2007
23

NIOSH
Fire Fighter Fatality Investigation and Prevention Program

Death in the line of duty...

September 28, 2007

Fire Fighter -Technician Suffers Cardiac Death 6 Hours after Responding to Several Emergency Calls.

SUMMARY

On July 6, 2007, a 34-year old male, career, Fire Fighter-Technician responded to three emergency calls, performed a fire prevention inspection, and attended training during his shift. About six hours after his emergency response, the FF-Technician experienced chest pain and shortness of breath. He alerted the Station's paramedic who initiated treatment prior to transport to the nearest hospital. An "evolving anterior myocardial infarction [heart attack]" was diagnosed and the FF-Technician was flown to a tertiary care hospital for a cardiac catheterization and possible angioplasty. Upon arrival in the cardiac catheterization laboratory, the FF-Technician went into cardiac arrest. Despite cardiopulmonary resuscitation (CPR) and advanced life support, including placement of an intra-aortic balloon pump, the FF-Technician died. The death certificate and autopsy, completed by the Deputy Medical Examiner, listed "myocardial infarct" as the immediate cause of death due to "hypertensive cardiovascular disease." NIOSH investigators agree with this determination, but cannot rule out the possibility of cardiomyopathy. In either case, the FF-Technician's fatal incident was probably triggered by the heat and physical stress of responding to the emergency calls during his shift.

NIOSH investigators offer the following recommendations to reduce the risk of on-duty heart attacks and sudden cardiac deaths in this and other fire departments across the country.

- ***Modify the current fitness-wellness program to be consistent with NFPA 1583,* Standard on Health-Related Fitness Programs for Fire Fighters *and the* Fire Service Joint Labor Management Wellness/Fitness Initiative *to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.***

- ***Secure funding from the governing municipality to upgrade the current fitness-wellness program.***

- ***Consider symptom-limiting stress tests for fire fighters at increased risk for coronary artery disease and sudden cardiac death.***

- ***Adopt NFPA 1582:* Standard on Comprehensive Occupational Medicine Program *for Fire Departments to ensure fire fighters have the medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others.***

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)

- ***Work with the local union to phase-in an annual physical ability test.***

INTRODUCTION and METHODS

On July 7, 2007, a 34-year-old male, career FF-Technician suffered on-duty cardiac death about six hours after responding to several emergency calls. On July 9th, NIOSH was notified of this fatality by the Fire Department. On September 12th, an occupational medicine physician and a safety specialist from the NIOSH Fire Fighter Fatality Investigation and Prevention Team traveled to the Fire Department to conduct an on-site investigation of the incident.

During the investigation NIOSH personnel met with or interviewed the following people:

- Fire Chief, Assistant Fire Chief, Battalion Chief of the Fire Department
- President and 2nd Vice President of the local chapter of the International Association of Fire Fighters (IAFF)
- Medial Director of the Fire Department
- Station members on duty with the FF-Technician
- Family members of the FF-Technician
- Medical Director of the clinic under contract with the Fire Department to conduct medical evaluations and administer the Fire Department's wellness program
- Medical services officer (Fire Department liaison to the medical clinic)
- Fire Department Infection Control Officer and Coordinator of the wellness program
- Deputy Medical Examiner who conducted the autopsy

During the site visit NIOSH personnel reviewed the following documents related to this incident:

- Fire Department investigation file
- Station 20 incident reports for July 6th and 7th, 2007
- Death certificate
- Autopsy report
- Fire Department medical clinic records of the FF-Technician
- Components of the wellness program
- Components of the medical clinic evaluation (post-offer/pre-placement and annual)
- National Climatic Data Center weather report

INVESTIGATIVE RESULTS

Incident. On July 6, 2007, the FF-Technician and his crew began their 24-hour shift at 0700 hours at their fire station (Station 20). The FF-Technician was a tiller operator for the ladder company (Truck 12), but was assigned as the Driver/Operator of Truck 12 during this shift. The shift began by verification of Fire Department credentials (identification card, driver's license, EMT certification, and CPR certification) and uniform inspection. The FF-Technician then inspected the ladder apparatus and tools and his personal protective gear, and performed startup/tests on certain appliances. The crew then began housecleaning assignments.

