2006
29
NIOSH
Fire Fighter Fatality Investigation and Prevention Program

Death in the line of duty...

A summary of a NIOSH fire fighter fatality investigation *April 20, 2007*

Fire Fighter Suffers Sudden Cardiac Death After Responding to a Water Rescue Call – Pennsylvania

SUMMARY

On July 4, 2006, a 35-year-old male volunteer Fire Fighter (FF) responded to a rescue call for rafters (boaters) who had fallen into a river at approximately 1431 hours. Once on scene, the FF stood by the apparatus while the rafters were rescued upstream and the emergency was declared under control. Units returned to their station, the equipment was readied for the next call, and the FF returned home for the evening.

The next morning, July 5th, the FF went to his regular job at a local manufacturing plant. After visiting the infirmary for a skin rash, he went to his work station and suddenly collapsed. Coworkers, including the plant's medical emergency response team responded, called 9-1-1, and began medical treatment including cardiopulmonary resuscitation (CPR). Ambulance personnel began advanced life support treatment and transported the FF to the hospital's emergency department. Despite advanced life support and CPR, the FF died. The death certificate and autopsy (completed by the forensic pathologist) listed "mitral valve prolapse" as the cause of death. The NIOSH investigator concluded that the FF's underlying mitral valve prolapse and/or left ventricular hypertrophy were responsible for his sudden cardiac death, possibly triggered by the physical stress of responding to the rescue call.

NIOSH investigators offer the following recommendations to address general safety and health issues. It is doubtful any of these recommendations would have prevented this FF's sudden cardiac death.

***Perform pre-placement and periodic medical evaluations consistent with National Fire Protection Association (NFPA) 1582,* Standard on Comprehensive Occupational Medical Program for Fire Departments.**

Secure endotracheal tubes to prevent dislodgment during patient treatment, transfer, and transport.

Ensure that fire fighters are cleared for duty by a physician knowledgeable about the physical demands of firefighting, the personal protective equipment used by fire fighters, and the various components of NFPA 1582.

Provide fire fighters with medical evaluations and clearance to wear self-contained breathing apparatus (SCBAs).

Develop a structured wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.

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

http://www.cdc.gov/niosh/fire/

or call toll free

1–800–CDC–INFO (1–800–232–4636)

Fire Fighter Suffers Sudden Cardiac Death After Responding to a Water Rescue Call – Pennsylvania

Perform an annual physical performance (physical ability) evaluation to ensure fire fighters are physically capable of performing the essential job tasks of structural firefighting.

INTRODUCTION & METHODS

On July 5, 2006, a 35-year-old male volunteer FF suffered sudden cardiac death at his regular job about 17 hours after responding to a water rescue call. NIOSH was notified of this fatality on July 10, 2006, by the United States Fire Administration. NIOSH contacted the affected fire department on July 14, 2006, to obtain further information and on November 27, 2006, to initiate the investigation. On December 4, 2006, a Safety and Occupational Health Specialist from the NIOSH Fire Fighter Fatality Investigation Team traveled to Pennsylvania to conduct an on-site investigation of the incident.

During the investigation, NIOSH personnel interviewed the following people:

- Fire Chief
- President of the Fire Company
- FF's wife

NIOSH personnel reviewed the following documents:

- Fire Department incident report
- Fire Department training records
- Fire Department 2005 annual response report
- Fire Department standard operating guidelines
- Manufacturing plant incident report
- Ambulance report
- Hospital record
- Death certificate
- Autopsy report
- Primary care provider records

INVESTIGATIVE RESULTS

On July 4, 2006, four fire departments were dispatched to a river rescue call at 1431 hours. Rafters had fallen out of their boat and were in need of rescue. The FF responded to his fire station during a heavy rain and, wearing full bunker gear, drove the Attack-Brush Unit to the scene where he distributed river rescue gear to rescue personnel. Upon reaching staging, the rain stopped and, while standing by the apparatus in staging, he removed his bunker coat. At this time the temperature was 81º Fahrenheit with 65% relative humidity.

The rafters were rescued upstream, and the emergency was declared under control at 1452 hours. The FF drove the Attack-Brush Unit back to the fire station, checked the equipment, and cleaned the Unit, preparing it for the next call. He left the fire station at about 1800 hours and drove to his home. During the evening, the FF did not perform any physically exerting activities. He did not complain of any chest discomfort or shortness of breath prior to going to sleep for the night.

