



## Fire Fighter Suffers Cardiac Arrest At Structure Fire - Illinois

### SUMMARY

On March 6, 2000 a 50-year-old male volunteer Assistant Chief, responded to a fire in a single-family dwelling. At 1355 hours, after ventilating the roof, the victim collapsed. A crew member, returning from checking hot spots, saw him lying on the roof, unconscious. Other crew members also came to his assistance and found him unresponsive, with no pulse and no respirations. Cardiopulmonary resuscitation (CPR) was begun immediately and an ambulance was requested. Approximately 65 minutes later, despite CPR and advanced life support (ALS) administered on-scene and at the hospital, the victim died. The autopsy, conducted by the County Coroner, listed "Cardiac Arrhythmia" as the cause of death. The death certificate, also completed by the County Coroner, listed "Cardiac arrhythmia" due to "cardiomegaly, left ventricular hypertrophy, and ischemic heart disease" as the immediate cause of death.

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.

- *Provide mandatory annual medical evaluations to ALL fire fighters to determine their medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others.*
- *Ensure that fire fighters are cleared for duty by a physician knowledgeable about the physical demands of fire fighting and the various components of NFPA 1582.*
- *Provide fire fighters with medical evaluations and clearance to wear SCBA.*
- *Incorporate exercise stress tests into the Fire Department's medical evaluation program.*
- *Phase in a mandatory wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.*
- *Conduct mandatory pre-placement medical evaluations consistent with NFPA 1582 to determine a candidate's 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 [www.cdc.gov/niosh/firehome.html](http://www.cdc.gov/niosh/firehome.html) or call toll free 1-800-35-NIOSH



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*Fire Fighter Suffers Cardiac Arrest At Structure Fire - Illinois*

**INTRODUCTION & METHODS**

On March 6, 2000, a 50-year-old male Assistant Chief lost consciousness after ventilating the roof during a structure fire. Despite CPR and ALS administered by crew members, the ambulance crew, and personnel in the emergency department, the victim died. On December 6, 2001, NIOSH contacted the affected Fire Department to initiate the investigation. On December 11, 2001, a Safety and Occupational Health Specialist and an Epidemiologist from the NIOSH Fire Fighter Fatality Investigation Team traveled to Illinois to conduct an on-site investigation of the incident.

During the investigation NIOSH personnel interviewed:

- The Fire Chief,
- Crew members 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 2000,
- Emergency medical service (ambulance) incident report,
- Hospital emergency department report,
- Death certificate,
- Autopsy report,
- Past medical records of the deceased.

**INVESTIGATIVE RESULTS**

*Incident.* On March 6, 2000, at approximately 1342 hours, the involved Fire Department was dispatched to a structure fire involving a 1½-story, wood frame, single-family dwelling, measuring approximately 1800 square feet, located 6.5 miles from the fire station. The victim, who was talking (in person) to the Fire Chief at the time, responded to the fire station in his privately-owned vehicle (POV) to drive Engine 1

to the scene. The Fire Chief responded to the scene and was first on-scene. Four additional fire fighters and three First Responders responded in their POVs to the scene.

The fire, which spread from burning trash, involved the north side of the dwelling, including the garage. Engine 1 arrived on-scene and the victim activated the pump. He delegated the Driver/ Operator duty to another fire fighter, and then stretched a 100-foot section of 1½-inch hoseline to extinguish the external portion of the fire. After this was accomplished, the remaining fire fighters arrived on-scene. The victim and one fire fighter retrieved a 20-foot extension ladder and raised it to the garage roof. The victim and the fire fighter, both wearing full bunker gear and self-contained breathing apparatus (SCBA), on air, and taking the 1½-inch hoseline and an axe with them, climbed to the roof of the garage and began to perform roof ventilation with the axe. The fire fighter climbed down the ladder to check for fire spread inside the garage area. He identified an area still burning and exited the garage intending on retrieving the hoseline from the roof to continue extinguishment.

