



Fire Fighter Suffers Sudden Cardiac Death After Emergency Recall - Massachusetts

SUMMARY

On January 21, 2004, a 48-year-old male career Fire Fighter-Paramedic (FF-P) provided station coverage in his fire station while his fire department (FD) was providing mutual aid to a neighboring FD. While in the station, he stocked the FD's new ambulance with supplies. When the crew members returned, he returned to his off-duty business. On January 22, approximately 21 hours after providing station coverage, the FF-P was working at his off-duty business when he suddenly collapsed. Despite cardiopulmonary resuscitation (CPR) performed by a bystander and advanced life support (ALS) performed by ambulance service emergency medical technicians (EMTs) and paramedics, he died. The death certificate listed "acute sudden cardiac death syndrome" due to "acute myocardial infarction" as the immediate cause of death and "obesity" as another significant condition. No autopsy was performed.

The following recommendations address some general health and safety issues. These selected recommendations have not been evaluated by NIOSH, but represent published research, or consensus votes of technical committees of the National Fire Protection Association (NFPA) or fire service labor/management groups.

- **Implement the annual medical evaluations mandated by the State in 1996 or recommended by NFPA 1582**
- **Phase in a mandatory wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity**

- **Perform an annual physical performance (physical ability) evaluation for ALL fire fighters to ensure fire fighters are physically capable of performing the essential job tasks of structural fire fighting**

The following recommendations are safety and health measures, but not contributory to this fatality:

- **Perform an autopsy on all on-duty fire fighter fatalities**
- **Provide pre-placement medical evaluations to ALL fire fighters consistent with NFPA 1582 or State mandate to determine their medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others**
- **Provide adequate fire fighter staffing to ensure safe operating conditions**

The **Fire Fighter Fatality Investigation and Prevention Program** is conducted by the National Institute for Occupational Safety and Health (NIOSH). The purpose of the program is to determine factors that cause or contribute to fire fighter deaths suffered in the line of duty. Identification of causal and contributing factors enable researchers and safety specialists to develop strategies for preventing future similar incidents. The program does not seek to determine fault or place blame on fire departments or individual fire fighters. To request additional copies of this report (specify the case number shown in the shield above), other fatality investigation reports, or further information, visit the Program Website at www.cdc.gov/niosh/firehome.html or call toll free 1-800-35-NIOSH



Fire Fighter Suffers Sudden Cardiac Death After Emergency Recall - Massachusetts

INTRODUCTION & METHODS

On January 21, 2004, a 48-year-old male FF-P responded to his fire station to provide standby coverage. The next day while off duty, he suddenly collapsed. Despite CPR performed by a bystander and ALS treatment by EMS personnel and at the hospital, the victim died. NIOSH was notified of this fatality on January 28, 2004, by the United States Fire Administration. NIOSH contacted the affected Fire Department on January 29, 2004 to initiate the investigation. On March 1, 2004, a Safety and Occupational Health Specialist from the NIOSH Fire Fighter Fatality Investigation Team traveled to Massachusetts to conduct an on-site investigation of the incident.

During the investigation NIOSH personnel interviewed:

- The Fire Chief
- Crew members on duty with the FF-P
- The FF-P's wife

During the site-visit NIOSH personnel reviewed:

- Fire Department policies and operating guidelines
- Fire Department training records
- The Fire Department annual report for 2003
- Fire Department incident report
- Hospital reports
- Fire Department physical examination protocols
- Death certificate
- Past medical records of the deceased

INVESTIGATIVE RESULTS

Incident. On January 21, 2004, the FF-P (the deceased) was off-duty working at his small engine repair shop. At 0958 hours, his fire station was dispatched for mutual aid to provide coverage for a neighboring FD fighting a fire in a six-family dwelling. Off-duty personnel, including the FF-P, were recalled to provide standby coverage at their fire station. The FF-P responded to his fire station, arriving at

approximately 1015 hours. During the standby period, the FF-P loaded supplies in the station's new ambulance. This involved moving an oxygen tank (weighing approximately 45 pounds), a spare tire, and a portable trailer (weighing approximately 800 pounds). At 1428 hours, the duty crew returned to their station and all recalled personnel were released. The FF-P returned to his small engine repair shop where he continued working until approximately 1845 hours when he went home. At approximately 2030 hours, complaining of being very tired, he retired for the night.

