           | 58                               | 20–23                         |
| Volunteer firefighters | Not available | 47                               | 30                            |
| Police55           | 37 (± 9)          | —                                | 21–23                         |
| Police56           | 38                | —                                | 27                            |
| Police57           | 47 (± 8)          | —                                | 24                            |
| EMT and paramedic recruits (unpublished observations) | 26 (± 4) | 59 | 9 |

Note: Prevalence of hypertension is defined at ≥140/90 mm Hg, diagnosis of hypertension, or antihypertensive medication use, unless otherwise noted. Prevalence of prehypertension is defined at 120–129/80–84 mm Hg or antihypertensive medication use. Self-reported hypertension.

Finally, in a prospective investigation of firefighters, almost 75% of those with hypertension were found to lack adequate control53 as similarly reported in the general population.75–77 A particular finding with important policy implications from the above study was that, despite annual occupational medical examinations, the control of hypertension did not improve over the course of a 4-year period.53 These hypertensive firefighters were provided with face-to-face and written follow-up recommendations to control their blood pressure and other cardiovascular disease risk factors; however, no workplace regulations required them to do so as a condition of continued employment. It is also notable that between 2 and 5% of the study population had stage 2 hypertension during the study period.53 Surveys of volunteer firefighters have shown even higher percentage of stage 2 blood pressure readings, on the order of 4–9%.54

HYPERTENSION-ASSOCIATED OUTCOMES IN EMERGENCY RESPONDER POPULATIONS

Similar to the general population, elevated blood pressure has been associated with several adverse effects in these professions. First, obesity and elevated blood pressure in emergency responders are both associated with cardiovascular disease risk factor clustering, including older age, dyslipidemia, insulin resistance, and glucose intolerance.53,57,61,64,65,78 Hence, total aggregate CHD risk is greater in the presence of such clustering, as opposed to with an isolated risk factor.

Second, retrospective case–control and prospective cohort studies of firefighters and police officers have shown strong and independent associations between hypertension and adverse employment outcomes, incident CHD and stroke, disability retirements due to heart disease, nonfatal myocardial infarction, and on-duty CHD fatalities (Table 3).48,14,15,57,62,63,78–80 In the Helsinki, Finland, police cohort, an elevated systolic blood pressure was an independent predictor of all-cause mortality (P = 0.004), cardiovascular mortality (P < 0.001), and CHD death (P < 0.001).78 Hypertension-related relative risk estimates reported in the medical literature regarding police officers are generally lower than those for firefighters (Table 3). Most likely this is due to different definitions of high blood pressure employed in the police studies, which by extension, change the definition of “normal blood pressure.” When hypertension for police officers is defined at ≥160/95 mm Hg (systolic) or by self-report only, this leads to many hypertensive individuals being classified as NOT having hypertension. Thus, the “control” group includes a significant number of police officers with stage 1 hypertension. Therefore, the above misclassification of hypertensive police officers as “normotensives,” would be expected to dilute the relative risk estimate.

There are several lines of evidence to suggest that hypertension-associated risks are concentrated among individuals with uncontrolled, rather than controlled, hypertension. Adverse job outcomes (combined outcome including: on-duty death, injured on-duty, termination of duty, resignation, premature retirement,
Blood Pressure in Emergency Responders

It is crucial to note, however, that, as is seen in the general population, the majority of incident cardiovascular disease events occur in emergency responders who are initially prehypertensive or only mildly hypertensive. In Table 4, we show baseline mean blood pressures in firefighters and police officers who were later found in prospective follow-up to have an incident cardiovascular event or a clinical diagnosis compared to subjects who remained free of disease. Although the differences are highly significant on statistical comparison, the mean pressures observed in those who eventually developed disease were in the range of 140–146/88–92 mm Hg. Many primary care physicians still hesitate to prescribe medications for patients with such levels of blood pressure. This potential gap between the clinical and epidemiologic perception of risk is an