After the victim completed roof ventilation, he took his SCBA facepiece off and suddenly collapsed. On-scene crew members initially thought he was looking down the ventilation hole. The fire fighter standing on the ground below yelled to the victim to pass the hoseline down the ladder. After getting no response, the fire fighter backed away from the edge of the garage and, again, asked the victim to pass the hoseline down the ladder. After backing up a few more feet, the fire fighter saw the victim had collapsed. The fire fighter yelled that a man was down and a radio call informed Dispatch of the situation.

Crew members climbed onto the garage roof to aid the victim. Initial assessment by crew members found the Assistant Chief to be unresponsive, not breathing,



*Fire Fighter Suffers Cardiac Arrest At Structure Fire - Illinois*

and pulseless. CPR (chest compressions and assisted ventilations via mouth-to-mouth) began immediately. First Responders on-scene retrieved a bag-valve-mask (BVM). However, attempts to ventilate via BVM were unsuccessful, and ventilations via mouth-to-mouth were resumed. The victim was then extricated from the roof and placed onto the ground.

The ambulance was dispatched at 1358 hours. Medic units arrived on-scene at 1419 hours, finding the victim unresponsive, not breathing, and pulseless with CPR in progress. A cardiac monitor was attached to the victim, revealing ventricular fibrillation (V.Fib.) (a heart rhythm unable to sustain life), which was immediately defibrillated (shocked). The victim's heart rhythm reverted to asystole (no heart beat). ALS measures, including intubation and intravenous therapy, were begun. The cardiac monitor again revealed V.Fib. and one additional shock was administered, without change in patient status. The victim's heart rhythm again reverted to asystole and CPR continued. The victim was then loaded onto a stretcher and placed into the ambulance, which began transport to the hospital at 1429 hours. Enroute, the cardiac monitor again revealed V.Fib. and two additional shocks were administered, without change in patient status. The victim arrived at the hospital's emergency department (ED) at 1446 hours. Inside the ED, CPR and ALS measures continued until 1508 hours, when the victim was pronounced dead by the attending physician.

**Medical Findings.** The death certificate was completed by the County Coroner, who listed "Cardiac arrhythmia due to cardiomegaly, left ventricular hypertrophy, and ischemic heart disease" as the immediate cause of death. Pertinent findings from the autopsy, performed by a forensic pathologist, on March 7, 2000, included:

- Atherosclerosis of the coronary arteries  
50% to 75% narrowing of the proximal left anterior descending coronary artery

- Cardiomegaly due to left ventricular hypertrophy
- Ischemic heart disease

The Assistant Chief had the following risk factors for coronary artery disease (CAD): age over 45, male gender, smoking, and lack of exercise. The victim's last medical evaluation was in 1999, at which time he was not prescribed any medications and he was not under any restrictions for fire fighting duties. According to his wife and crew members, the Assistant Chief did not express symptoms of chest pain or any other symptom indicative of a heart attack at any time preceding the incident.

**DESCRIPTION OF THE FIRE DEPARTMENT**

At the time of the NIOSH investigation, the volunteer Fire Department consisted of 15 volunteer fire fighters and served a population of 1,500 in a geographic area of 100 square miles. There is one fire station. In 2000, the Department responded to 75 calls: 40 wildland fires, 20 dwelling fires, 10 outbuilding fires, and 5 vehicle fires.

**Training.** New fire fighter applicants must attend three consecutive meetings, pass a background check, and must then be voted on by the membership prior to being selected as a member. Once selected, the fire fighter receives training on the essentials of fire fighting. New members are placed on probation for 6 months, after which they become full members. Fire fighters receive recurrent training in their station at bi-weekly drills. There is no State requirement for minimum volunteer fire fighter certification.

There is no State requirement for annual volunteer fire fighter re-certification. Annual re-certification is required for hazardous materials certification. First Responders, EMTs and Paramedics recertify every two years. The victim was trained as a Fire Fighter and a Driver/Operator, and had 13 years of fire fighting experience.