The next day, he arose at approximately 0530 hours and went to work at his shop. At approximately 1214 hours, while working on a computer, the FF-P stated to a customer, "I have an emergency and I need something to eat" and then collapsed. The bystander assessed the FF-P, found him to be unresponsive, not breathing, and pulseless, and began CPR. After performing CPR for one minute, the bystander notified 911.

Ambulance 568 was dispatched at 1217 hours to a call for a man having a seizure. The ambulance arrived on the scene four minutes later finding the FF-P unresponsive, pulseless, apneic, and CPR in progress. A cardiac monitor attached to the FF-P's chest revealed ventricular fibrillation (V.fib.) and one shock (defibrillation) was delivered. His heart rhythm reverted to asystole (no heart beat) and CPR continued. An intravenous (IV) line was established, cardiac medications consistent with ALS protocols were administered, and the FF-P was intubated, with tube placement confirmed by auscultation and capnography. The cardiac monitor revealed V.fib. and a second shock was delivered, with his heart rhythm again reverting to asystole. CPR and ALS measures continued and he was placed inside the ambulance, which departed the scene at 1242 hours enroute to the hospital.



Fire Fighter Suffers Sudden Cardiac Death After Emergency Recall - Massachusetts

Upon arrival at the emergency department (ED) at 1252 hours, CPR and ALS measures continued with no positive change in status. He was re-intubated due to no positive color change (his endotracheal tube had apparently become dislodged during transfer from ambulance to ED), and CPR and ALS continued until 1308 hours, when he was pronounced dead and resuscitation measures were stopped.

Medical Findings. The death certificate, completed by the Medical Examiner, listed “Acute sudden cardiac death syndrome” due to “acute myocardial infarction” as the immediate cause of death and “obesity” as an other significant condition. No autopsy was performed.

The FF-P had a comprehensive pre-placement physical evaluation in March, 1999, including a resting electrocardiogram. The exam was normal and he was subsequently cleared for fire fighting duty including the use of a self-contained breathing apparatus (SCBA). A physical evaluation in August 2002 to obtain an aircraft pilot’s license was normal. A physical evaluation in May 2003 performed by a new physician revealed an elevated blood pressure [142/100 millimeters of mercury (mmHg)], weight of 250 pounds, elevated lipids, and a normal EKG. He was diagnosed with hypertension, hyperlipidemia, and obesity. He was advised to consume a low fat, low cholesterol, low sodium diet. Follow-up blood chemistry revealed elevated cholesterol [210 milligrams per deciliter (mg/dL)(normal <200 mg/dL), elevated low density lipoprotein (LDL) 146 mg/dL (normal <129 mg/dL), and an elevated cholesterol/high density lipoprotein (chol/HDL) ratio 5.53 (normal <4.97)].

On December 29, 2003, he suffered a syncopal (unexplained loss of consciousness) episode and was hospitalized. An EKG revealed sinus tachycardia (heart rate of 105 beats per minute) (normal range 60-100 beats per minute) and probable left

ventricular hypertrophy (LVH) by voltage criteria with non-specific ST-T wave abnormalities. His subsequent work-up was significant for a normal head computed tomography (CT) scan, normal pulse oximetry, and normal blood glucose, but lung tests (spirometry) showed a combined restrictive and obstructive airways disease with post-bronchodilator improvement in flow rates. Cardiac work-up included a Doppler echocardiogram significant for an enlarged left atrium and a sclerotic-looking mitral valve with no significant stenosis. A thallium exercise stress test (EST) was conducted using the Bruce protocol. The FF-P exercised for 7 minutes and 15 seconds, stopping due to shortness of breath. He achieved a VO_2 max of 24 milliliters per kilogram of body weight per minute (ml/kg/min) or 6.82 metabolic equivalents (METs), which is considered poor aerobic capacity (fitness).^{1,2} He did not develop chest pain, ischemic changes on his EKG, or arrhythmias, reaching a maximum heart rate of 138 (80% of maximum). The thallium portion of the EST revealed a fixed inferior apical defect; the defect being present on both resting and stress images. This type of image suggests an old (remote) heart attack, otherwise known as a myocardial infarction (MI). The gated SPECT images revealed normal wall motion with a normal ejection fraction of 51%. A Holter monitor was negative. His physicians concluded his syncope was a “vagal” episode due to dehydration with a possible viral syndrome, obesity hypoventilation syndrome, and obstructive sleep apnea.