**Table 3 | Adverse associations of hypertension with selected health outcomes in firefighters and police**

| Endpoint                                      | Hypertension criteria                                                                 | Unadjusted odds ratio or hazard ratio (95% CI) | Multivariable-adjusted odds ratio or hazard ratio (95% CI) | Study design/population |
|-----------------------------------------------|--------------------------------------------------------------------------------------|-----------------------------------------------|----------------------------------------------------------|-------------------------|
| Adverse change in employment<sup>65, 8</sup>   | Stage 2 hypertension                                                                | NA                                            | 2.9 (1.1–8.1)                                            | Prospective Cohort/    |
|                                               | Stage 2 hypertension and no BP medication                                           | NA                                            | 4.6 (2.1–10.1)                                           | firefighters            |
| Incident CHD<sup>62</sup>                      | SBP > 140                                                                            | 6.1 (2.6–14.2)                                 | NA                                                       | Prospective cohort/    |
|                                               | DBP > 90                                                                             | 4.9 (2.1–11.4)                                 | NA                                                       | firefighters            |
| Incident CHD<sup>57</sup>                      | ≥160/95 mm Hg or antihypertensive medication (multivariate hazard ratio based on 18 mm Hg increase in SBP treated as a continuous variable) | 1.97 (1.34–2.89)                              | 1.19 (1.03–1.38)                                         | Prospective cohort/police |
| Incident stroke<sup>79</sup>                   | ≥160/95 mm Hg or antihypertensive medication (multivariate hazard ratio based on 18 mm Hg increase in SBP treated as a continuous variable) | 2.42 (1.35–4.33)                              | 1.36 (1.18–3.06)                                         | Prospective cohort/police |
| CHD retirement<sup>14</sup>                    | ≥140/90 mm Hg, diagnosis of hypertension, or antihypertensive medication             | 5.4 (3.7–7.9)                                 | 1.2 (0.6–2.4)                                            | Retrospective case–control/ |
| Non-CHD cardiovascular retirement<sup>14</sup> | ≥140/90 mm Hg, diagnosis of hypertension, or antihypertensive medication             | 11.0 (6.1–20.0)                               | 4.8 (1.3–17.9)                                           | firefighters            |
| Myocardial infarction<sup>56, 93</sup>        | Self-report of hypertension diagnosis                                                 | 2.2 (1.6–3.2)                                 | —                                                       | Retrospective case–control/ |
| On-duty CHD death<sup>15</sup>                 | ≥140/90 mm Hg, diagnosis of hypertension, or antihypertensive medication             | 12.0 (5.8–24.9)                               | 4.7 (2.0–11.1)                                           | firefighters            |
| Case-fatality for on-duty CHD events<sup>80</sup> | ≥140/90 mm Hg, diagnosis of hypertension, or antihypertensive medication             | 3.8 (2.0–7.1)                                 | 4.2 (1.8–9.4)                                           | Retrospective case-fatality/ |

CHD, coronary heart disease; DBP, diastolic blood pressure; SBP, systolic blood pressure.

<sup>a</sup>Combined outcome including: on-duty death, injured on-duty, termination of duty, resignation, premature retirement and incident cardiovascular event.
important consideration in developing effective guidelines for blood pressure screening and management among emergency responders.

**OCCUPATIONAL GUIDELINES FOR BLOOD PRESSURE IN EMERGENCY RESPONDERS**

One might expect that occupational standards for blood pressure control would be stricter and updated regularly, given legislated cardiovascular disease benefits and the documented associations between uncontrolled hypertension and cardiovascular disease. Unfortunately, however, existing guidelines for emergency responders appear to be weak and outdated (Table 5). In addition to potentially contributing to imprudent decisions regarding fitness for duty, such occupational guidelines may also provide emergency responders with a false sense of security. Many occupational physicians

---

### Table 4 | Baseline blood pressures for firefighters and police with and without later incident cardiovascular events

| Endpoint               | Mean SBP | Mean DBP | Mean SBP | Mean DBP | Mean SBP | Mean DBP | Study design/population |
|------------------------|----------|----------|----------|----------|----------|----------|-------------------------|
| Incident CHD<sup>62</sup> | 140      | 92       | 125      | 82       | <0.0001<sup>a</sup> | <0.0001<sup>a</sup> | Prospective cohort/firefighters |
| Incident CHD<sup>79</sup> | 141      | 88       | 134      | 84       | <0.01<sup>b</sup>   | <0.001<sup>b</sup>  | Prospective cohort/police       |
| Incident stroke<sup>79</sup> | 146      | 91       | 134      | 84       | <0.01<sup>b</sup>   | <0.01<sup>b</sup>   | Prospective cohort/police       |

**CHD:** coronary heart disease; **DBP:** diastolic blood pressure; **SBP:** systolic blood pressure.

<sup>a</sup>Adjusted for age, race and BMI.  
<sup>b</sup>Adjusted for age.