The next morning, the FF arose and left for work at 0615 hours. He worked on the production line for a local manufacturing company. After arriving at work at about 0700

hours, the FF went to the infirmary complaining of a skin rash (contact dermatitis due to poison ivy exposure). The occupational health nurse applied topical hydrocortisone cream to the rash, and the FF went to his work station.

According to a coworker, the FF walked off a semi-trailer onto the dock, appeared disoriented, staggered, and suddenly collapsed face down. The coworker notified the infirmary (at 0725 hours) that the FF had fallen and was bleeding. Two occupational health nurses responded to the scene with the company ambulance cart, arriving at the dock at 0730 hours. The nurses observed the FF was unresponsive but had some chest movement with slow, labored breathing, a faint pulse, and was bleeding from his nose. The nurses applied dressings to his face to stop the bleeding and suspected the FF suffered a head injury during the fall. Oxygen was administered via non-rebreather face mask. 9-1-1 was called and an ambulance was dispatched at 0739 hours for "an unknown problem." En route, Dispatch notified the ambulance that the patient had fallen and was unconscious. Plant medical emergency response team members arrived at about 0744 hours, applied a cervical collar, transferred him onto a stretcher, and took him to the infirmary. His deteriorating condition was first detected during the trip to the infirmary, when the FF stopped breathing and became pulseless; CPR was begun. Once the FF was delivered to the infirmary, the local ambulance arrived (0747 hours).

Ambulance personnel found the FF to be unconscious and in cardiac arrest. The plant's automated external defibrillator (AED) was attached to the FF and no shock was advised. A cardiac monitor from the ambulance was attached to the FF, revealing asystole (no heart beat). Intubation (a breathing tube inserted into the windpipe) was successful on the second attempt and proper placement was confirmed by a colorimetric monitor with positive color change. An intravenous line was inserted and cardiac resuscitation medications were administered. The FF was placed into the ambulance, which departed the scene en route to the hospital's Emergency Department at 0807 hours.

During the 14-minute ride to the hospital the FF's heart rhythm remained in asystole. The ambulance arrived at the Emergency Department at 0821 hours. Inside the Emergency Department, CPR and advanced life support treatment continued. Due to sluggish end tidal carbon dioxide detector color change and concern that the endotracheal tube may have become displaced, the FF was re-intubated. After an additional 11 minutes of advanced life support in the Emergency Department without improvement in the FF's condition, he was pronounced dead by the attending physician at 0832 hours and resuscitation efforts were discontinued.

Medical Findings. The death certificate and the autopsy (completed by the forensic pathologist) listed "mitral valve prolapse" as the cause of death. Pertinent findings from the autopsy, performed on July 5, 2006, included the following:

- Severe mitral valve prolapse
- Cardiomegaly (enlarged heart: heart weighed 445 grams [g] [normal is <400 g])[1]
  - Left ventricular hypertrophy with:
    - a left ventricular wall thickness of 1.7 centimeters (cm) (normal is 0.6-1.1 cm)[2]

  - A right ventricular wall thickness of 0.5 cm (normal)
  - Interventricular hypertrophy
    - an interventricular septal wall thickness of 2.5 cm (normal is 0.6-1.1 cm) [2]

- Mild atherosclerotic coronary artery disease (CAD)
  - 25% stenosis of the left anterior descending coronary artery
- No evidence of thrombus (blood clot) in the coronary arteries
- No evidence of thromboemboli in the pulmonary arteries
- Negative alcohol tests
- Drug testing was positive for over-the-counter decongestant

The FF was not known to have a heart murmur or a heart valve problem until his autopsy despite multiple visits to health care providers over the 2-3 years prior to his death. According to his wife and crew members, he did not express any symptoms of cardiac-related problems during the days or months prior to his death. However, on the day of his death, he had symptoms of poison ivy exposure and visited his employer's infirmary about 30 minutes prior to his collapse. He had no other symptoms at that time and went to his duty location in the factory.

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, this volunteer Fire Department consisted of 24 uniformed personnel, served a population of 5,000 in a 5-square-mile area, and had 1 fire station. In 2005, the Fire Department responded to 104 calls including: 9 structure fires, 6 other fires, 3 brush fires, 2 vehicle fires, 1 rubbish fire, 16 motor vehicle crashes, 16 medical calls, 12 alarm/investigation calls, 8 hazardous condition calls, 6 traffic control calls, 2 hazardous materials calls, 6 standbys, 2 mutual aid calls, and 15 other calls.