The FF-P had some shortness of breath on exertion, some occasional palpitations (fast heart beats), and some episodes of chest pain with diaphoresis (sweating) during the two to three weeks prior to his death including. He self-medicated with one sublingual nitroglycerin tablet that resolved his chest pain, but did not seek medical advice. Subsequently, there were intermittent episodes of mild chest pain usually with exertion, but resolved with rest. The



Fire Fighter Suffers Sudden Cardiac Death After Emergency Recall - Massachusetts

last episode was December 26, 2003. He had increasing lower extremity edema for the last few months but no calf pain. A follow-up visit to his primary care physician revealed a blood pressure of 158/90 mmHg. An EKG revealed T-wave depression in leads II, III, F, and V⁴⁻⁶. He was apparently cleared for duty.

At the time of his death, the FF-P weighed approximately 250 pounds and was 70 inches tall, giving him a body mass index (BMI) of 36 kilograms per square meter (kg/m²). (A BMI over 30.0 kg/m² is considered obese).³ According to his wife and crew members, the FF-P did not have any other syncopal episodes.

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, the combination Fire Department consisted of 15 career uniformed personnel and 15 call personnel that served a population of 30,000 during the day and 7,000 permanent residents at night in a geographic area of 16.5 square miles. There is one fire station. The FD staffs an engine with at least three personnel. Incoming personnel provide staffing on each successive engine and ladder. Fire fighters work the following schedule: day shift (0730 hours to 1730 hours) for two days, night shift (1730 hours to 0730 hours) for two nights, then are off-duty for four days. Emergency Medical Service is a component of the Fire Department.

In 2003, the FD responded to 2,534 calls: 15 structure fires, 33 vehicle fires, 8 brush/grass fires, 17 other fires, 4 outside fires, 221 motor vehicle accidents, 2 extrications, 37 mutual aid calls, 50 hazardous condition calls, 1024 emergency medical calls, 125 fire alarms, 116 public service calls, 76 details, 25 false alarms, 18 fire drills, 5 Med-flight

calls, 2 police assist calls, 256 inspections, and 391 other calls.

Training. The FD requires all new career fire fighter applicants to pass the State Civil Service Commission wellness examination, psychological exam, and physical ability test and an interview prior to being given a condition of employment. Newly hired fire fighters are on probation for one year. If they have previous fire fighter training, they may respond to fires and will receive additional training at the MA Fire Fighting Academy. If the newly hired fire fighter has only medical training, they may respond only to medical calls and will receive fire fighter training at the MA Fire Fighting Academy. Company officers monitor new hire training and at the end of the one year probationary period, the fire fighter has achieved training to the Fire Fighter II and First Responder level.

Recurrent training occurs daily on each shift. The State minimum requirements for fire fighter certification are: (1) the candidate must be at least 18 years of age, (2) possess a high school diploma or GED, (3) be a member of the MA fire service, and (4) complete the State Fire Fighter I and II and First Responder course. There is no State requirement for fire fighter recertification. The victim was certified as a Fire Fighter II, Emergency Medical Technician-Paramedic, and Crash-Fire-Rescue. While only employed on this FD for 5 years, he had 32 years of fire fighting experience.

Pre-placement Evaluations. The FD requires a pre-placement medical evaluation for career new hires, regardless of age. The components of this evaluation, mandated by the Human Resources Division of the Commonwealth of Massachusetts since 1996. Components of this evaluation include the following:

- A complete medical history
- Vital signs



Fire Fighter Suffers Sudden Cardiac Death After Emergency Recall - Massachusetts

- Physical examination
- Pulmonary function test (PFT)
- Resting EKG
- Complete blood count (CBC)
- Urinalysis
- Audiogram
- Vision screen
- Tuberculosis/latex screening
- Respirator clearance

These evaluations are performed by a contract physician with guidance from the State Human Resources Division. Once this evaluation is complete, the physician makes a determination regarding medical clearance for fire fighting duties and forwards this decision to the City's personnel director.