### Table 5 | Occupational blood pressure guidelines for firefighters and police officers compared to JNC 7

| Organization/year | Population | Blood Pressure stage/levels in mm Hg | Determination/action |
|-------------------|------------|------------------------------------|----------------------|
| National Fire Protection Association, 2007<sup>62</sup> | Firefighters | <180 systolic and <100 diastolic | Acceptable blood pressure—controlled hypertension (if no target organ damage) |
|                    |            | ≥180 systolic; ≥100 diastolic; 1/3 systolic + 2/3 diastolic >120 mm Hg; or presence of target organ damage | Severe uncontrolled hypertension, restricted from duty |
| Massachusetts Human Resources Division, 1998<sup>83</sup> | Firefighters and police officers | <160 systolic and <100 diastolic | Acceptable blood pressure |
|                    |            | ≥160 systolic or ≥100 diastolic | Uncontrolled hypertension, restricted from duty |
| California Peace Officer Standards and Training, 2004<sup>84</sup> | Police officers | <160 systolic and <90 diastolic | “Group I” normal blood pressure, no restrictions |
|                    |            | >160 systolic or 90–104 diastolic; or diagnosis of hypertension controlled by diet/medications | “Group II” mild hypertension, no restrictions if normal blood pressure response to exercise on stress ECG |
|                    |            | 105–114 diastolic | “Group III” moderate hypertension |
|                    |            | >115 diastolic | “Group III” severe hypertension, restricted duty and treatment required |
| National Heart, Lung, and Blood Institute National High Blood Pressure Education Program (JNC 7), 2003<sup>3</sup> | General population | <120 systolic and <80 diastolic | Normal |
|                    |            | 120–139 systolic or 80–89 diastolic | Pre-hypertension/increased education to reduce BP and prevent hypertension |
|                    |            | 140–159 systolic or 90–99 diastolic | Stage 1 Hypertension/lifestyle modifications ± single-agent treatment |
|                    |            | ≥160 systolic or ≥100 diastolic | Stage 2 Hypertension/lifestyle modifications + Most need 2 – drug combination |

**ECG:** electrocardiogram; **JNC 7:** seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure.
Table 6  Proposed blood pressure management scheme for emergency responders

| Blood pressure       | Fitness determination | Recommended intervention(s)                                                                 | Occupational follow-up |
|----------------------|-----------------------|--------------------------------------------------------------------------------------------|------------------------|
| Normal               | Unrestricted duty     | • Population-based wellness programs                                                            | • 12–24 months based on overall CVD risk factor profilea                           |
| Prehypertension      | Unrestricted duty     | • Population-based wellness programs                                                            | • 6–12 months based on overall CVD risk factor profilea                           |
|                      |                       | • Individual educationb                                                                       |                         |
| Stage 1 hypertension | Time-limited clearance for duty | • Population-based wellness programs                                                            | • Time-limited clearance (6–12 months) based on overall CVD risk factor profilea |
|                      |                       | • Individual educationb                                                                       | • Expect controlled blood pressure at follow-up                                  |
|                      |                       | • Hypertension treatment and evaluation                                                        | • If blood pressure control improves, revert to annual follow-up                |
| Stage 2 hypertension | Restricted to modified duty (excluding physical exertion related duties) until blood pressure reaches stage 1 or lower | • Population-based wellness programs                                                            | • Time-limited clearance after adequate blood pressure control                    |
|                      |                       | • Individual educationb                                                                       | • Follow steps for stage 1, as above                                             |
|                      |                       | • Clinical management of Hypertension                                                          |                         |

Assumes absence of comorbid conditions potentially affecting fitness for duty, prognosis, and treatment decisions.

CVD, cardiovascular disease.

bFull CVD risk factor assessment, including tobacco use, fasting lipid profile, blood glucose level, etc.  

*see* Dietary Approaches to Stop Hypertension, 3 and other nonpharmacologic measures.
proposal represents a balanced approach based on voluminous scientific evidence. One should also recognize that workplace guidelines are always challenging to develop and even more complicated to implement in practice. Therefore, our proposal should be viewed as providing a broad framework that could be adapted and negotiated as locally appropriate to accommodate different administrative and labor management circumstances. The overarching goal of our proposal is to ensure continuous efforts to improve blood pressure and risk factor control among hypertensive emergency responders. In other words, it is crucial that hypertensive emergency responders with inadequate blood pressure control are not passively encouraged (as they are by the current guidelines) to believe that their blood pressure is “under control.”