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*Fire Fighter Suffers Cardiac Arrest At Structure Fire - Illinois*

*Pre-placement Evaluations.* The Fire Department does not require a pre-placement medical evaluation for new members. No timed performance evaluation of typical fire fighting duties (physical ability test) is required.

*Periodic Evaluations.* No annual medical evaluations are required by the Department. Fire fighters receive physical examinations through their jobs or at their own expense.

Medical clearance for SCBA use is not required. If a fire fighter is injured on-duty, he/she must be cleared for “return to work” by their personal physician. There are no other return to work clearances required.

No strength or aerobic equipment is available at the fire station. No wellness program is available.

## **DISCUSSION**

In the United States, coronary artery disease (atherosclerosis) is the most common risk factor for cardiac arrest and sudden cardiac death.<sup>1</sup> 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.<sup>2,3</sup> The victim had four of these risk factors (age over 45, male gender, smoking, and physical inactivity). The narrowing of the coronary arteries by atherosclerotic plaques occurs over many years, typically decades.<sup>4</sup> This victim had evidence of atherosclerotic disease in one of his coronary arteries with 50% to 75% narrowing of the proximal left anterior descending coronary artery.

This victim died of a “cardiac arrhythmia due to cardiomegaly, left ventricular hypertrophy (LVH), and ischemic heart disease.” Atherosclerosis in a coronary artery may cause ischemic heart disease

which occurs when the blood flow within a coronary artery, probably the proximal left anterior descending coronary artery in this case, is limited to the point where the oxygen needs of the heart muscle cannot be met. Ischemic heart disease causes hypertrophy of the heart muscle and cardiomegaly. All of these factors, independently and in combination, increase the risk of cardiac arrhythmia.

Firefighting is widely acknowledged to be one of the most physically demanding and hazardous of all civilian occupations.<sup>5</sup> 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.<sup>6-8</sup> 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.<sup>9</sup> Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks.<sup>10-14</sup> At the scene, the victim stretched a 100-foot section of 1½-inch hoseline, extinguished the external fire, climbed up a 20-foot extension ladder onto the garage roof, and, breathing air from a SCBA, chopped a ventilation hole in the garage roof prior to his collapse. This is considered a heavy level of physical exertion.<sup>15</sup>

To reduce the risk of heart attacks and sudden cardiac arrest 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.”<sup>16</sup> NFPA 1582 recommends a yearly physical evaluation to include a medical history, height, weight, blood pressure, and visual acuity test.<sup>16</sup> NFPA 1582 recommends a thorough examination to include vision testing, audiometry, pulmonary function testing, a



*Fire Fighter Suffers Cardiac Arrest At Structure Fire - Illinois*

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). The FD does not currently offer pre-placement or periodic physical evaluations to fire fighters.

NFPA 1582 also recommends fire fighters over the age of 35 with risk factors for CAD be screened for obstructive CAD by an EST.<sup>16</sup> Unfortunately, the EST has problems with both false negatives (inadequate sensitivity) and false positives (inadequate specificity), particularly for asymptomatic individuals (individuals without symptoms suggestive of angina), young men, and women.<sup>17,18</sup> This has led other expert groups to **not** recommend EST for asymptomatic individuals without risk factors for CAD.<sup>19,20</sup>

When these asymptomatic individuals **have** risk factors for CAD, however, recommendations vary by organization. The American College of Cardiology/American Heart Association (ACC/AHA) identifies two groups for EST: 1) men over the age of 40 with a history of cardiac disease (as a screening test prior to beginning a strenuous exercise program), and 2) men over age 40 with one or more risk factors.<sup>19</sup> They define five risk factors for CAD: hypercholesterolemia (total cholesterol > 240 mg/dL), hypertension (systolic >140 mm Hg or diastolic > 90 mm Hg), smoking, diabetes, and family history of premature CAD (cardiac event in 1<sup>st</sup> degree relative < 60 years old).<sup>18</sup> The U.S. Preventive Services Task Force (USPSTF) does not recommend EST for asymptomatic individuals, even those with risk factors for CAD; rather, they recommend the diagnosis and treatment of modifiable risk factors (hypertension, high cholesterol, smoking, and diabetes).<sup>20</sup>