At 1000 hours, the crew participated in "classroom" training using books and videos followed by lunch around 1200 hours. The FF-Technician had an outgoing personality but was unusually quiet during this shift. According to a crew member, the FF-Technician did not eat lunch because he wasn't feeling well. At 1400 hours, the crew of Truck 12 conducted self-contained breathing apparatus (SCBA) face-piece fit tests, performed a fire prevention inspection, and returned to the station.

Between 1701 hours and 1833 hours, Truck 12 was dispatched to three calls: two medical emergencies and an automatic fire alarm. The FF-Technician drove Truck 12 using lights and siren to each incident. He maintained apparatus operations at each response until his unit was cleared to return to service. Engine 31 handled the last call and Truck 12 was returned to service at 1835 hours. The FF-Technician was wearing his station uniform during these responses. The temperature and relative humidity at the local airport during this time was 87 degrees Fahrenheit with a relative humidity of 39% for a heat index 86.4 [CDC 2007].

At 2100 hours, the FF-Technician ate dinner with crewmembers. The FF-Technician did not report, or appear to be having, any symptoms of chest pain or shortness of breath at that time. Between 2300 and 2330 hours, crewmembers heard the FF-Technician coughing in his bunk. At 0050 hours, the FF-Technician awoke Engine 20's paramedic saying he was having trouble breathing. The paramedic noted not only his shortness of breath, but also his profuse sweating, and pink frothy secretions accompanying his coughing. The symptoms worsened by laying the FF-Technician flat. The FF-Technician related mild chest pain earlier in the evening, but had not told anyone or pursued medical treatment.

The paramedic accessed Engine 20's medical equipment for treatment of a cardiac condition. The FF-Technician's blood pressure was 188/110 millimeters of mercury (mmHg), his pulse was 114 beats per minute, and he was breathing at a rate of 26 breaths per minute. A cardiac monitor showed sinus tachycardia (a fast heart rate) but no arrhythmia. On chest examination, fluid in the lungs was noted. An intravenous line was started and a diuretic (a drug to increase excretion of water by the kidneys) was given, in addition to nitroglycerin (under the tongue) and high flow oxygen by mask for treatment of an acute heart attack. Ambulance 20 transported the FF-Technician to a local emergency department at 0105 hours.

En route, the FF-Technician's blood pressure rose to 220/110 mmHg, while his pulse remained at 114 beats per minute with a breathing rate of 26 breaths per minute. The ambulance arrived at the emergency department at 0108 hours. As the FF-Technician was wheeled into the emergency department he gave the "thumb up" sign to crewmembers.

In the emergency department, the physician elicited a history of sub-sternal chest pain followed by shortness of breath at about 0050 hours. A chest X-ray showed a possible left lower lobe infiltrate, and the FF-Technician's cardiac blood tests (troponin and CPK-MB) were normal (increases are not expected until about 6 hours after a heart attack) [AHA 2007a]. An EKG showed a fast heart rate (sinus tachycardia) at 115 beats per minute with possible left and right atrial enlargement, left ventricular hypertrophy (LVH) by voltage criteria, and non-specific anterolateral T-wave abnormalities (biphasic/inverted T waves in V_3-V_6). This tracing was reported by the emergency department's consulting

cardiologist as an evolving anterior myocardial infarction (heart attack). The FF-Technician was given oxygen, aspirin, nitroglycerin, Lopressor® (a beta-blocker), and Plavix® (a platelet inhibitor). At 0315 hours, the FF-Technician telephoned his station to report that he was being flown to another hospital for a cardiac catheterization and possible angioplasty and that he would need a ride home the next morning.

In flight, the FF-Technician became increasingly agitated. He arrived at the tertiary care hospital by helicopter at 0330 hours. He was immediately wheeled into the cardiac catheterization lab, where his clinical condition deteriorated. He was intubated (a breathing tube inserted into his windpipe) and an intra-aortic balloon pump was inserted to maintain his falling blood pressure. Multiple intravenous medications consistent with advanced life support were given. Despite these measures, the FF-Technician went into cardiac arrest and CPR was started. After 40 minutes of advanced life support, the FF-Technician's condition did not change. He was pronounced dead at 0410 hours and all resuscitation measures were discontinued.