Complementary considerations along with assessing cardiovascular disease risk factors include appropriate investigations for target organ damage in emergency responders with stage 2 hypertension or long-standing stage 1 hypertension with undocumented control. For example, an echocardiogram should be considered in such cases to rule out left ventricular hypertrophy.

PREScribing CONsiderations
In general, the initial drug of choice for hypertension in emergency responders should follow the recommendations of the seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure for individuals with or without compelling indications.3 However, during emergency responses, these workers may be exposed to extreme temperatures and experience significant physical exertion. For example, experiments have demonstrated decreased stroke volume due to vasodilatation and/or large fluid losses by firefighters entering high-temperature environments wearing nonbreathable full personal protective equipment.89 Thus, caution should be exercised when diuretics are prescribed for hypertension in these professions, and alternative choices should be considered.90,91 In addition, given the nature of occupational duties in first responders, clinicians should be especially attentive to potential adverse medication effects such as dizziness that might compromise the operation of vehicles or machinery or the performance of safety-sensitive tasks.

CONClusions
Approximately three-quarters of emergency responders have elevated blood pressure (prehypertension or hypertension), and their prevalence of hypertension is expected to increase. Currently, elevated blood pressure is inadequately controlled among these professions and strongly linked to on-duty cardiovascular disease morbidity and mortality. Private employers are increasingly recognizing the benefits of health promotion on the well-being, health-care costs, and productivity of diverse groups of workers.92 Given the important roles of emergency responders to our local communities and society at large, it is of paramount importance that the public and private authorities overseeing our public safety professionals, recognize the potential benefits of prevention and take specific actions to promote cardiovascular disease wellness programs. Efforts to maintain healthy weight and achieve blood pressure control should be emphasized as practical and high-yield starting points.

Acknowledgments: The study was supported in part by grant number EMW-2006-FP-01493 from the US Department of Homeland Security. The funding agency had no involvement in study design, data analysis, writing of the paper, and/or the decision to submit the paper for publication. The contents are solely the responsibility of the authors and do not necessarily reflect the views of the US Department of Homeland Security. S.N.K. conceived of the idea for the paper. A.J.T. and C.Z. identified the relevant literature. All authors reviewed part of the medical literature. S.N.K. and A.J.T. wrote the first draft of the manuscript. All authors contributed to, read and approved of the final version of the manuscript.

Disclosure: S.N.K. reports serving as paid expert witness, independent medical examiner, or both in workers' compensation and disability cases, including cases involving emergency responders. S.N.K. also reports funding from Respironics, Inc. None of the other authors report any potential conflict(s) of interest relevant to this article.

1. Hall WD, Ferrario CM, Moore MA, Hall JE, Flack JM, Cooper W, Simmons J, Egan BM, Lackland DT, Perry M Jr, Roccella EJ. Hypertension-related morbidity and mortality in the southeastern United States. Am J Med Sci 1997; 313:195–209.
2. Sykowksi PA, D’Agostino RB, Belanger AJ, Kannel WB. Secular trends in long-term sustained hypertension, long-term treatment, and cardiovascular mortality: the Framingham Heart Study 1950 to 1990. Circulation 1996; 93:697–703.
3. Chobanian AV, Bakris GL, Black HR, Cushman WC, Green LA, Izzo JL Jr, Jones DW, Materson BJ, Oparil S, Wright JT Jr, Roccella EJ; the National High Blood Pressure Education Program Coordinating Committee. The seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. JAMA 2003; 289:2560–2571.
4. National Fire Protection Association (NFPA). Fire statistics: the U.S. fire service. <http://www.nfpa.org/category_list.asp?categoryId=955&URL=Research&%20Reports/Fire%20Statistics/The%20U.S.%20Fire%20Service> (2007). Accessed 25 October 2007.
5. U.S. Department of Labor—Bureau of Labor Statistics. Occupational outlook handbook: police and detectives. <http://www.bls.gov/oco/ocos160.htm> (2007). Accessed 16 January 2007.
6. U.S. Department of Labor—Bureau of Labor Statistics. Occupational outlook handbook: emergency medical technicians and paramedics. <http://www.bls.gov/oco/ocos101.htm> (2006). Accessed 7 November 2007.
7. Law Enforcement Wellness Association, Inc. Physical fitness. <http://www.cophealth.com/fittness.html>. Accessed 27 May 2008.
8. Barnett RJ, Duncan HW. Heart rate and ECG responses of fire fighters. J Occup Med 1975; 17:247–250.
9. Kuorinka I, Korhonen O. Firefighters’ reaction to alarm, an ECG and heart rate study. J Occup Med 1981; 23:762–766.
10. Mittleman MA, Madlener M, Toffler GH, Sherwood JB, Goldberg RJ, Muller JE. Triggering of acute myocardial infarction by heavy physical exertion. Protection against triggering by regular exertion. Determinants of myocardial infarction onset study investigators. N Engl J Med 1993; 329:1677–1683.
11. Franklin BA, Bonzheim K, Gordon S, Timmis GC, Snow shoveling, a trigger for acute myocardial infarction and sudden coronary death. Am J Cardiol 1996; 77:855–858.
12. Wilbert-Lampen U, Leistner D, Greven S, Pohl T, Sper S, Volker C, Guthlin D, Plasse A, Kneze A, Kuchenhoff H, Steinbeck G. Cardiovascular events during World Cup soccer. N Engl J Med 2008, 358:475–483.
Blood Pressure in Emergency Responders