Membership and Training. The Fire Department requires the following of all fire fighter applicants:

- complete an application
- possess a valid State driver's license for apparatus operators
- pass a background check
- complete a medical history report

The applicant is then voted on by the Fire Department trustees and, if successful, voted on by the Fire Department members. The successful applicant is assigned to a certified fire fighter who oversees orientation and training. The new fire fighter trains to the assigned duties. There are no mandatory State minimum standards for fire fighter certification.

The FF was certified as a Driver/Operator and in Hazardous Materials at the awareness level. He had 5 years of firefighting experience.

Pre-placement and Periodic Medical Evaluations. No pre-placement or periodic medical evaluations are required at this Fire Department. The applicant's medical history report is reviewed by the Safety Officer and the Fire Chief, who makes the determination for medical clearance for duty. Medical clearance for SCBA use is not required. A return-to-duty medical clearance is required

from the fire fighter's primary care physician for Worker's Compensation-related injuries. If a non-duty-related injury or illness prevents a fire fighter from performing his or her duty, a medical return-to-duty clearance may be required from the fire fighter's primary care physician. Both clearances are reviewed by the Safety Officer and the Fire Chief, who makes the final medical clearance decision.

Health/Wellness. No annual physical agility test is required for members. However, a physical agility test is performed as part of routine training. There is no wellness/fitness program and exercise equipment (strength or aerobic) is not available in the fire station.

DISCUSSION

The autopsy revealed mild coronary artery disease and no blood clot in any of the coronary arteries, therefore, it is unlikely the FF suffered a heart attack (myocardial infarction). The autopsy did reveal a heart valve problem (severe mitral valve prolapse) and an enlarged heart which probably was due to the valve problem.

Mitral Valve Prolapse and the Pathophysiology of Sudden Cardiac Death. Mitral valve prolapse results from abnormalities in one or more portions of the mitral valve (e.g., mitral valve apparatus, valve leaflets, chordae tendineae, papillary muscle, or valve annulus).[3,4] It is the most common valve dysfunction, affecting 2.4% of the population and has been observed in patients of all ages and both sexes.[5] Mitral valve prolapse typically occurs as the primary condition, not associated with other diseases.[3,4] The mitral valve prolapse syndrome exhibits a strong hereditary component.[3,4]

The clinical presentations of the mitral valve prolapse syndrome are diverse. Most patients are asymptomatic throughout their lives, however non-specific symptoms (fatigue, palpitations, chest pain) can occur.[6] In patients with severe mitral valve prolapse, symptoms of reduced cardiac reserve (e.g., fatigue, shortness of breath on exertion, and reduced exercise tolerance) are typically present.[3]

The diagnosis of mitral valve prolapse is suggested by a heart murmur and confirmed by an echocardiogram where the abrupt posterior movement of one or both of the mitral valve leaflets during systole can be measured.[7] The electrocardiogram (EKG) is usually normal in asymptomatic patients, but in severe cases can show signs of left ventricular hypertrophy. Usual pathology findings are the "myxomatous proliferation" of the mitral valve (middle layer of the valve leaflet is composed of loose material).[8]

The syndrome has a strong hereditary component, and some cases are associated with:

1. rare inheritable disorders of connective tissue (e.g., Marfan syndrome, Ehlers-Danlow syndrome, osteogenesis imperfecta, pseudoxanthoma elasticum, periarteritis nodosa, myotonic dystrophy, von Willebrand disease, etc.)
2. congenital malformations (e.g., Ebstein anomaly of the tricuspid valve, atrial septal defect of the ostium secundum variety, the Holt-Oram syndrome)
3. hypertrophic cardiomyopathy.

Patients with mitral valve prolapse have a slight increased risk of sudden cardiac death, reported to be about 1% per year.[3] This risk is pronounced in patients with severe mitral regurgitation, complex ventricular arrhythmias, QT interval prolongation, and a history of syncope and palpitations.[3,4] The immediate cause of the sudden, unexpected death is probably ventricular fibrillation.