Medical Findings. The death certificate, completed by the Deputy Medical Examiner, listed "myocardial infarct" (otherwise known as a heart attack) as the immediate cause of death due to "hypertensive cardiovascular disease." The autopsy, also completed by the Deputy Medical Examiner, revealed:

- A large heart of 610 grams (normal < 386 for males with a height of 72 inches)
- Mild atherosclerotic changes of the coronary arteries (focal 25-50% blockages)
- No blood clots (thrombus) in the coronary arteries
- Thickened cardiac ventricles:
  - left ventricle free wall = 1.3 centimeters (cm) (normal by echocardiogram, 0.6-1.1 cm) [Feigenbaum 1997]
  - the inter-ventricular septum = 2.0 cm (normal by echocardiogram, 0.6-1.1cm) [Feigenbaum 1997]
- Dilated cardiac ventricles
  - left ventricular cavity = 5 X 5 cm (normal internal dimension by echocardiogram 3.7-5.7cm) [Feigenbaum 1997]
  - right ventricular cavity = 5 X 4 cm (normal internal dimension by echocardiogram 0.7-2.3cm) [Feigenbaum 1997]
- No blood clots in the pulmonary arteries (e.g., no pulmonary embolus)
- Negative blood testing for alcohol or illicit drugs (amphetamines, barbiturates, benzodiazepines, cocaine metabolites, methadone, methamphetamines, opiates, phencyclidine and propoxyphene).
- Histology (microscopic) sections of the heart are pending

The FF-Technician had a history of being overweight [body mass index (BMI) = 27.3] first noted in the medical clinic notes in 1992 [CDC 2007]. In 1997 this progressed to obesity, with a BMI ranging from 32 to 37.7 over the next 10 years. The medical clinic notes began recommending weight loss in 2000 with follow-up by his private physician.
In 1997 the FF-Technician was diagnosed with high blood cholesterol during the Fire Department's annual medical evaluation. Over

the ensuing 10 years, the FF-Technician always had elevated cholesterol (increased total cholesterol, increased LDL cholesterol, and low HDL cholesterol) with clinic notes recommending follow-up by his private physician. According to medical records available at the time of this report, a low cholesterol diet was never mentioned nor were medication(s) to reduce his cholesterol prescribed.

In 2000, the FF-Technician had high blood pressure which was diagnosed as hypertension in 2003 (Stage I) [JNC 2003]. The FF-Technician's blood pressure remained elevated over the ensuing 4 years despite treatment with a diuretic, then a diuretic and a beta-blocker, then a diuretic, beta-blocker, and an angiotensin-converting enzyme (ACE) inhibitor prescribed by his private physician.

The FF-Technician had multiple resting electrocardiograms (EKGs) taken in the medical clinic beginning in 1989 and continuing periodically through 2006. Several of those tracings (1989, 1992, 2003, 2005, and 2006) met the voltage criteria for LVH [Schoillaci 1994]. The 2003, 2005, and 2006 tracings were interpreted by a computer program as "high QRS voltage" and questioned whether this was normal for his age (34 years old in 2006).

The FF-Technician's last Fire Department annual physical occurred in October 2006 after which he was medically cleared for fire fighter duties. Family and crewmembers reported that the FF-Technician never reported symptoms suggestive of heart disease at home, during leisure activities, or while performing fire fighter duties. The FF-Technician did not exercise regularly but occasionally would walk around the block (2 miles), jog, play basketball, or use an eliptical exercise machine. According to medical history taken during his fire department annual medical evaluation, he reported no family history of coronary artery disease. He was a former cigarette smoker.

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, the Fire Department consisted of 2,100 uniformed personnel and served a population of over 600,000 residents in a geographic area of 69 square miles. The Fire Department has 34 fire stations, where fire fighters work 24 hours on duty from 0700 to 0700 hours, and are off duty for 72 hours. Each engine is staffed with four personnel (an officer and three fire fighters) while the ladder companies are staffed with five personnel (an officer and four fire fighters).

Training. The Fire Department requires all newly hired fire fighters to complete the 32-week Fire Academy course. Once completed, the fire fighter is NFPA certified as a Fire Fighter I & II, as a Hazmat responder at the "awareness" level, as an emergency medical technician (EMT), and in cardiopulmonary resuscitation (CPR). The FF-Technician had 16 years of fire fighting experience and was a certified Fire Fighter Technician and Driver Operator.