Periodic Evaluations

In 1996, the State of Massachusetts mandated annual fire fighter physical examinations, but did not provide funding. Consequently, this FD did not require periodic medical evaluations. Additionally, as part of the State's Wellness Act, fire fighters are not permitted to smoke cigarettes or cigars. Medical clearance for self-contained breathing apparatus (SCBA) use and for fire suppression is required for new-hire career fire fighters only.

If an employee is injured at work, or is ill and off work for more than five shifts, the employee is evaluated by their personal physician, who forwards their recommendation regarding "return to work" to the City Personnel Director, who makes the final determination. There is a mandatory wellness/fitness program for fire fighters hired under the State Wellness Act, including membership in a local health club. There is a voluntary wellness/fitness program for the other career fire fighters who are offered health club memberships. Exercise (strength and aerobic) equipment is not currently available in the fire station. The FF-P did not take advantage of this fitness program and did not exercise regularly.

The FF-P was cleared for duty by his primary care physician following his syncopal episode two weeks prior to his death.

DISCUSSION

In the United States, coronary artery disease (atherosclerosis) is the most common risk factor for cardiac arrest and sudden cardiac death.⁴ Risk factors for its development include increasing age, male gender, family history of coronary artery disease, smoking, high blood pressure (systolic >140 mmHg or diastolic > 90 mmHg), high blood cholesterol (total cholesterol > 240 mg/dL), obesity/physical inactivity, and diabetes.⁵ The deceased had six of these risk factors (increasing age, male gender, family history, high blood pressure, high blood cholesterol, and obesity/physical inactivity).

The narrowing of the coronary arteries by atherosclerotic plaques occurs over many years, typically decades.⁶ However, the growth of these plaques probably occurs in a nonlinear, often abrupt fashion.⁷ Heart attacks typically occur with the sudden development of complete blockage (occlusion) in one or more coronary arteries that have not developed a collateral blood supply.⁸ This sudden blockage is primarily due to blood clots (thrombosis) forming on the top of atherosclerotic plaques.

It is also possible/probable that the FF-P suffered a heart attack. The term "probable" is used because autopsy findings (thrombus formation), blood tests (cardiac isoenzymes), or ECG findings are required to "confirm" a heart attack [myocardial infarction (MI)]. No autopsy was performed, the FF-P died prior to the cardiac isoenzymes becoming positive, and he had no heart beat to show the characteristic findings of a heart attack on his EKG.

Angina is the most common presenting symptom of myocardial ischemia and underlying CAD, but in



Fire Fighter Suffers Sudden Cardiac Death After Emergency Recall - Massachusetts

many persons the first evidence of CAD may be myocardial infarction or sudden death.⁹ In retrospect, the FF-P had symptoms very suggestive of angina (chest pain on exertion, relieved by rest and nitroglycerin, associated with shortness of breath, diaphoresis, and palpitations). However, his thallium EST was not positive for ischemia. Closer scrutiny of this test suggests he was not able to exercise long enough (stopped secondary to fatigue) to uncover his probable underlying CAD.

Another explanation for the FF-P's sudden cardiac death could be related to his hypertension (HTN). HTN is associated with heart rhythm problems, some of which can be life-threatening.

Firefighting is widely acknowledged to be one of the most physically demanding and hazardous of all civilian occupations.¹⁰ Firefighting activities are strenuous and often require fire fighters to work at near maximal heart rates for long periods. The increase in heart rate has been shown to begin with responding to the initial alarm and persist through the course of fire suppression activities.¹¹⁻¹³ Even when energy costs are moderate (as measured by oxygen consumption) and work is performed in a thermoneutral environment, heart rates may be high (over 170 beats per minute) owing to the insulative properties of the personal protective clothing.¹⁴ Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks.¹⁵⁻¹⁸ The deceased responded to his fire station and assisted with stocking a new ambulance, including moving some heavy items. This is considered a moderate level of physical exertion.^{19,20} The physical stress of responding to the alarm, moving some heavy equipment to stock the ambulance, and his probable underlying atherosclerotic CAD contributed to this fire fighter's "probable heart attack" and sudden cardiac death. Most life threatening arrhythmias