The FF did not have a history of syncope or palpitations and did not have an EKG taken prior to this incident. For the 3 years prior to his death, the FF received multiple examinations by at least five different physicians. These included a pre-operative examination performed by an anesthesiologist and an orthopedic surgeon, a gastroenterologist, a commercial drivers license physical examination consistent with the U.S. Department of Transportation performed by an Occupational Medicine Physician, and normal check-ups with his primary care physician. A physical was performed as recently as 5 months prior to his death. Most of these examinations included auscultation of the heart; yet none revealed a murmur. No EKGs were performed. Given the FF's severe degree of mitral valve pathology at autopsy, it is unclear why no heart murmur was detected. Possibilities include:

1) his condition significantly worsened in the 5 months prior to his death,
2) the murmur was either too faint to be identified, or
3) the examining physicians missed the heart murmur.

The first possibility is unlikely due to the FF's left ventricular hypertrophy, a result of long-standing severe mitral valve prolapse.

Left Ventricular Hypertrophy. On autopsy, the FF was found to have left ventricular hypertrophy, interventricular hypertrophy, and an enlarged heart. These conditions increase the risk for sudden cardiac death. Hypertrophy of the heart's left ventricle is a relatively common finding among individuals with long-standing high blood pressure (hypertension), a heart valve problem, or chronic cardiac ischemia (reduced blood supply to the heart muscle).[1] Because the FF was not diagnosed with high blood pressure or CAD, his left ventricular hypertrophy was likely due to a heart valve problem.

Firefighting is widely acknowledged to be one of the most physically demanding and hazardous of all civilian occupations.[9] Firefighting activities are strenuous and often require fire fighters to work at near maximal heart rates for long periods. 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.[10] The FF responded to the water rescue call and distributed equipment while wearing full bunker gear. This is considered a light level of physical exertion.[9,11] This fire fighter's sudden cardiac death was probably due to an arrhythmia associated with mitral valve prolapse and/or left ventricular hypertrophy. It is unclear if the light physical exertion 17 hours earlier could have triggered sudden cardiac death.

Intubation. Immediately after insertion of the tracheal tube, tube placement should be confirmed by auscultating over the epigastrium, the midaxillary, and the anterior chest line on the right and left sides of the

chest. Even when the tracheal tube is seen to pass through the vocal cords and is verified in the trachea by auscultation, secondary confirmation of placement should be made with an end-tidal CO_2 or esophageal detection device.[12,13] Ambulance personnel followed these procedures. Once the tube is placed, especially out of hospital, the location of the tracheal tube must be monitored closely. A specific, validated technique (taping or strapping) or device to prevent dislodgement should be used, especially in the prehospital setting or whenever transporting a patient.[13] In the hospital's Emergency Department, sluggish end tidal carbon dioxide detector color change was noted and there was concern that the endotracheal tube may have become displaced and the FF was re-intubated. It is unclear exactly when the tube became displaced.

Occupational Medical Standards for Structural Fire Fighters. To reduce the risk of sudden cardiac arrest or other incapacitating medical conditions among fire fighters, the National Fire Protection Association developed NFPA 1582, *Standard on Comprehensive Occupational Medical Program for Fire Departments*.[14] According to NFPA 1582, mitral valve prolapse interferes with safe performance of critical job tasks if it is associated with arrhythmias or if moderate to severe mitral regurgitation is present.[14] The FF was asymptomatic and prior medical evaluations did not detect a heart murmur. NFPA 1582 recommends an EKG as part of the annual medical evaluation. An EKG within the past year would probably have detected the FF's left ventricular hypertrophy. If left ventricular hypertrophy was detected, perhaps the FF would have been referred for further medical evaluation (e.g., an echocardiogram). Even with a diagnosis of mitral valve prolapse, however, it is difficult to state whether impairment would have been recognized as severe enough to restrict duties.

RECOMMENDATIONS

NIOSH investigators offer the following recommendations to address general safety and health issues. It is doubtful any of these recommendations would have prevented this FF's sudden cardiac death.

Recommendation #1: Perform pre-placement and periodic medical evaluations consistent with NFPA 1582.

NFPA 1582 requires fire departments to conduct pre-placement and annual medical evaluations. Guidance regarding the content and frequency of these evaluations can be found in NFPA 1582[14] and in the International Association of Fire Fighters (IAFF)/International Association of Fire Chiefs (IAFC) *Fire Service Joint Labor Management Wellness/Fitness Initiative*.[15] However, the Fire Department is not legally required to follow this standard or this initiative.

Recommendation #2: Secure endotracheal tubes to prevent dislodgment during patient treatment, transfer, and transport.