Pre-employment/Pre-placement Evaluations. The Fire Department requires a pre-employment/pre-placement medical evaluation for all new hires, regardless of age. Components of this evaluation for all applicants include the following:

- A complete medical history

- Height, weight, and vital signs
- Physical examination
- Complete blood count
- Blood chemistries (basic metabolic panel)
- Blood lipid profile (total cholesterol, HDL cholesterol, triglycerides)
- Urinalysis
- Urine drug test for illicit drug use
- Chest X-ray
- Resting EKG
- Hepatitis B immunization
- Tuberculosis (TB) skin testing
- Vision testing (titmus)
- Hearing testing (audiogram)

These evaluations are performed by a physician group affiliated with a local hospital under contract with the City. Once the evaluation is complete, a physician makes a decision regarding medical clearance for fire fighting duties which is forwarded to Human Resources. The FF-Technician was cleared for duty during his "cadet" medical evaluation in 1989 and subsequent post-offer/pre-placement medical evaluation in 1992.

Prospective candidates are also required to complete a physical ability test conducted at the Fire Department's training academy. This is a timed-performance evaluation of typical fire fighting duties that is very similar to the Candidate Physical Ability Test [IAFF/IAFC 1999]. The FF-technician passed the Fire Department's physical ability test in 1992.

Periodic Evaluations. The Fire Department requires annual medical evaluations. The content of these evaluations is the same as for the post-offer / pre-employment medical evaluation except that for the annual evaluations:

1) the EKG is conducted every other year until age 36, after which it is performed annually
2) chest X-rays are performed every 4 years
3) Blood lipids (cholesterol, triglycerides) are measured annually.

The Fire Department does not conduct routine stress tests (treadmill). If, however, the fire fighter is above the age of 40 with two or more risk factors for coronary artery disease, the contract physicians recommend the fire fighter obtain a stress test from their private physician. It is unclear how many fire fighters in this Department are considered at "increased risk" for coronary artery disease. It is also unclear how many of these "at risk" fire fighters actually get stress tests from their private physicians.

If the medical clinic finds a medical condition requiring restrictions, the physician notifies the Fire Department medical services officer who then informs the Operations division who then notifies the fire fighter's company. As mentioned previously, the FF-Technician had his last medical evaluation in October 2006 after which he was cleared for full duty.

Most stations have exercise (strength and aerobic) equipment, frequently donated to or purchased by the fire fighters. The condition and use of this equipment varies by station. State-of-the-Art exercise equipment is available for FF use at the fire fighter training academy, the police training academy, and at the health clinic, but there is no "protected time" for fire

fighters to exercise at any of these sites or at their station.

Prior to 2007, the Fire Department contracted with the hospital conducting the medical evaluations to administer a voluntary fitness/wellness program with assistance from the Fire Department infection control officer. The program includes aerobic conditioning, health maintenance (smoking cessation classes, weight control programs, nutrition counseling, and education on high blood pressure, diabetes, and cholesterol), and a critical incident stress debriefing program. In 2007, the Fire Department changed this program from voluntary to mandatory. While program participation seems to have increased, fiscal constraints and limited personnel assigned to the program precluded 100% participation. The FF-Technician was not a voluntary participant of the fitness-wellness program. On July 2, 2007 (5 days prior to his death) he was scheduled for his mandatory health assessment, however he was on vacation that shift, and his health assessment was never performed.
Finally, as part of the City's Omnibus Act of 2004, the Fire Department began a mandatory baseline physical abilities assessment for all members. Pending funding, the Fire Department anticipates fully implementing a physical ability testing requirement in 2008.

DISCUSSION

Coronary Artery Disease and the Pathophysiology of Heart Attacks. In the United States, coronary artery disease (atherosclerosis) is the most common risk factor for cardiac arrest and sudden cardiac death. 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 [AHA 2007b]. The FF-Technician had several of these coronary artery disease risk factors (male gender, high blood pressure, high blood cholesterol, and obesity/physical inactivity), but had only mild coronary atherosclerosis (25-50% blockage) at autopsy.

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 [Fuster 1992]. This sudden blockage is primarily due to blood clots (thrombosis) forming on the top of atherosclerotic plaques. At autopsy, the FF-Technician did not have a thrombus in his coronary arteries. According to the Deputy Medical Examiner, this is a relatively common finding in patients with sudden cardiac death due to a myocardial infarction. For patients with relatively mild coronary atherosclerosis and myocardial infarction, spontaneous thrombolysis (dissolving of the thrombus) or coronary artery spasm must be considered. Coronary artery spasm has been reported to cause not only myocardial infarctions, but also sudden death [Bory 1996].

