F2002
19
NIOSH
Fire Fighter Fatality Investigation and Prevention Program

Death in the line of duty...

A Summary of a NIOSH fire fighter fatality investigation *August 5, 2003*

Fire Fighter Dies During Live Fire Training - North Carolina

SUMMARY

On April 10, 2002, a 56 year-old male career Captain, wearing full turnout gear and self-contained breathing apparatus (SCBA) (on air), finished igniting a training fire and exited the structure. After leaving his SCBA bottle with the Air Unit to be refilled, he walked by the stand-by ambulance to sit down on the ground. After telling nearby crew members that he was not well, he had a witnessed collapse. Approximately 29 minutes later, despite cardiopulmonary resuscitation (CPR) and advanced life support (ALS) administered on the scene and at the hospital, the victim died. The Death Certificate, completed by the Medical Examiner, listed "ischemic heart disease due to coronary artery disease" as the cause of death. An autopsy, conducted by the Office of the Chief Medical Examiner, listed the cause of death as "probable cardiac arrhythmia secondary to ischemic heart disease caused by severe coronary artery atherosclerosis."

The following recommendations address some general health and safety issues. This list includes some preventive measures that have been recommended by other agencies to reduce the risk of on-the-job heart attacks and sudden cardiac arrest among fire fighters. 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.

- ***Use a secondary (technological) test to confirm placement of the ET tube in the trachea***
- ***Phase in a mandatory wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity***
- ***Provide both strength and aerobic exercise equipment in all fire stations***

INTRODUCTION & METHODS

On April 10, 2002, a 56-year-old male Captain lost consciousness during live-fire training. Despite CPR and ALS administered by crew members, the ambulance crew, and personnel in the hospital's emergency department (ED), the victim died. NIOSH was notified of this fatality on April 11, 2002, by the United States Fire Administration. On April 23, 2002, NIOSH contacted the affected Fire Department to initiate the investigation. On May 22, 2002, a Safety and Occupational Health Specialist and an Occupational Nurse Practitioner from the NIOSH Fire Fighter Fatality Investigation Team traveled to North Carolina to conduct an on-site investigation of the incident.

During the investigation NIOSH personnel interviewed:

- The Fire Chief
- The Assistant Chief/Chief of Staff
- Union Treasurer
- Crewmembers on duty with the victim
- The victim'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 2001
- Fire Department incident report
- Dispatch records
- Witness statements
- Emergency medical service (ambulance) incident report
- Hospital emergency department report
- Fire Department physical examination protocols
- Death certificate
- Autopsy record
- Past medical records of the deceased

INVESTIGATIVE RESULTS

Incident. On April 10, 2002, the victim reported to a training location for a live-fire exercise at approximately 0800 hours. He performed a hazard check around the structure and assisted in removing some boards from the structure.

Participating in the training that day was Quint 9, Engine 1, Air 12, Incident Commander, Safety Officer, an EMS unit, 8 instructors, and 20 recruits. The recruits were divided into four groups of five fire fighters each. One instructor would lead each group. Two additional instructors would be in the burn building at a time conducting fire attacks. The remaining five instructors would perform safety monitoring functions on the exterior of the building. Two fire fighters would be assigned as Fire Equipment Operators. Groups would rotate in the following order: fire attack, back-up, safety, exposure protection, rehabilitation, and staging. Instructors would lead two fire attacks, then rotate.

The live-fire exercise was in compliance with all components of NFPA 1403, Standard on Live Fire Training Evolutions,[1] (permits and documentation, asbestos survey, planning, building preparation, safety briefing, and equipment checks).

The structure used as the burn building was a two-story, 3,600 square feet brick and wood structure, measuring 60' x 30', consisting of four apartments (condo style). The main roof was pitched and shingle layered, with each apartment divided into six areas and includes a foyer, living room, two bedrooms, kitchen, bath, and hall. Materials used to initiate the fire were pallets (weighing approximately 25 pounds each) and straw (each bale weighing 50 pounds each)(which the victim brought to the scene in his privately-owned vehicle).