After the endotracheal tube is inserted into the trachea and positive breath sounds are confirmed by auscultation and end-tidal CO_2, the tube should be secured in place by a specific, validated technique or device to prevent dislodgement.[13] These include taping and strapping.

Recommendation #3: Ensure that fire fighters are cleared for duty by a physician knowledgeable about the physical demands of firefighting, the personal protective equipment used by fire fighters, and the various components of the NFPA 1582.

The Fire Department should have an officially designated physician who is responsible for guiding, directing, and advising the members with regard to their health, fitness, and suitability for duty as required by NFPA 1500.[16] The physician should review job descriptions and essential job tasks required for all Fire Department positions and ranks, in order to understand the physiological and psychological demands of fire fighters and the environmental conditions under which they must perform, as well as the personal protective equipment they must wear during various types of emergency operations. Medical evaluations may be performed by the fire fighter's primary care physician. However, the results must be communicated to the Fire Department physician, who makes the final determination for clearance for duty.

Recommendation #4: Provide fire fighters with medical evaluations and clearance to wear SCBAs.

The Occupational Safety and Health Administration (OSHA)'s *Revised Respiratory Protection Standard* requires employers to provide medical evaluations and clearance for employees using respiratory protection.[17] Such employees include fire fighters who utilize SCBA in the performance of their duties. These clearance evaluations are required for private industry employees and public employees in States operating OSHA-approved State plans. However, Pennsylvania is not a State-plan State, and public sector employers are not required to comply with OSHA standards. Regardless, the NIOSH investigator recommends voluntary compliance for safety reasons.

Recommendation #5: Develop a structured wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.

Currently, the Fire Department does not have a wellness/fitness program and exercise equipment is not available in the fire station. NIOSH recommends a formal, structured wellness/fitness program to ensure all members receive the benefits of physical exercise.

Physical inactivity is the most prevalent modifiable risk factor for CAD in the United States. Physical inactivity, or lack of exercise, is associated with other risk factors, including obesity and diabetes.[18] NFPA 1500 requires a wellness program that provides health promotion activities for preventing health problems and enhancing overall well-being.[16] Wellness programs have been shown to be cost effective, typically by reducing the number of work-related injuries and lost work days.[19-21] Health promotion programs in the fire service have been shown to improve coronary artery disease risk factors and fitness levels with mandatory programs showing the most improvement.[22-24] The one mandatory program was able to show a cost savings of $68,741 due to reduced absenteeism.[25] 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.[26] Guidance for implementation and components of a wellness/fitness program may be found in

NFPA 1583, *Standard on Health-Related Fitness Programs for Fire Fighters*,[27] in the IAFF/IAFC, *Fire Service Joint Labor Management Wellness/Fitness Initiative*,[15] and in the National Volunteer Fire Council (NVFC)'s *Health and Wellness Guide*.[28] Given the structure of the Fire Department, the NVFC program might be the most appropriate model.

Recommendation #6: Perform an annual physical performance (physical ability) evaluation to ensure fire fighters are physically capable of performing the essential job tasks of structural firefighting.

NFPA 1500 requires Fire Department members who engage in emergency operations to be annually evaluated and certified by the Fire Department as having met the physical performance requirements identified in paragraph 8-2.1 of the standard.[16]

REFERENCES

1. Siegel RJ [1997]. Myocardial hypertrophy. In: Bloom S, ed. Diagnostic criteria for cardiovascular pathology acquired diseases. Philadelphia, PA: Lippencott-Raven, pp. 55-57.

2. Armstrong WF, Feigenbaum H [2001]. Echocardiography. In: Braunwald E, Zipes DP, Libby P, eds. Heart disease: a text of cardiovascular medicine. 6th ed. Vol. 1. Philadelphia, PA: W.B. Saunders Company, p. 167.

3. Braunwald E [2001]. Valvular heart disease. In: Braunwald E, Zipes DP, Libby P, eds. Heart disease. 6th ed. Philadelphia, PA:W.B. Saunders, pp. 1665-1671.

4. Braunwald E [2005]. Valvular heart disease. In: Kasper DL, Braunwald E, Fauci AS, Hauser SL, Longo DL, Jameson JL, eds. Harrison's principles of internal medicine. 16th ed. New York: McGraw Hill, pp. 1390-1403.

5. Freed LA, Levy D, Levine RA, Larson MG, Evans JC, Fuller DL, Lehman B, Benjamin EJ [1999]. Prevalence and clinical outcome of mitral-valve prolapse. N Engl J Med 341:1.