Epidemiologic studies in the general population have found that heavy physical exertion can trigger a heart attack and cause sudden cardiac death [Willich 1993; Mittleman 1993; Tofler 1992; Albert 2000]. Fire fighting 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 response activities [Barnard 1975; Kuorinka 1981; Lemon 1977; Hurley 1980; Manning 1983; Guidotti 1992; Smith 2001]. Therefore, it should not be surprising that recent epidemiologic studies found fire suppression, training, alarm

response, and strenuous physical activity on the job in the preceding 12 hours, independently increase the risk for a sudden cardiac event [Kales 2003, Kales 2007, Hales 2007]. The FF-Technician operated the truck during three emergency responses with a heat index of 86.4. NIOSH investigators considered this moderately strenuous physical activity.

Cardiomyopathy. On autopsy the FF-Technician was noted to have dilated ventricular cavities and thickened ventricle walls. These findings raise the possibility that the FF-Technician could have had a mixed dilated/hypertrophic cardiomyopathy. Dilated cardiomyopathy is characterized by dilatation of the heart chambers and impaired ventricular contraction (pumping). Although most cases of dilated cardiomyopathy are of unknown etiology (idiopathic), a variety of acquired or hereditary disorders can cause the disorder [Dec 1994]. Hypertrophic cardiomyopathy is a relatively common form of genetic heart disease [Maron 2006]. It is associated with exertional shortness of breath, impaired exercise performance, pre-syncope, syncope, and sudden cardiac death.

Screening Tests for Cardiac Disease – EKG. Regardless of the type of heart condition (coronary artery disease or mixed cardiomyopathy), could the FF-Technician's condition been identified before his sudden death? The fact that the FF-Technician was asymptomatic up until July 6th, 2007, makes an earlier diagnosis very difficult. However, the FF-Technician did have an EKG showing borderline criteria for LVH in 1989, but given his age, it was reasonable to dismiss this finding as an "athletic heart" [Maron 2005]. In 2005 and 2006, this LVH finding on his resting EKGs became much more pronounced. Given his obesity, this finding would be unlikely due to an "athletic heart," and obesity has been shown to obscure LVH [Levy 1990]. But by 2003, the FF-Technician was diagnosed with hypertension, and LVH is very common complication of hypertension. Thus, once again, the FF-Technician has a reasonable explanation for his LVH finding, and no clear indication for further evaluation. This is unfortunate, because if an echocardiogram had been done to evaluate his LVH, perhaps his enlarged heart would have been detected and he could have been referred for further evaluation and treatment.

Screening Tests for Cardiac Disease – Stress Tests. Stress testing asymptomatic individuals for coronary artery disease is controversial. NFPA 1582 states, "Stress EKG with or without echocardiogram or radionuclide scanning shall be performed as clinically indicated by history or symptoms" and refers the reader to Appendix A [NFPA 2007a]. Items in the Appendix A are not standard requirements, but are provided for "informational purposes only." Appendix A recommends that sub-maximal (85% of predicted heart rate) stress tests be used as a screening tool to evaluate a fire fighter's aerobic capacity. Maximal (e.g., symptom limiting) stress tests with imaging should be use for fire fighters with:

- abnormal screening sub-maximal tests
- cardiac symptoms
- known coronary artery disease
- Males over the age of 45 and females over the age of 55 with two or more risk factors for coronary artery disease. Risk factors are defined as hypercholesterolemia (total cholesterol greater than 240 mg/dL), hypertension (diastolic blood pressure greater than 90 mm Hg), smoking, diabetes

mellitus, or family history of premature coronary artery disease (heart attack or sudden cardiac death in a first-degree relative less than 60 years old).

If the stress test is negative, it should be repeated when clinically indicated or at least every 5 years.