These recommendations change for individuals who might endanger public safety if an acute episode were

experienced, or those who require high cardiovascular performance such as police and fire fighters. The NFPA recommends fire fighters without CAD risk factors get their first EST at age 40; for those with one or more CAD risk factors, at age 35.<sup>16</sup> NFPA considers CAD risk factors to be family history of premature (less than age 55) cardiac event, hypertension, diabetes mellitus, cigarette smoking, and hypercholesterolemia (total cholesterol greater than 240 or HDL cholesterol less than 35).<sup>16</sup> The EST should then be performed on a periodic basis, at least once every two years.<sup>16</sup> The ACC/AHA indicates that there is insufficient data to justify periodic EST in people involved in public safety, however, as mentioned previously, they recommend that men over age 40 with a history of cardiac disease be screened before beginning a strenuous exercise program.<sup>19</sup> Fire suppression activities involve strenuous physical activity; therefore, the ACC/AHA seem to be making a distinction between those already engaged in strenuous physical activity (conditioning), and those **beginning** a strenuous exercise program. The USPSTF indicates that there is insufficient evidence to recommend screening middle age and older men or women in the general population, however, "screening individuals in certain occupations (pilots, truck drivers, etc.) can be recommended on other grounds, including the possible benefits to public safety."<sup>20</sup>

Since the victim was over 45 years of age and asymptomatic, the performance of an EST is recommended by NFPA 1582. However, the AHA and the USPSTF are less clear about whether an EST should have been performed on this individual. In either case, if an EST would have been performed, his CAD might have been detected. And, if the CAD was detected, the victim could have undergone further evaluation and treatment, and possibly prevented the sudden cardiac death.



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*Fire Fighter Suffers Cardiac Arrest At Structure Fire - Illinois*

**RECOMMENDATIONS**

The following recommendations address health and safety generally. 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 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: Conduct mandatory pre-placement medical evaluations consistent with NFPA 1582 to determine a candidate's medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others.***

Guidance regarding the content and frequency of pre-placement medical evaluations and examinations for fire fighters can be found in NFPA 1582, Standard on Medical Requirements for Fire Fighters and Information for Fire Department Physicians,<sup>16</sup> and in the report of the International Association of Fire Fighters/International Association of Fire Chiefs (IAFF/IAFC) wellness/fitness initiative.<sup>21</sup> The Fire Department is not legally required to follow any of these standards. Nonetheless, we recommend the Fire Department be consistent with the above guidelines.

In addition to providing guidance on the frequency and content of the medical evaluation, NFPA 1582 provides guidance on medical requirements for persons performing fire fighting tasks. NFPA 1582 should be applied in a **confidential, nondiscriminatory** manner. Appendix D of NFPA 1582 provides guidance for Fire Department Administrators regarding legal considerations in applying the standard.

Applying NFPA 1582 also involves economic issues. These economic concerns go beyond the costs of

administering the medical program; they involve the personal and economic costs of dealing with the medical evaluation results. NFPA 1500, Standard on Fire Department Occupational Safety and Health Program, addresses these issues in Chapter 8-7.1 and 8-7.2.<sup>22</sup>

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

Unfortunately, the second and third requirements may not be workable in a volunteer department and could thus impair both acceptance by fire fighters and the Fire Department's ability to recruit and retain fire fighters. Applying this recommendation involves economic repercussions and may be particularly difficult for small, rural, volunteer Fire departments to implement. To overcome the financial obstacle, the Fire Department could urge current members to get annual medical clearances from their private physicians (but see Recommendation #3). Another option is having the brief annual medical evaluations recommended by NFPA 1582 completed by the volunteer fire fighters themselves (medical and occupational history) and by EMTs from the local emergency medical service (vital signs, height, weight, and visual acuity). This information could then be provided to a community physician, perhaps volunteering his or her time, to review the data and provide medical clearance (or further evaluation, if needed). The more extensive periodic medical examinations could be performed by a private physician at the fire fighter's expense, provided by a physician volunteer, or paid for by the Fire Department. Sharing the financial responsibility for these evaluations between volunteers, the Fire



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*Fire Fighter Suffers Cardiac Arrest At Structure Fire - Illinois*

Department, and willing physician volunteers should reduce the negative financial impact on recruiting and retaining needed volunteers.