13. Kales SN, Soteriades ES, Christouphi CA, Christiani DC. Emergency duties and deaths from heart disease among firefighters in the United States. N Engl J Med 2007; 356:1207–1215.

14. Holder JD, Stallings LA, Peeples L, Burress JW, Kales SN. Firefighter heart presumption retirements in Massachusetts 1997–2004. J Occup Environ Med 2006; 48:1047–1053.

15. Kales SN, Soteriades ES, Christoudias SG, Christiani DC. Firefighters and on-duty deaths from coronary heart disease: a case control study. Environ Health 2003; 2:14.

16. Firefighter fatality retrospective study, April 2002. (Prepared for the Federal Emergency Management Agency, United States Fire Service, National Fire Data Center) Arlington, VA: TrDiData Corp., 2002.

17. Maguire B, Hunting K, Smith GS, Levcik NR. Occupational fatalities in emergency medical services: a hidden crisis. Ann Emerg Med 2002; 40:625–632.

18. Rosenstock L, Olsen J. Firefighting and death from cardiovascular causes. N Engl J Med 2007; 356:1261–1263.

19. Franke WD, Ramey SL, Shelley MC 2nd. Relationship between cardiovascular disease morbidity, risk factors, and stress in a law enforcement cohort. J Occup Environ Med 2002; 44:1182–1189.

20. International Association of Fire Fighters (IAFF). US and Canadian presumptive laws. <http://www.iaff.org/hrIS/PSoB/infectsex.aspx> (2007). Accessed 8 November 2007.

21. U.S. Department of Justice—Bureau of Justice Assistance (BJA). Public Safety Officers’ Benefits (PSOB) Program: Hometown Heroes Survivors Benefits Act of 2003. <http://www.ojp.usdoj.gov/BJA/grant/psob/psob_heroes.html>. Accessed 8 November 2007.

22. Bilev ME, Montgomery CH, Blewett J. Dietary intakes of police department employees in a wellness program. J Am Diet Assoc 1990; 90:65–68.

23. Paley MJ, Tepas DJ, Fatigue and the shiftworker: firefighters working on a rotating shift schedule. Hum Factors 1994; 36:269–284.

24. International Association of Fire Chiefs (IAFC). Effects of sleep deprivation on firefighters and EMS responders: final report. <http://www.iafc.org/associations/4685/files/progsleep_SleepDeprivationReport.pdf> (2007). Accessed 7 November 2007.

25. Steuer T, Herr E, Eikeberg O, Lau B. Health problems and help-seeking in a nationwide sample of operational Norwegian ambulance personnel. BMC Public Health 2008; 8:3.

26. Tubbs RL. Noise and hearing loss in firefighting. Occup Med 1995; 10:843–856.

27. Bryant R, Harvey A. Posttraumatic stress reaction in volunteer fire fighters. J Trauma Stress 1996; 9:1–52.

28. Jonsson A, Segesten K, Mattsson B. Post-traumatic stress among Swedish ambulance personnel. Emerg Med J 2003; 20:79–84.