The American College of Cardiology / American Heart Association (ACC/AHA) has also published stress test guidelines [Gibbons 2002]. The ACC/AHA states that the evidence to conduct stress tests in asymptomatic individuals with diabetes mellitus is "Class IIa" which is defined as "conflicting evidence and/or a divergence of opinion about the usefulness/efficacy but the weight of the evidence/opinion is in favor." The ACC/AHA goes on to say the evidence is "less well established" (Class IIb) for the following groups:

1. Evaluation of persons with multiple risk factors as a guide to risk-reduction therapy with the risk factors essentially the same as the NFPA listed above.
2. Evaluation of asymptomatic men older than 45 years, and women older than 55 years:
   - Who are sedentary and plan to start vigorous exercise
   - Who are involved in occupations in which impairment might jeopardize public safety [e.g. fire fighters]
   - Who are at high risk for coronary artery disease due to other diseases (e.g. peripheral vascular disease and chronic renal failure)

The U. S. Department of Transportation has also provided guidance for those seeking medical certification for a commercial drivers license. Their expert medical panel recommended stress tests for asymptomatic "high risk" drivers [Blumenthal 2007]. They define high risk drivers as those with any of the following:

- Diabetes mellitus
- Peripheral vascular disease
- Person above the age of 45 with multiple risk factors for coronary heart disease
- Framingham risk score predicting a 20% coronary heart disease event risk over the next 10 years

Finally, the U.S. Preventive Services Task Force (USPSTF) does not recommend stress tests for asymptomatic individuals, even those with risk factors for coronary artery disease. Rather, they recommend the diagnosis and treatment of modifiable risk factors (hypertension, high cholesterol, smoking, and diabetes) [USPSTF 1996]. The USPSTF indicates that there is insufficient evidence to recommend screening middle age and older men or women in the general population but notes that "screening individuals in certain occupations (pilots, truck drivers, etc.) can be recommended on other grounds, including the possible benefits to public safety."

Given that this FF-Technician was asymptomatic and age 34, none of the above organizations would have recommended a diagnostic stress test. If, however, the Fire Department was conducting screening sub-maximal aerobic capacity tests, perhaps the FF-Technician's condition could have been identified and referred on for further evaluation and treatment.

RECOMMENDATIONS

NIOSH investigators offer the following recommendations to reduce the risk of on-duty heart attacks and sudden cardiac deaths in this, and other fire departments across the country.

Recommendation #1: Modify the current fitness-wellness program to be consistent with NFPA 1583, *Standard on Health-Related Fitness Programs for Fire Fighters* and the *Fire Service Joint Labor Management Wellness/Fitness Initiative* to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.

We applaud the Fire Department and the Union for developing a fitness-wellness program which became mandatory in 2007. However, when compared to the NFPA program and the IAFF/IAFC initiative, several components are missing [NFPA 2000, IAFF/IAFC 1997]. These include:

- Ensuring medical clearance for members prior to their fitness assessment or their participation in the exercise and fitness program. This would be a minor bureaucratic effort since the vast majority of fire fighters are medically cleared for fire fighting duties on an annual basis
- Providing "protected time" (i.e., out of service) for exercise during each work shift
- Using peer fitness trainers to educate, motivate, and run the program. These trainers should take a personal trainer course and consider obtaining certification as a personal trainer
- Ensuring the participation of all uniformed personnel, even those performing administrative shifts
- Developing a process for tracking participation
- Developing a process (preferably electronic) for collecting and maintaining the data from this program
- Scheduling regular maintenance for the exercise equipment.

Developing a State-of-the-Art fitness-wellness program is the responsibility of both the Fire Department and the local union. Union support can play an important role in gaining acceptance. Therefore, we recommend that the Fire Department and the local union negotiate upgrades to the current program to ensure it is educational and rehabilitative and not punitive.

Recommendation #2: Secure funding from the governing municipality to upgrade the current fitness-wellness program.

Worksite health promotion programs have been shown to be cost effective by increasing productivity, reducing absenteeism, reducing the number of work-related injuries, and reducing the number of work-related lost work days [Maniscalco 1999; Stein 2000; Aldana 2001, IOM 2005]. Fire service health promotion programs have been shown to reduce coronary artery disease risk factors and improve fitness levels, with mandatory programs showing the most benefit [Blevins 2006; Dempsey 2002; Womack 2005]. One mandatory program was able to show a cost savings of $68,741 due to reduced absenteeism [Stein 2000]. 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 [Phoenix 1997].

Recommendation #3: Consider symptom-limiting stress tests for fire fighters at increased risk for coronary artery disease and sudden cardiac death.