The victim performed eight entry evolutions/fire starts, wearing full turnout gear and while breathing air from his SCBA. The morning evolutions were performed on the second floor, lasting approximately 10 minutes each. The victim and his partner had taken one 15 minute break during the morning while his SCBA bottle was being refilled. During this break he commented to a crew member that he was tired.

On his last evolution, which was now located on the first floor, the victim was on the ignition crew. At this time, the victim was in no apparent distress. After igniting the fire, he stood by until the fire grew adequately, then exited the structure. Passing by the Incident Commander, he appeared to be in no distress. He removed his SCBA and bottle, and carried the bottle to the Air Unit, parked approximately 150 feet away, to be refilled. At this time, crew members noticed he appeared tired and was not acting normally. He walked to the stand-by ambulance, parked approximately 60 feet away and

advised the paramedic that he did not feel well, and sat down beside a pickup truck. The paramedic noted his pale, sweaty appearance and immediately took his vital signs (1135 hours), finding a weak and thready pulse, labored respirations, and a palpated blood pressure of 80mm Hg (millimeters of mercury). After removing the victim's turnout coat, the paramedic turned to retrieve the medic box, and the victim slumped over.

At this time, the victim was unresponsive, but with a carotid pulse, and agonal respirations. He was ventilated via bag-valve-mask and 100% oxygen and a cardiac monitor was attached to the victim which revealed ventricular tachycardia. The victim then became pulseless, the monitor revealed ventricular fibrillation (V.Fib.), and three shocks (defibrillations) were administered with no change in patient status. CPR (chest compressions and assisted ventilations via bag-valve-mask) was initiated. The victim was placed onto a long spine board, and loaded into the ambulance. The ambulance departed the scene en route to the hospital at 1137 hours. Once en route, the victim was intubated (bilateral breath sounds were confirmed by both paramedics), intravenous access was obtained (began an IV), and cardiac resuscitation medications were administered. One additional defibrillation was delivered en route. The cardiac monitor then revealed pulseless electrical activity (PEA) and CPR continued. Cardiac pacing began and was successful with a capture rate of 100 and 100 milliamps with positive return of a pulse.

The ambulance arrived at the hospital's emergency department at 1144 hours. Upon removing the victim from the ambulance, the cardiac pacer lost capture, the victim became pulseless, and CPR continued. Inside the ED, CPR and ALS continued. Placement of the endotracheal (ET) tube was checked and the tube was found to be in the victim's esophagus. The tube was repositioned and placement was confirmed with an end-tidal CO_2 detector. A faint carotid pulse was obtained, but quickly disappeared. The cardiac monitor revealed asystole (no heart beat) and PEA. At 1204 hours the victim was pronounced dead by the attending physician, and CPR/ALS was discontinued.

Medical Findings. The autopsy, performed by the Office of the Chief Medical Examiner on April 11, 2002, listed "coronary atherosclerosis" as the cause of death. A carboxyhemoglobin level (to assess the victim's carbon monoxide exposure) was measured at less than 5%. Pertinent findings from the autopsy included:

- Severe coronary atherosclerosis of the left anterior descending and right coronary arteries
- Proximal to mid left anterior descending diffuse lesions causing a pinpoint lumen
- 80 % stenosis of right coronary alternating to minimal throughout length of lumen
- Obesity (height of 67 inches and weight of 195 pounds)(Body Mass Index of 30.5 kilograms per square meter (kg/m^2) [normal $\leq 25\ kg/m^2$])

The Captain had the following risk factors for coronary artery disease (CAD): male gender, age over 45, family history of coronary artery disease, hyperlipidemia, physical inactivity and mild obesity.

On February 4, 2002, the victim had his annual physical examination performed by the city's contracted clinic. The exam revealed mild obesity, hypercholesterolemia, and an aerobic capacity of 27.4 ml/kg/min using a cycle ergometer test (CET). The CET lasted for 5 minutes during which time the victim reached 81% of his maximum heart rate. A 12 lead electrocardiogram (EKG) used during the physician monitored CET did not reveal any ischemic changes. The victim was cleared by the contractor for full duty.