associated with MI's occur during the 24 hours after symptoms first began.²¹⁻²³

Recurrent syncope is considered a "Category A" condition that would preclude a person from performing as a member in a training or emergency operational environment by presenting a significant risk to the safety and health of the person or others.²⁴ Recurrent syncope can result in the potential for sudden incapacitation.²⁴ The FF-P, however, had only one episode of syncope, which would be considered a "Category B" condition. A Category B condition is a medical condition that, based on its severity or degree, could preclude a person from performing as a member in a training or emergency operational environment by presenting a significant risk to the safety and health of the person or others.²⁴

RECOMMENDATIONS

The following recommendations address health and safety generally.

Recommendation #1: Implement the annual medical evaluations mandated by the State or recommended by NFPA 1582.

The City and Union should **work together** to establish the content and frequency in order to be consistent with the State regulations or national consensus guidelines (NFPA).

Recommendation #2: Phase in a mandatory wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.

NFPA 1500, Standard on Fire Department Occupational Safety and Health Program, requires a wellness program that provides health promotion activities for preventing health problems and enhancing overall well-being.²⁵ NFPA 1583,

Fire Fighter Suffers Sudden Cardiac Death After Emergency Recall - Massachusetts

Standard on Health-Related Fitness Programs for Fire Fighters, provides the minimum requirements for a health-related fitness program.²⁶ Physical inactivity is the most prevalent modifiable risk factor for CAD in the United States. Additionally, physical inactivity, or lack of exercise, is associated with other risk factors, namely obesity and diabetes.²⁷ In 1997, the International Association of Fire Fighters (IAFF) and the International Association of Fire Chiefs (IAFC) published a comprehensive Fire Service Joint Labor/Management Wellness/Fitness Initiative to improve fire fighter quality of life and maintain physical and mental capabilities of fire fighters. Ten fire departments across the United States joined this effort to pool information about their physical fitness programs and to create a practical fire service program. They produced a manual and a video detailing elements of such a program.²⁸ The Fire Department should review these materials to identify applicable elements for the Department. Other large-city negotiated programs can also be reviewed as potential models. Wellness programs have been shown to be cost effective, typically by reducing the number of work-related injuries and lost work days.²⁹⁻³¹ A similar cost savings has been reported by the wellness program at the Phoenix Fire Department, where a 12-year commitment has resulted in a significant reduction in their disability pension costs.³²

Recommendation #3: Perform an annual physical performance (physical ability) evaluation for ALL fire fighters to ensure fire fighters are physically capable of performing the essential job tasks of structural fire fighting.

NFPA 1500 requires fire department members who engage in emergency operations to be annually evaluated and certified by the fire department as meeting the physical performance requirements identified in paragraph 8-2.1.²⁵

The following recommendations are safety and health measures, but not contributory to this fatality:

Recommendation #4: Perform an autopsy on all on-duty fire fighter fatalities.

In 1995, the United States Fire Administration (USFA) published the Firefighter Autopsy Protocol.³³ This publication hopes to provide “a more thorough documentation of the causes of firefighter deaths for three purposes:

1. to advance the analysis of the causes of firefighter deaths to aid in the development of improved firefighter health and safety equipment, procedures, and standards;
2. to help determine eligibility for death benefits under the Federal government’s Public Safety Officer Benefits Program, as well as state and local programs; and
3. to address an increasing interest in the study of deaths that could be related to occupational illnesses among firefighters, both active and retired.”

Recommendation #5: Provide pre-placement medical evaluations to ALL fire fighters consistent with NFPA 1582 or State mandate to determine their medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others.

Guidance regarding the content and frequency of periodic medical evaluations and examinations for fire fighters can be found in NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments,²⁴ and in the report of the International Association of Fire Fighters/International Association of Fire Chiefs (IAFF/IAFC) wellness/fitness initiative.²⁸ The Department is not legally required to follow any of these standards.