We applaud the occupational health clinic for implementing a comprehensive medical evaluation program, in addition to the fitness-wellness program mentioned above. This program, however, has some discrepancies with NFPA 1582, a copy of which has been provided to the Fire Department [NFPA 2007a]. One specific concern is the issue of stress tests. Currently, the clinic recommends fire fighters with two or more coronary artery disease risk factors get a stress test from their personal physician. A system is needed to ensure this test is performed and the results are forwarded to the medical clinic. This lack of communication with a fire fighter's personal physician may be occurring for other aspects of the medical evaluation program.

Recommendation #4: Adopt *NFPA 1582: Standard on Comprehensive Occupational Medicine Program for Fire Departments* to ensure fire fighters have the medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others.

The Fire Department contracts with a local hospital and occupational health clinic to conduct medical evaluations of fire fighter applicants and members. The content of these evaluations is very similar to NFPA 1582. However, NFPA 1582 provides not only guidance on the content and frequency of the medical evaluation, but also on medical clearance for duty [NFPA 2007a]. Adopting NFPA 1582 will allow the occupational medical clinic to use the NFPA's consensus medical opinions on medical fitness for duty issues.

Adopting NFPA 1582 will raise legal and economic issues. Appendix B of NFPA 1582 outlines the legal consideration for the Fire Department administrators. The economic issues go beyond the costs of administering the medical program. Department administrators, unions, and fire fighters must be ready to address the personal and economic costs of the medical testing results. NFPA 1500 addresses these issues in Chapter 8-7.1 and 8-7.2 [NFPA 2007b]. Success of the program can hinge on support for the affected fire fighter. For fire fighters in rehabilitation programs, the Fire Department should provide alternate duty positions. If the fire fighter is not medically qualified to return to duty after repeat testing, supportive and/or compensated alternatives for the fire fighter should be pursued by the Fire Department.

Recommendation #5: Work with the local union to phase-in an annual physical ability test.

NFPA 1500 requires fire departments to develop physical performance requirements for not only fire fighter candidates, but also fire department members. "Members who engage in emergency operations shall be annually qualified as meeting the physical performance requirements established by the fire department" [NFPA 2007b]. We suggest the Fire Department's pending annual physical ability test be phased-in after an operational comprehensive fitness-wellness program (Recommendation #1) is implemented. This will allow some members to establish their own individualized rehabilitation program and prevent potential disruption of service.

REFERENCES

AHA (American Heart Association) [2007a]. Blood tests of rapid detection of heart attack. [http://www.americanheart.org/presenter.jhtml?identifier=4477]. Date accessed September 20, 2007.

AHA (American Heart Association) [2007b]. Risk factors and coronary artery disease. [http://www.americanheart.org/presenter.jhtml?identifier=4726]. Date accessed September 19, 2007.

Albert CM, Mittleman MA, Chae CU, Lee IM, Hennekens CH, Manson JE [2000]. Triggering of sudden death from cardiac causes by vigorous exertion. N Engl J Med *343*:1355-1361

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

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

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.

Blumenthal RS, Epstein AE, Kerber RE [2007]. Expert Panel Recommendations: Cardiovascular disease and commercial motor vehicle safety (expedited review). [http://www.mrb.fmcsa.dot.gov/documents/CVD_Commentary.pdf] Accessed on September 21, 2007.

Bory M, Pierron F, Panagides D, Bonnet JL, Yvorra S, Desfossez L [1996]. Coronary artery spasm in patients with normal or near normal coronary arteries. Eur Heart J 17:1015-1021.

CDC (Centers for Disease Control and Prevention) [2007]. BMI – Body Mass Index. [http://www.cdc.gov/nccdphp/dnpa/bmi/adult_BMI/english_bmi_calculator/bmi_calculator.htm]. Date accessed September 19, 2007.

Dec, GW, Fuster V [1994]. Medical Progress: Idiopathic Dilated Cardiomyopathy. N Eng J Med 331:1564-1575.

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.

Feigenbaum H [1997]. Chapter 3: Echocardiography. In: Braunwald E, ed. Heart Disease. A Textbook of Cardiovascular Medicine, 5th Edition. Philadelphia, PA: W.B. Saunders Company. p 64.

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.

Gibbons RJ, Balady GJ, Bricker JT, et al. [2002]. ACC/AHA 2002 guideline update for exercise testing: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. Circulation 106:1883-1892.

Guidotti TL [1992]. Human factors in firefighting: ergonomic, cardiopulmonary, and psychogenic stress-related issues. Int Arch Occup Environ Health *64*:1-12.