According to his family, co-workers, and crew members, the victim had no history of heart problems

or pain during the days or weeks prior to his fatal event.

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, the career Fire Department was a Nationally Accredited Agency (by the Commission on Fire Accreditation International), maintained a Class 1 rating from the Insurance Services Office, consisted of 394 uniformed personnel and served a population of 223,000 residents in a geographic area of 114 square miles. There are 18 fire stations. Fire fighters work the following schedule: 24-hours on-duty, 48-hours off-duty, from 0800 hours to 0800 hours.

In 2001, the Department responded to 19,157 calls: 12,257 rescue/medical calls, 2,580 false calls, 1,718 good intent calls, 1,120 fire/explosions, 792 hazard calls, 410 other calls, 266 service calls, and 14 overpressure/rupture calls. The victim was Captain on Quint 7. In 2001, Quint 7 was the busiest quint in this city for the year, responding to 1,373 calls.

Training. The Fire Department requires all new fire fighter applicants to pass a written/ psychological examination, pass a physical ability test, pass an oral interview, pass a background check, pass a psychological evaluation, and complete a medical screening and drug screen prior to being selected. The newly hired fire fighter is placed in a recruit class for the 20-week training program. Upon completion, the fire fighter is certified as: Firefighter II, Emergency Medical Technician, Rescue Technician, and Hazardous Materials Responder. Recruits are then assigned to a fire company and serve a six month probationary period. After six months, the recruit must pass a written test, drill ground applications, and physical fitness prior to being selected as a permanent employee. Recurrent training occurs on each shift. All Captains are State-certified Fire Service Instructors.

The State minimum requirement for career fire fighter certification is NFPA 1001 Fire Fighter I requirements.[2] The State requirement for fire fighter recertification is every five years. EMT/Paramedics recertify every 2 years and hazardous materials technicians recertify every year. The victim was certified as a Fire Fighter II, Driver/Operator, EMT, Hazmat Operations, Fire Inspector I, Live Burn Instructor, and Fire Service Instructor, and had 13 years of career fire fighting experience and 40 years volunteer fire fighting experience.

Preplacement Evaluations. The Fire Department requires a preplacement medical evaluation for all new hires, regardless of age. The components of this evaluation are listed below:

- A complete medical history
- Height, weight, and vital signs
- Physical examination
- Blood tests: Comprehensive metabolic panel, complete blood count with differential (CBC), lipid, and liver profile
- Urine tests: 24-hour collection urinalysis drug screen
- Spirometry
- Resting electrocardiogram (ECG)
- Chest x-ray
- Audiogram
- Vision test

These evaluations are performed by the city medical services. Once this evaluation is complete, a decision regarding medical clearance for fire fighting duties is made by the examining physician and forwarded to the FD.

The Fire Department requires all fire fighter candidates to complete a timed performance evaluation of typical fire fighting duties (physical ability

test or PAT). Medical clearance is required prior to the PAT evaluation (discussed below) by the city medical services.

Periodic Evaluations

Medical evaluations are required by this FD on a yearly basis consisting of:

- A complete medical history
- Height, weight, and vital signs
- Physical examination
- Blood tests: Comprehensive metabolic panel, complete blood count with differential (CBC), lipid, and liver profile
- Urine tests: urinalysis drug screen
- Spirometry
- Resting electrocardiogram (ECG)
- Audiogram
- Vision test
- Cardiovascular testing, measured by the volume of oxygen consumed while using the CET

These evaluations are performed by a medical clinic under contract with the city. Once this evaluation is complete, a decision regarding medical clearance for fire fighting duties is made by the examining physician and forwarded to the FD. The cardiovascular fitness testing consisted of a cycle ergometer test (CET) utilizing a 12 lead EKG to ascertain the pulse rate. If EKG changes are noted during the cardiovascular fitness testing, follow-up with the primary care physician is recommended before clearance can be given for fire suppression activities.

The FD has implemented a voluntary wellness program which includes nutrition and wellness information along with individualized fitness plans based on the results of the cycle ergometer test provided by the contractor.