Fire Fighter Suffers Sudden Cardiac Death After Emergency Recall - Massachusetts

The success of medical programs hinges on protecting the affected fire fighter. The Department must **1)** keep the medical records confidential, **2)** provide alternate duty positions for fire fighters in rehabilitation programs, and **3)** if the fire fighter is not medically qualified to return to active fire fighting duties, provide permanent alternate duty positions or other supportive and/or compensated alternatives.

Recommendation #6: Provide adequate fire fighter staffing to ensure safe operating conditions.

Currently, the FD staffs its first-due engine with three personnel and its additional responding apparatus with two-three call personnel. NFPA 1710 requires that “on-duty personnel assigned to fire suppression shall be organized into company units and shall have appropriate apparatus and equipment assigned to such companies.”³⁴ Those companies may respond with two apparatus, depending on the seating configuration of the apparatus to ensure four personnel arrive on scene.³⁴ Personnel assigned to the initial arriving company shall have the capability to implement an initial rapid intervention crew (IRIC),³⁴ which requires four personnel (two to enter the structure and two standing by outside). NFPA 1500 recommends that “members operating in hazardous areas at emergency incidents shall operate in teams of two or more.”²⁵ Understaffing causes those members on-scene to work harder and for longer periods of time. Additionally, it requires the use of extra fire companies in order to meet the demand for manpower. Engine and Ladder Companies should be staffed with four personnel at a minimum.

REFERENCES

1. WorldAR [2002]. Bruce treadmill protocol. World Wide Web (Accessed March 2004).

Available from <http://www.worldar.com/endurance/bruce.htm>

2. ExRx.net [2004]. Maximum treadmill cardiovascular test. World Wide Web (Accessed March 2004). Available from <http://www.exrx.net/Calculators/Treadmill.html>

3. National Heart Lung Blood Institute [2004]. Obesity education initiative. World Wide Web (Accessed March 2004.) Available from <http://www.nhlbisupport.com/bmi/bmicalc.htm>

4. Meyerburg RJ, Castellanos A [2001]. Cardiovascular collapse, cardiac arrest, and sudden cardiac death. In: Braunwald E, Fauci AS, Kasper DL, Hauser SL, Longo DL, Jameson JL, eds. Harrison’s principles of internal medicine. 15th Edition. New York: McGraw-Hill. pp. 228-233.

5. AHA [1998]. AHA Scientific Position, Risk Factors for Coronary Artery Disease. Dallas, TX: American Heart Association.

6. Libby P [2001]. The pathogenesis of atherosclerosis. In: Braunwald E, Fauci AS, Kasper DL, Hauser SL, Longo DL, Jameson JL, eds. Harrison’s principles of internal medicine. 15th Edition. New York: McGraw-Hill. p.1378.

7. Shah PK [1997]. Plaque disruption and coronary thrombosis: new insight into pathogenesis and prevention. Clin Cardiol 20 (11 Suppl2): II-38-44.

8. Fuster V, Badimon JJ, Badimon JH [1992]. The pathogenesis of coronary artery disease and the acute coronary syndromes. N Eng J Med 326:242-250.

9. Thaulow E, Erikssen J, et. al [1993]. Initial clinical presentation of cardiac disease in asymptomatic men with silent myocardial ischemia and angiographically documented coronary artery