Hales T, Jackson S, Baldwin T [2007]. NIOSH Alert: Preventing Fire Fighter Fatalities Due to Heart Attacks and Other Sudden Cardiovascular Events. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health Publication No. 2007-133.

Hurley BH, Glasser SP, Phelps CP [1980]. Cardiovascular and sympathetic reactions to in-flight emergencies among base fire fighters. Aviat Space Environ Med *51*:788-792.

IAFF/ IAFC (International Association of Fire Fighters / International Association of Fire Chiefs) [1997]. The fire service joint labor management wellness/fitness initiative. Washington, D.C.

IAFF, IAFC (International Association of Fire Fighters / International Association of Fire Chiefs) [1999]. Candidate physical ability test. Washington, D.C.

IOM (Institute of Medicine) [2005]. Integrating Employee Health: A Model Program for NASA. National Academy Press, Washington, DC.

JNC (Joint National Commission) [2003]. National High Blood Pressure Education Program. The seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. Hypertension 42:1206-1252.

Kales SN, Soteriades ES, Christoudias SG, Christiani DC [2003]. Firefighters and on-duty deaths from coronary heart disease: a case control study. Environ health: a global access science source. 2:14. [http://www.ehjournal.net/content/2/1/14]. Date accessed: February 15, 2007.

Kales SN, Soteriades ES, Christophi CA, Christiani DC [2007]. Emergency duties and deaths from heart disease among fire fighters in the United States. N Eng J Med 356:1207-1215.

Kuorinka I, Korhonen O [1981]. Firefighters' reaction to alarm, an ECG and heart rate study. J Occup Med *23*:762-766.

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

Levy D, Labib SB, Anderson KM, Christransen JC, Kannel WB, Castell WD [1990]. Determinates of sensitivity and specificity of electrocardiographic criteria for left ventricular hypertrophy. Circulation 81:815-820.

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.

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.

Maron BJ [2005]. Distinguishing hypertrophic cardiomyopathy from athlete's heart: a clinical problem of increasing magnitude and significance. Heart 91:1380-1382.

Maron BJ, Towbin JA, Thiene G, et al. [2006]. Contemporary Definition and Classification of the Cardiomyopathies. American Heart Association Scientific Statement from the Council on Clinical Cardiology, Heart Failure and Transplantation Committees; Quality of Care and Outcomes Research and Functional Genomics and Translational Biology Interdisciplinary Working Groups; and Council on Epidemiology and Prevention. Circulation 113:1807-1816.

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.

NFPA (National Fire Protection Association) [2007a]. NFPA 1500: Standard on Fire Department Occupational Safety and Health Program. Quincy, MA.
Phoenix City Auditor, City of Phoenix, AZ. Disability retirement program evaluation. Unpublished data. January 28, 1997.

NFPA (National Fire Protection Association) [2007b]. NFPA 1582: Standard on Comprehensive Occupational Medicine Program for Fire Departments. Quincy, MA.

NFPA (National Fire Protection Association) [2000]. NFPA 1583: Standard on Health-Related Fitness Programs for Fire Fighters. Quincy, MA.

Schillaci G, Verdecchia P, Gorgioni C, et al [1994]. Improved electrocardiographic diagnosis of left ventricular hypertrophy. Am J Cardiol 74:714-725.

Smith DL, Petruzzello SJ, Manning TS [2001]. Effect of strenuous live-fire drills on cardiovascular and psychological responses of recruit firefighters. Ergonomics *44*:244-254.

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.

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

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) Stiudy Group. J Am Coll Cardiol 20:1049-1055.

USPSTF (U.S. Preventive Services Task Force) [1996]. Guide to clinical prevention services, 2nd ed. Baltimore: Williams & Wilkins; pp. 3-14.

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.

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.

INVESTIGATOR INFORMATION

This investigation was conducted by and the report written by:

Thomas R. Hales, MD, MPH
Senior Medical Epidemiologist

Tommy Baldwin, MS
Safety and Occupational Safety Specialist

Dr. Hales and Mr. Baldwin are with the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiovascular Disease Component located in Cincinnati, Ohio. Dr. Hales is board certified in Internal Medicine, Occupational Medicine, and a member of NFPA Fire Service Occupational Safety and Health Committee. Mr. Baldwin is a National Association of Fire Investigator (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.