Medical clearance for SCBA use is conducted yearly by the same clinic performing the periodic evaluations. If an employee is injured at work, he/she must be cleared for "return-to-work" by the city medical services. In addition, if a fire fighter has a non-occupational injury or medical condition, the employee must be cleared for "return-to-work" by their private physician, unless return-to-work is an issue. In that case, return-to-work is determined by the city medical services.

Time is allotted during the workday for a fitness program, but participation is not mandatory. All fire stations have either strength or aerobic equipment. The victim did not exercise frequently either at home or work.

DISCUSSION

In the United States, coronary artery disease (atherosclerosis) is the most common risk factor for cardiac arrest and sudden cardiac death.[3] Risk factors for its development include age over 45, male gender, family history of coronary artery disease, smoking, high blood pressure, high blood cholesterol, obesity, physical inactivity, and diabetes.[4,5] The victim had six of these risk factors (male gender, age over 45, family history of coronary artery disease, high blood cholesterol, physical inactivity and mild obesity). By all accounts, the victim never reported symptoms of angina (e.g., chest pain on exertion), or congestive heart failure (e.g., shortness of breath on exertion, swollen ankles). Unfortunately, sudden cardiac death is often the first overt manifestation of ischemic heart disease.[6-8]

The narrowing of the coronary arteries by atherosclerotic plaques occurs over many years, typically decades.[9] However, the growth of these plaques probably occurs in a nonlinear, often abrupt fashion.[10] 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.[11] This sudden blockage is primarily due to blood clots

(thrombosis) forming on the top of atherosclerotic plaques. Blood clots, or thrombus formation, in coronary arteries is initiated by disruption of atherosclerotic plaques. Certain characteristics of the plaques (size, composition of the cap and core, presence of a local inflammatory process) predispose the plaque to disruption.[11] Disruption then occurs from biomechanical and hemodynamic forces, such as increased blood pressure, increased heart rate, increased catecholamines, and shear forces, which occur during heavy exercise.[12,13] No thrombus was present at autopsy, however there was identified "severe focally calcified atherosclerosis with diffuse lesions causing a pinpoint lumen of the left anterior descending coronary artery and a greater than 80% stenosis of the lumen of the right coronary artery."

Firefighting is widely acknowledged to be one of the most physically demanding and hazardous of all civilian occupations.[14] 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.[15-17] Prior to his collapse, the victim had carried in approximately ten 50-pound bales of straw and approximately ten 25-pound pallets to be used for fire ignition, and, wearing full turnout gear and SCBA, had participated in eight fire starts over a three hour period and had remained in the structure to ensure the fire grew adequately. This is considered a moderate level of physical exertion.[18]

To reduce the risk of sudden cardiac arrest and heart attacks among fire fighters, the NFPA has developed the NFPA 1582 guideline entitled "Standard on Medical Requirements for Fire Fighters and Information for Fire Department Physicians."[19] NFPA 1582 recommends a yearly physical evaluation to include a medical history, height, weight, blood pressure, and visual acuity test.[19] NFPA 1582 recommends a thorough examination to include vision testing, audiometry, pulmonary function testing, a complete blood count, urinalysis, and biochemical (blood) test battery be conducted on a periodic basis according to the age of the fire fighter (less than 30: every 3 years; 30-39: every 2 years; over 40 years: every year).

NFPA 1582 also recommends, not as part of the requirements but for informational purposes only, fire fighters over the age of 35 with risk factors for CAD be screened for obstructive CAD by an Exercise Stress Test (EST).[19] In this case, the victim had a CET performed to assess his aerobic capacity, but did not receive an EST to screen for ischemic heart disease. His CET showed an aerobic capacity of 27.4 ml/kg/min giving him a below average capacity for his age group (30-31ml/kg/min).[20] Minimal aerobic capacities recommended for fire fighters range from 38-45 ml/kg/min.[14,21-25]

Since the victim wore an SCBA and was on air, the Fire Department reviewed the air system records and found that Mobile Air Unit 1 had been tested in March 2002 and passed the test for Grade D breathing air. An additional air sample was analyzed after the incident and was found to pass the criteria for breathing air.