6. Zuppiroli A, Rinaldi M, Kramer-Fox R, Favilli S, Roman MJ, Devereux RB [1995]. Natural history of mitral valve prolapse. Am J Cardiol 75:1028.

7. Malkowski MJ, Peasrson AC [2000]. The echocardiographic assessment of the floppy mitral valve: An integrated approach. In: Boudoulas J, Wooley CF (eds). Mitral Valve: Floppy Mitral Valve, Mitral Valve Prolapse, Mitral Valvular Regurgitation. 2nd ed. Armonk, NY: Futura, pp. 231-252.

8. Becker AE, Davies MJ [2000]. Pathomorphology of mitral valve prolapse. In: Boudoulas J, Wooley CF (eds). Mitral Valve: Floppy Mitral Valve, Mitral Valve Prolapse, Mitral Valvular Regurgitation. 2nd ed. Armonk, NY: Futura, pp. 91-114.

9. Gledhill N, Jamnik VK [1992]. Characterization of the physical demands of firefighting. Can J Spt Sci 17(3):207-213.

10. Smith DL, Petruzzello SJ, Kramer JM, Warner SE, Bone BG, Misner JE [1995]. Selected physiological and psychobiological responses to physical activity in different configurations of firefighting gear. Ergonomics 38(10):2065-2077.

11. American Industrial Hygiene Association Journal [1971]. Ergonomics guide to assessment of metabolic and cardiac costs of physical work. Am Ind Hyg Assoc J 32:560-564.

12. AHA [2000]. Advanced cardiovascular life support: section 3: adjuncts for oxygenation, ventilation, and airway control. Circ 102(8)(Suppl):I-95 – I-104.

13. AHA [2000]. The most important changes in the international ECC and CPR guidelines 2000. Circ 102(8)(Suppl):I-371 – I-376.

14. NFPA [2007]. NFPA 1582: Standard on comprehensive occupational medical program for fire departments. Quincy, MA: National Fire Protection Association.

15. IAFF, IAFC [2000]. The fire service joint labor management wellness/fitness initiative. Washington, DC: International Association of Fire Fighters, International Association of Fire Chiefs.

16. NFPA [2002]. NFPA 1500: Standard on fire department occupational safety and health program. Quincy, MA: National Fire Protection Association.

17. CFR. 29 CFR 1910.134, Respiratory protection. Code of Federal Regulations. Washington, DC: U.S. Government Printing Office, Office of the Federal Register.

18. Plowman SA, Smith DL [1997]. Exercise physiology: for health, fitness and performance. Boston, MA: Allyn and Bacon.

19. 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.

20. 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. J Occup Environ Med 42:1148-1155.

21. Aldana SG [2001]. Financial impact of health promotion programs: a comprehensive review of the literature. Am J Health Promot 15:296-320.

22. Blevins JS, Bounds R, Armstrong E, Coast JR [2006]. Health and fitness programming for fire fighters: does it produce results? Med Sci Sports Exerc 38(5):S454.

23. Dempsey WL, Stevens SR, Snell CR [2002]. Changes in physical performance and medical measures following a mandatory firefighter wellness program. Med Sci Sports Exerc 34(5):S258.

24. Womack JW, Humbarger CD, Green, JS, Crouse, SF [2005]. Coronary artery disease risk factors in firefighters: effectiveness of a one-year voluntary health and wellness program. Med Sci Sports Exerc 37(5):S385.

25. Stevens SR, Dempsey WL, Snell CR [2002]. The reduction of occupational absenteeism following two years of firefighter wellness program. Med and Sci in Sports and Exer 34(5):S194.

26. Unpublished data [1997]. City Auditor, City of Phoenix, AZ. Disability retirement program evaluation. January 28, 1997.

27. NFPA [2000]. NFPA 1583: Standard on health-related fitness programs for fire fighters. Quincy, MA: National Fire Protection Association.

28. USFA [2004]. Health and wellness guide. Emmitsburg, MD: Federal Emergency Management Agency; United States Fire Administration Publication No. FA-267.

INVESTIGATOR INFORMATION

This investigation was conducted by 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, a Kentucky Certified Fire Fighter and Emergency Medical Technician (EMT), and a former Fire Chief, is with the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiovascular Disease Component located in Cincinnati, Ohio.