29. Wolk R, Somers VK. Sleep and the metabolic syndrome. Exp Physiol 2007; 92:67–78.

30. Getz GS, Reardon CA. Nutrition and cardiovascular disease. Arterioscler Thromb Vasc Biol 2007; 27:2499–2506.

31. Vilke GM, Tornabene SV, Stepanis BK, Shipp HE, Ray LU, Metz MA, Worman D, Anderson M, Murrin PA, Davis DP. Harvey J. Paramedic self-reported medication errors. Prehosp Emerg Care 2007; 11:86–94.

32. Gallagher S, McGilloway S. Living in critical times: the impact of critical incidents on fire fighters and EMS responders: final report. <http://www.iafc.org/associations/4685/files/progsleep_SleepDeprivationReport.pdf> (2007). Accessed 8 November 2007.

33. Ramey SL, Franke WD, Shelley MC 2nd. Relationship among risk factors for nephrolithiasis, cardiovascular disease, and ethnicity: focus on a law enforcement cohort. AAOHN J 2004; 52:116–121.

34. Ramey SL, Downing NR, Knoblauch A. Developing strategic interventions to reduce cardiovascular disease risk among law enforcement officers: the art and science of data triangulation. AAOHN J 2008; 56:54–62.

35. Pyorala M, Miettinen H, Laasko M, Pyorala K. Hyperinsulinemia predicts coronary heart disease risk in healthy middle-aged men: the 22-year follow-up results of the Helsinki Policemen Study. Circulation 1998; 98:398–404.

36. Volpin P, Tomelli F, LaValle C, Tomaselli F, Rosati MV, Ciarcocci M, De Sio S, Cangemi B, Viglavico R, Fedele F. Respiratory and cardiovascular function at rest and during exercise testing in a healthy working population: effects of outdoor traffic air pollution. Occup Med (Lond) 2004; 54:475–482.

37. Davis SC, Jankowitz KZ, Rein S. Physical fitness and cardiovascular risk factors of professional firefighters across the career span. Res Q Exerc Sport 2002; 73:363–370.

38. Franke WD, Cox DF, Schultz DP, Anderson DF. Coronary heart disease risk factors in employees of Iowa’s Department of Public Safety compared to a cohort of the general population. Am J Ind Med 1997; 31:733–737.

39. Kales SN, Polykronopoulos GN, Aldrich JM, Laitos EC, Christiani DC. Correlates of body mass index in hazardous materials firefighters. J Occup Environ Med 1999; 41:589–595.

40. Glueck CJ, Kelley W, Wang P, Gartsides PS, Black D, Tracy T. Risk factors for coronary heart disease among firefighters in Cincinnati. Am J Ind Med 1996; 30:331–340.