During the resuscitation effort, the ED physician reported the ET tube was placed in the victim's esophagus, not the trachea. It is not possible to know exactly when the ET tube became dislodged; possibly during movement of the victim from the ambulance to the ED. Provided the cuff of the ET tube was inflated properly, dislodgment could have been prevented. The EMS personnel properly used primary confirmation of ET tube placement by physical examination (auscultation of bilateral breath sounds). However, they did not proceed with secondary confirmation and varied from American Heart Association Guidelines and their departmental

protocol of using an end-tidal CO_2 detector.[26] Primary confirmation was validated by other EMS personnel.

RECOMMENDATIONS

The following recommendations address health and safety generally. However, it is unclear if any of these recommendations could have prevented the sudden cardiac arrest and subsequent death of this fire fighter. This list includes some preventive measures that have been recommended by other agencies to reduce the risk of on-the-job heart attacks, sudden cardiac arrest, and death among fire fighters. These recommendations have not been evaluated by NIOSH, but represent published research, or consensus votes of technical committees of the NFPA or fire service labor/management groups.

Recommendation #1: Use a secondary (technological) test to confirm placement of the ET tube in the trachea.

To reduce the risk of improper intubation, the American Heart Association along with the International Liaison Committee on Resuscitation published recommendations in the Guidelines 2000 for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care.[26] In this incident, the current recommended guidelines were continued, namely Cricoid pressure by a second rescuer followed by the actual intubation. Once this is accomplished, primary confirmation of the tracheal tube is completed. Primary confirmation is the 5-point auscultation: left and right anterior chest, left and right midaxillary, and over the stomach. These recommendations are now followed by secondary confirmation which can be either an end-tidal CO_2 detector or an esophageal detector device. After both primary and secondary confirmations have been verified, Cricoid pressure can then be released. Bilateral breath sounds were confirmed by auscultation. However, the guidelines suggest that EMS personnel confirm ET tube placement by primary confirmation (physical examination) and secondary confirmation (technological test)(end-tidal CO_2 detection). Although the current recommended primary confirmation guidelines were continued, the committee added the suggestion of using one of several commercial devices that includes end-tidal CO_2 detectors or esophageal detector devices for the secondary confirmation.[26]

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

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] 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.[28] 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.[29] The Wellness/Fitness Initiative provides guidance regarding wellness program content, to include physical examination and evaluation, fitness, and behavioral health. Wellness programs have been shown to be cost effective, typically by reducing the number of work-related injuries and lost work days.[30,31] The

Fire Department and the Union should review these materials to identify applicable elements for their Department. Other large-city negotiated programs can also be reviewed as potential models.

Recommendation #3: Provide both strength and aerobic exercise equipment in all fire stations.

Currently, most of the fire stations have either strength or aerobic exercise equipment. NFPA 1583 recommends providing exercise equipment through the contracted use of a public gym or other facility, or placing the equipment directly in the fire stations.[32] Contracting the use of a facility requires a company (engine, ladder, etc.) of fire fighters to exercise at the same time daily at a location separate from their fire station. The gym should be centrally located, but due to emergency responses and daily work duties, the facility may not be convenient and thus, underutilized. The fire companies may also have to be taken out of service during the time of exercise, depending on the location of the facility and the staffing level of the Fire Department. To place the equipment in the fire stations, allows the fire fighters to exercise within the constraints of their daily work schedules and emergency responses while remaining more readily available for response.

REFERENCES

1. NFPA [1997]. Standard on live fire training evolutions. Quincy, MA: National Fire Protection Association, NFPA 1403-1997.

2. NFPA [1997]. Standard for fire fighter professional qualifications. Quincy, MA: National Fire Protection Association. NFPA 1001-1997.

3. Braunwald E, Fauci AS, Kasper DL, Hauser SL, Longo DL, Jameson JL [2001]. Harrison's principles of internal medicine. 15th ed. New York, NY: McGraw-Hill Publishing, pp.228-233.