Fire Fighter Suffers Sudden Cardiac Death After Emergency Recall - Massachusetts

- disease (the Oslo Ischemia Study). *Am J Cardiol* 72:629-633.
10. Gledhill N, Jamnik, VK [1992]. Characterization of the physical demands of firefighting. *Can J Spt Sci* 17(3):207-213.
11. Barnard RJ, Duncan HW [1975]. Heart rate and ECG responses of fire fighters. *J Occup Med* 17:247-250.
12. Manning JE, Griggs TR [1983]. Heart rate in fire fighters using light and heavy breathing equipment: Simulated near maximal exertion in response to multiple work load conditions. *J Occup Med* 25:215-218.
13. Lemon PW, Hermiston RT [1977]. The human energy cost of fire fighting. *J Occup Med* 19:558-562.
14. Smith DL, Petruzzello SJ, Kramer JM, et al. [1995]. Selected physiological and psychobiological responses to physical activity in different configurations of firefighting gear. *Ergonomics* 38(10):2065-2077.
15. Willich SN, Lewis M, Lowel H, et al. [1993]. Physical exertion as a trigger of acute myocardial infarction. *N Eng J Med* 329:1684-1690.
16. Mittleman MA, Maclure M, Tofler GH, et al. [1993] Triggering of acute myocardial infarction by heavy physical exertion. *N Eng J Med* 329:1677-1683.
17. Siscovick DS, Weiss NS, Fletcher RH, Lasky T [1984]. The incidence of primary cardiac arrest during vigorous exercise. *N Eng J Med* 311:874-877.
18. Tofler GH, Muller JE, Stone PH, et al. [1992] Modifiers of timing and possible triggers of acute myocardial infarction in the Thrombolysis in Myocardial Infarction Phase II (TIMI II) Study Group. *J Am Coll Cardiol* 20:1049-1055.
19. Ainsworth BE, Haskell WL, Leon AS, et al [1993]. Compendium of physical activities: classification of energy costs of human physical activities. *Med Sci Sports Exerc* 25(1):71-80.
20. American Industrial Hygiene Association Journal [1971]. Ergonomics guide to assessment of metabolic and cardiac costs of physical work. *Am Ind Hyg Assoc J* 560-564.
21. Dhurandhar RW, MacMillan RL, and Brown KWG [1970]. Primary ventricular fibrillation complicating acute myocardial infarction. *Am J Cardiol* 27:347-351.
22. Lown B, Fakhro AM, Hood WB Jr., and Thorn GW [1967]. The coronary care unit. *JAMA* 199(3):156-166.
23. Campbell RWF, Murray A, and Julian DG [1981]. Ventricular arrhythmias in first 12 hours of acute myocardial infarction. *Br Heart J* 46:351-357.
24. NFPA [2003]. Standard on comprehensive occupational medical program for fire departments. Quincy MA: National Fire Protection Association. NFPA 1582-2003.
25. NFPA [1997]. Standard on fire department occupational safety and health program. Quincy MA: National Fire Protection Association. NFPA 1500-1997.
26. NFPA [2000]. Standard on health-related fitness programs for fire fighters. Quincy MA: National Fire Protection Association. NFPA 1583-2000.



Fire Fighter Suffers Sudden Cardiac Death After Emergency Recall - Massachusetts

27. Plowman SA and Smith DL [1997]. Exercise physiology: for health, fitness and performance. Boston, MA: Allyn and Bacon.
28. IAFF, IAFC. [2000]. The fire service joint labor management wellness/fitness initiative. Washington, D.C.: International Association of Fire Fighters, International Association of Fire Chiefs.
29. Maniscalco P, Lane R, Welke M, Mitchell J, Husting L [1999]. Decreased rate of back injuries through a wellness program for offshore petroleum employees. *J Occup Environ Med* 41:813-820.
30. Stein AD, Shakour SK, Zuidema RA [2000]. Financial incentives, participation in employer sponsored health promotion, and changes in employee health and productivity: HealthPlus health quotient program. *JOEM* 42:1148-1155.
31. Aldana SG [2001]. Financial impact of health promotion programs: A comprehensive review of the literature. *Am J Health Promot* 15:296-320.
32. Unpublished data [1997]. City Auditor, City of Phoenix, AZ. Disability retirement program evaluation. Jan 28, 1997.
33. United States Fire Administration [1995]. Firefighter Autopsy Protocol. Emmitsburg: Federal Emergency Management Agency; USFA, Publication No. FA-156.
34. NFPA [2001]. Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments. Quincy, MA: National Fire Protection Association. NFPA 1710-2001.

INVESTIGATOR INFORMATION

This investigation was conducted and the report written by Tommy N. Baldwin, MS, Safety and Occupational Health Specialist. Mr. Baldwin, a National Association of Fire Investigators (NAFI) Certified Fire and Explosion Investigator, an International Fire Service Accreditation Congress (IFSAC) Certified Fire Officer I, and a Kentucky Certified Fire Fighter and Emergency Medical Technician (EMT), is with the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiovascular Disease Component located in Cincinnati, Ohio.