***Recommendation #2: Provide mandatory annual medical evaluations to ALL fire fighters to determine their medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others.***

Guidance regarding the content and frequency of periodic medical evaluations and examinations for fire fighters can be found in NFPA 1582<sup>16</sup> and in the IAFF/IAFC wellness/fitness initiative.<sup>21</sup> The Fire Department is not legally required to follow any of these standards. Nonetheless, we recommend the FD establish the content and frequency in order to be consistent with the above guidelines.

***Recommendation #3: Ensure that fire fighters are cleared for duty by a physician knowledgeable about the physical demands of fire fighting and the various components of NFPA 1582.***

Physicians providing input regarding medical clearance for fire fighting duties should be knowledgeable about the physical demands of firefighting and familiar with the consensus guidelines published by NFPA 1582. To ensure physicians are aware of these guidelines, we recommend that the Fire Department provide the contract and private physicians with a copy of NFPA 1582. In addition, we recommend the Fire Department not automatically accept the opinion of the employee's private physician regarding return to work. This decision requires knowledge not only of the employee's medical condition, but also the employee's job duties. Frequently, private physicians are not familiar with an employee's job duties, or guidance documents, such as NFPA 1582. Lastly, we recommend that all return-to-work clearances

be reviewed by the City/County/Fire Department contracted physician. Thus, the final decision regarding medical clearance for return to work lies with the City/County/Fire Department with input from many sources including the employee's private physician.

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

OSHA's Revised Respiratory Protection Standard requires employers to provide medical evaluations and clearance for employees using respiratory protection.<sup>23</sup> These clearance evaluations are required for private industry employees and public employees in states operating OSHA-approved State plans. Illinois is a State-plan State, therefore, public sector employers are required to comply with OSHA standards. A copy of the OSHA medical checklist has been provided to the Fire Department.

***Recommendation #5: Incorporate exercise stress tests into the Fire Department's medical evaluation program.***

NFPA 1582 and the IAFF/IAFC wellness/fitness initiative both recommend at least biannual EST for fire fighters.<sup>16,21</sup> They recommend that these tests begin at age 35 for those with CAD risk factors, and at age 40 for those without CAD risk factors. The EST could be conducted by the fire fighter's personal physician or a City/County contract physician. If the fire fighter's personal physician conducts the test, the results must be communicated to the contract physician, who should be responsible for decisions regarding medical clearance for fire fighting duties.

***Recommendation #6: Phase in a mandatory wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.***

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*Fire Fighter Suffers Cardiac Arrest At Structure Fire - Illinois*

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.<sup>24</sup> NFPA 1500, Standard on Fire Department Occupational Safety and Health Program, and NFPA 1583, Standard on Health-Related Fitness Programs for Fire Fighters, require a wellness program that provides health promotion activities for preventing health problems and enhancing overall well-being.<sup>22,25</sup> 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.<sup>21</sup> The Fire Department should review these materials to identify applicable elements. Other large-city negotiated programs can also be reviewed as potential models.