4. American Heart Association [2002]. Risk factors and coronary artery disease (AHA scientific position). World Wide Web (Accessed June 2002.) Available from: URL=http://www.americanheart.org

5. Jackson E, Skerrett PJ, Ridker PM [2001]. Epidemiology of arterial thrombosis. In: Coleman RW, Hirsh J, Marder VIJ, et al eds. Homeostasis and thrombosis: basic principles and clinical practice. 4th ed. Philadelphia, PA: Lippincott Williams and Wilkins.

6. Selwyn AP, Braunwald E [2001]. Ischemic heart disease. In: Braunwald E, Fauci AS, Kasper DL, et al eds. Harrison's principles of internal medicine. 15th ed. New York, NY: McGraw-Hill Publishing, pp.1399-1410.

7. Kannel WB, Abbott RD [1996]. Incidence and prognosis of unrecognized myocardial infarction. In Fuster V, Ross R, Topol EJ et al eds. Atherosclerosis and coronary artery disease. Philadelphia, PA: JB Lippincott, pp.1561-1576.

8. Sigurdsson E, Thorgeirsson G, Sigvaldson H, Sigfusson N [1995]. Unrecognized myocardial infarction: Epidemiology, clinical characteristics, and the prognostic role of angina pectoris: The Reyjavik study. Annals of Internal Medicine 122(2):96-102.

9. 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.

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

11. Fuster V, Badimon JJ, Badimon JH [1992]. The pathogenesis of coronary artery disease and the acute coronary syndromes. N Eng J Med 326:242-50.

12. Kondo NI, Muller JE [1995]. Triggering of acute myocardial infarction. J Cardiovasc Risk 2(6):499-504.

13. Opie LH [1995]. New concepts regarding events that lead to myocardial infarction. Cardiovasc Drug Ther 9 Supp l3:479-487.

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

15. Barnard RJ, Duncan HW [1975]. Heart rate and ECG responses of fire fighters. J Occup Med 17:247-250.

16. 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.

17. Lemon PW, Hermiston RT [1977]. The human energy cost of fire fighting. J Occup Med 19:558-562.

18. American Industrial Hygiene Association Journal [1971]. Ergonomics guide to assessment of metabolic and cardiac costs of physical work. Am Ind Hyg Assoc J 32(8):560-564.

19. NFPA [2000]. Standard on medical requirements for fire fighters and information for fire department physicians. Quincy, MA: National Fire Protection Association, NFPA 1582-2000.

20. American College of Sports Medicine [1995]. Guidelines for exercise testing & prescription. 5th ed. Baltimore, MD: Lippincott Williams and Wilkins.

21. Sparks PJ [1987]. Minimum medical standards for firefighters. Olympia, WA: Association of Washington Cities.

22. O'Connell ER, Thomas PC, Cady LD, Karwasky RJ [1986]. Energy costs of simulated stair climbing as a job-related task in fire fighting. J Occup Med 28:282-284.

23. Doolittle TL [1979]. Validation of physical requirements for firefighters. Seattle, WA: Seattle Fire Department.

24. Jacobs DT [1976]. Physical fitness and the fire services. Boston, MA: National Fire Protection Association.

25. Lemon PW, Hermiston RT [1977]. The human energy cost of fire fighting. J Occup Med 19:558-562.

26. American Heart Association (AHA) and the International Liaison Committee on Resuscitation (ILCOR) [2000]. Guidelines 2000 for cardiopulmonary resuscitation and emergency cardiovascular care: International consensus on science. Circulation 102(8):I95-I104.

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

28. NFPA [1997]. Standard on fire department occupational safety and health program. Quincy, MA: National Fire Protection Association, NFPA 1500-1997.

29. International Association of Fire Fighters, International Association of Fire Chiefs [2000]. The

fire service joint labor management wellness/fitness initiative. Washington DC: IAFF, IAFC.

30. 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 41:813-20.

31. 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 42:1148-55.

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

INVESTIGATOR INFORMATION

This investigation was conducted by and the report written by Tommy N. Baldwin, MS, Safety and Occupational Health Specialist, and Scott Jackson, MSN, Occupational Nurse Practitioner. Mr. Baldwin and Mr. Jackson are with the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiovascular Disease Component located in Cincinnati, Ohio.