41. Sparrow D, Thomas HE, Jr, Weiss ST. Coronary heart disease in police officers participating in the normative aging study. Am J Epidemiol 1983; 118:508–513.
64. Soteriades ES, Hauser R, Kawachi I, Liakopoulos D, Christiani DC, Kales SN. Obesity and cardiovascular disease risk factors in firefighters: a prospective cohort study. Obes Res 2005; 13:1756–1763.
65. Kales SN, Soteriades ES, Chrustidias SG, Tucker SA, Nicolaou M, Christiani DC. Firefighters’ blood pressure and employment status on hazardous materials teams in Massachusetts: a prospective study. J Occup Environ Med 2002; 44:669–676.
66. Ogden CL, Carroll MD, Curtin LR, McDowell MA, Tabak CJ, Flegal KM. Prevalence of overweight and obesity in the United States, 1999–2004. JAMA 2006; 295:1549–1555.
67. Pi-Sunyer FX. The obesity epidemic: pathophysiology and consequences of obesity. Obes Res 2002; 10(Suppl 2):97S–104S.
68. Gledhill N, Jammik VK. Development and validation of a fitness screening protocol for firefighter applicants. Can J Sport Sci 1992; 17:199–206.
69. Clark S, Rene A, Theurer WM, Marshall M. Association of body mass index and health status in firefighters. J Occup Environ Med 2002; 44:940–946.
70. Vgontzas AN, Tan T-L, Bixler EO, Martin LF, Shubert D, Kales A. Sleep apnea and sleep disruption in obese patients. JAMA 2000; 283:1829–1836.
71. Lavie P, Herer P, Hoffstein V. Obstructive sleep apnoea syndrome as a risk factor for hypertension: population study. BMU 2000; 320:479–482.
72. Nieto FJ, Young TB, Lind BK, Shahar E, Samet JM, Redline S, D’Agostino RB, Newman AB, Lebowitz MD, Hoffstein V. Association of sleep-disordered breathing, sleep apnea, and hypertension in a large community-based study. Sleep Heart Health Study. JAMA 2000; 283:1829–1836.
73. Peppard PE, Young T, Palta M. Prospective study of the association between sleep-disordered breathing and hypertension. N Engl J Med 2000; 342:1378–1384.
74. Vasan RS, Larson MG, Leip E, Kelly WB, Levy D. Assessment of frequency of progression to hypertension in non-hypertensive participants in the Framingham Heart Study: a cohort study. Lancet 2001; 358:1862–1866.
75. Hajjar I, Kotchen TA. Trends in prevalence, awareness, treatment, and control of hypertension in the United States, 1988–2000. JAMA 2003; 290:199–206.
76. Kotchen TA. Why the slow diffusion of treatment guidelines into clinical practice?. Arch Intern Med 2007; 167:2394–2395.
77. Fang J, Alderman MH, Keenan NL, Ayala C, Croft JB. Hypertension control at physicians’ offices in the United States. Am J Hypertens 2008; 21:134–135.
78. Pyorola M, Miettinen H, Laakso M, Pyorola K. Plasma insulin and all-cause, cardiovascular, and noncardiovascular mortality: the 22-year follow-up results of the Helsinki Policemen Study. Diabetes Care 2000; 23:1097–1102.
79. Pyorola M, Miettinen H, Halonen P, Laakso M, Pyorola K. Insulin resistance syndrome predicts the risk of coronary heart disease and stroke in healthy middle-aged men: the 22-year follow-up results of the Helsinki Policemen Study. Arterioscler Thromb Vasc Biol 2000; 20:538–544.
80. Geibek JR, Holder J, Peeples L, Kinney AM, Buness JW, Kales SN. Predictors of on-duty coronary events in U.S. male firefighters. Am J Cardiol 2008; 101:585–589.
81. Laxxes CM, Vander Hoorn S, Rodgers A. International Society of Hypertension. Global burden of blood-pressure-related disease. 2001. Lancet 2008; 371:1513–1518.
82. National Fire Protection Association (NFPA). NFPA 1582: Standard on Comprehensive Occupational Medical Program for Fire Departments. National Fire Protection Association: Quincy, MA, 2007.
83. Commonwealth of Massachusetts Human Resources Division. Police Officer and Firefighter Medical Standards Conference. Commonwealth of Massachusetts: Boston, 1998.
84. Weyers SG. California Commission on Peace Officer Standards and Training (POST) Medical Screening Manual for California Law Enforcement. <http://www.post.ca.gov/selection/pdf/Cardio.pdf> (2007). Accessed 24 October 2007.
85. International Association of Fire Fighters (IAFF), International Association of Fire Chiefs (IAFC). The Fire Service Joint Labor Management Wellness/Fitness Initiative. International Association of Fire Fighters, International Association of Fire Chiefs: Washington, DC, 2000.
86. Svetkey LP. Management of prehypertension. Hypertension 2005; 45:1056–1061.
87. U.S. Department of Transportation—Federal Motor Carrier Safety Administration. Cardiovascular Advisory Panel Guidelines for the Medical Examination of Commercial Motor Vehicle Drivers. <http://www.fmcsa.dot.gov/documents/cardio.pdf> (2002). Accessed 8 November 2007.
88. Harshman RS, Richerson GT, Hadker N, Greene BL, Brown TM, Foster TS, Turner BH, Skrepnek SH, Doyle JJ. Impact of a hypertension management/health promotion program on commercial driver’s license employees of a self-insured utility company. J Occup Environ Med 2008; 50:359–365.
89. Smith DL, Manning TS, Petruzello SJ. Effect of strenuous live-fire drills on cardiovascular and psychological responses of recruit firefighters. Ergonomics 2001; 44:244–254.
90. McInnes GT, Macdonald EB. Therapeutics of hypertension in the work environment. J Soc Occup Med 1981; 31:3–7.
91. Wexler RK. Evaluation and treatment of heat-related illnesses. Am Fam Physician 2002; 65:2307–2314.
92. Okie S. The employer as health coach. N Engl J Med 2007; 357:1465–1469.
93. North Carolina Justice. Academy. Officer Safety Tip—Heart Disease. <http://www.jus.state.nc.us/NCJA/w-08–99tip.htm>. Accessed 4 June 2008.