**REFERENCES**

1. Fauci AS, Braunwald E, Isselbacher KJ, et al. [1998]. Harrison's principles of internal medicine. 14<sup>th</sup> ed. New York: McGraw-Hill, pp. 222-225.
2. American Heart Association (AHA) [1998]. AHA scientific position, risk factors for coronary artery disease. Dallas, TX.
3. Jackson E, Skerrett PJ, Ridker PM [2001]. Epidemiology of arterial thrombosis. In: Coleman RW, Hirsh J, Marder VIJ, et al., eds. 4<sup>th</sup> ed. Homeostasis and thrombosis: basic principles and clinical practice. Philadelphia, PA: Lippincott Williams and Wilkins.
4. Fauci AS, Braunwald E, Isselbacher KJ, et al. [1998]. Harrison's principles of internal medicine. 14<sup>th</sup> ed. New York: McGraw-Hill, p. 1348.
5. Gledhill N, Jamnik, VK [1992]. Characterization of the physical demands of firefighting. *Can J Spt Sci* 17(3):207-213.
6. Barnard RJ, Duncan HW [1975]. Heart rate and ECG responses of fire fighters. *J Occup Med* 17:247-250.
7. 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.
8. Lemon PW, Hermiston RT [1977]. The human energy cost of fire fighting. *J Occup Med* 19:558-562.
9. Smith DL, Petruzzello SJ, Kramer JM, et al. [1995]. Selected physiological and psychobiological responses to physical activity in different configurations of firefighting gear. *Ergonomics* 38(10):2065-2077.
10. Smith DL, Manning TS, Petruzzello SJ [2001]. Effect of strenuous live-fire drills on cardiovascular and psychological responses of recruit firefighters. *Ergonomics* 44(3):244-254.
11. 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.
12. 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.



*Fire Fighter Suffers Cardiac Arrest At Structure Fire - Illinois*

13. Siscovick DS, Weiss NS, Fletcher RH, Lasky T [1984]. The incidence of primary cardiac arrest during vigorous exercise. *N Eng J Med* 311:874-877.
14. Tofler GH, Muller JE, Stone PH, et al. [1992]. Modifiers of timing and possible triggers of acute myocardial infarction in the Thrombolysis in Myocardial Infarction Phase II (TIMI II) Study Group. *J Am Coll Cardiol* 20:1049-1055.
15. American Industrial Hygiene Association Journal [1971]. Ergonomics guide to assessment of metabolic and cardiac costs of physical work. *Am Ind Hyg Assoc J*, pp. 560-564.
16. NFPA [2000]. NFPA 1582, Standard on medical requirements for fire fighters and information for fire department physicians. Quincy, MA: National Fire Protection Association.
17. Michaelides AP, Psomadaki ZD, Dilaveris PE [1999]. Improved detection of coronary artery disease by exercise electrocardiography with the use of right precordial leads. *New Eng J Med* 340:340-345.
18. Darrow MD [1999]. Ordering and understanding the exercise stress test. *American Family Physician*. January 15, 1999.
19. Gibbons RJ, Balady GJ, Beasley JW, Bricker JT, Duvernoy WFC, Froelicher VF, Mark DB, Marwick TH, McCallister BD, Thompson PD, Winters WL Jr, Yanowitz FG [1997]. ACC/AHA guidelines for exercise testing: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee on Exercise Testing). *J Am Coll Cardiol*.30:260-315.
20. U.S. Preventive Services Task Force [1996]. Guide to clinical prevention services. 2<sup>nd</sup> ed. Baltimore, MD: Williams & Wilkins, pp. 3-15.
21. IAFF, IAFC [2000]. The fire service joint labor management wellness/fitness initiative. Washington, D.C.: International Association of Fire Fighters, International Association of Fire Chiefs.
22. NFPA [1997]. NFPA 1500, Standard on fire department occupational safety and health program. Quincy, MD: National Fire Protection Association.
23. 29 CFR 1910.134. Code of Federal Regulations. Occupational Safety and Health Administration: Respiratory Protection. Washington, DC: National Archives and Records Administration, Office of the Federal Register.
24. Plowman SA, Smith DL [1997]. Exercise physiology: for health, fitness and performance. Boston, MA: Allyn and Bacon.
25. NFPA [2000]. NFPA 1583, Standard on health-related fitness programs for fire fighters. Quincy, MA: National Fire Protection Association.

**INVESTIGATOR INFORMATION**

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