



Death in the line of duty...

Fire Fighters Suffers Fatal Pulmonary Embolism after Knee Surgery for a Work-related Injury – North Carolina

SUMMARY

On April 18, 2003 a fire fighter/engineer (FF/E) suffered a knee injury while battling a two alarm apartment building fire. After five months of unsuccessful conservative therapy, the FF/E underwent arthroscopic surgery. On November 30, 2003, six weeks after surgery, the FF/E awoke from sleep at with acute chest pain and shortness of breath. Despite advance life support (ALS) provided by ambulance paramedics and physicians in the hospital's emergency department (ED), and cardiopulmonary resuscitation (CPR) in the hospital's ED, the FF/E died. An autopsy conducted by a pathologist from the Office of the County Medical Examiner determined the cause of death to be a massive pulmonary embolism (PE) due to a deep vein thrombus (DVT) due to knee injury that was treated surgically.

Given the cause of death, it is unlikely the Fire Department (FD) could have done anything to prevent the tragic and untimely death of this FF/E. Therefore, the following recommendations address general health and safety issues identified during the National Institute for Occupational Safety and Health (NIOSH) evaluation. This list includes some preventive measures that have been recommended by other agencies to reduce the risk of sudden cardiac arrest and or death among fire fighters. These recommendations have not been evaluated by NIOSH, but represent research presented in the literature or of consensus votes of Technical Committees of the National Fire Protection Association (NFPA) or labor/management groups within the fire service. This strategy consists of: 1) minimizing physical stress on fire fighters; 2) screening to identify and subsequently rehabilitate high risk individuals; and 3) encouraging increased

individual physical capacity. Issues relevant to this FD include:

- *Provide annual medical evaluations to fire fighters to determine their medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others. The Department and Union should negotiate the content and frequency to be consistent with NFPA 1582.*
- *Following an injury/illness, the final determination of a fire fighter's return-to-work status should be made by the FD physician who is knowledgeable about the physical demands of fire fighting, the medical requirements of fire fighters, and the various components of NFPA 1582. Only after requesting, receiving, and reviewing all relevant medical information should the fire department physician clear fire fighters for full duty.*

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



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- ***Fire fighters should be medically cleared prior to participating in the FD's Physical Fitness Qualification (PFQ) test.***
- ***Provide fire fighters with medical evaluations and clearance to wear self-contained breathing apparatus (SCBA) as required by the Occupational Safety and Health Administration (OSHA).***
- ***Complement the impressive mandatory fitness program with a mandatory, rather than voluntary, wellness program. Specific programs that can reduce modifiable coronary artery disease (CAD) risk factors include smoking cessation, weight control, and low fat/ low cholesterol diets.***

• Local President and Secretary of the International Association of Fire Fighters (IAFF)

• The deceased's spouse

• Contract occupational medicine physician for the FD

• Pathologist who conducted the autopsy for the County Medical Examiner

During the site-visit NIOSH personnel also reviewed the:

- FD policies and operating guidelines
- FD medical records of the FF/E
- Emergency medical services - ambulance report
- Hospital ED report
- Autopsy report

INVESTIGATIVE RESULTS

Incident. On April 18, 2003 at 0950 hours the FD received a 911 call regarding a structure fire. The structure was a two story wood frame apartment building consisting of four apartment units. The entire structure consisted of approximately 4800 square feet. The exterior of the structure was brick and the interior was wood frame with drywall. The air temperature was 48° Fahrenheit with a steady rain. Engine 2 (E-2) (the deceased's company) was the first to arrive on-scene and called a working fire with heavy smoke showing. E-2's Captain assumed the role of incident commander (IC) and advised Engine-12 to reverse lay and establish a water supply to E-2. He also advised E-12's Captain to take over suppression efforts and assume responsibility for his crew who were advancing a 1 3/4 inch hand line off E-2 into the involved apartment. At this time E-2's engineer (the deceased) was making his supply connection and charging the 1 3/4 inch hand line. The IC then advised Ladder-16 to perform vertical ventilation and Engine-1 to conduct a primary search of the apartment for civilians.

INTRODUCTION & METHODS

On April 18, 2003, a 46 year-old male FF/E suffered an acute right knee injury while pulling hose off his engine during a working residential fire. Despite five months of medical care, the condition got worse and on October 17, 2003 he underwent arthroscopic knee surgery. Six weeks after the surgery, the FF/E suffered a fatal massive pulmonary embolus from a deep vein thrombosis in his right leg. NIOSH was notified of this fatality in November 2003 by the United States Fire Administration and the Office of the State Fire Marshal – North Carolina. On June 29, 2004, an occupational medicine physician from the NIOSH Fire Fighter Fatality Investigation Team and a fire safety specialist from the Office of the State Fire Marshal office traveled to the FD to conduct an onsite investigation of the incident.

During the investigation NIOSH personnel met with and/or interviewed the:

- Fire Chief, Deputy Fire Chiefs, and FD Safety and Health Officer
- Fire Fighters on duty with the FF/E

At this time the on-duty Battalion Chief was arriving on-scene to find heavy smoke and visible fire



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extending from the downstairs apartment on the front side of the building. He assumed IC, and due to the initial indication of fire spread into the attic space, he called dispatch for a second alarm response. At this time the IC also advised E-2 to pull another additional 2 ½ inch hand line as back-up. The FF/E did this by first grabbing the hose, then putting his left foot on the truck's tailboard, and then pushed off the ground with his right foot. At this point the FF/E felt a "pop" and sudden pain behind his right knee. The FF/E was able to continue with the fire suppression effort, but when the fire was brought under control, he notified his Captain of the injury. E-2's Captain notified the IC and then transported the FF/E to the occupational medicine clinic under contract with the FD.

The initial diagnosis was of right knee pain treated with elevation, ice, and a non-steroidal anti-inflammatory agent. He was taken off duty for that day (April 18), and then given modified duty (clerical work) for four days. The FF/E still had some residual pain at his follow-up evaluation (April 22) where the diagnosis was changed to a right hamstring muscle strain and he was put back to full duty. Two months later the pain persisted and was now exacerbated by stooping or walking down steps. He was diagnosed with a right knee bursitis and had his knee injected with a pain killer and a long acting steroid to reduce inflammation. He noticed some improvement and then on his next evaluation (July 9) was given some exercises to perform while he remained on full-duty.

Despite these interventions, the pain persisted and in August he had magnetic resonance image (MRI) taken of his right knee and was referred to an orthopedic specialist. The MRI showed cartilage damage (full thickness chondral defect) with a loose foreign body in the joint space (anterior aspect of the tibial plateau on the right side) and excess joint fluid (effusion). The orthopedic surgeon gave the FF/E the option of continuing with conservative care

versus arthroscopic surgery. The FF/E opted for the latter which was scheduled for October 17, 2003. Prior to the surgery the FF/E had increasing pain, swelling, clicking, and catching of this right knee. On September 19, a needle was inserted into the knee joint to remove excess fluid and then injected for the second time with pain killers and long-acting steroids.

On October 17, 2003 the FF/E had arthroscopic surgery performed ("arthroscopic chondroplasty of distal medial femoral condyle, medial tibial plateau" and "removal of multiple loose bodies."). According to the spouse, there was some confusion regarding post-operative care (pain medications, immobilization, etc.) and this confusion was exacerbated at his follow-up appointment one week later. However, at this time the FF/E did not notice any signs of a DVT in his right leg. It should be noted that signs of a DVT are very non-specific and variable. The most common complaint is calf pain, followed by warmth, modest swelling, and rarely a "cord" in the back of his thigh. Given the FF/E's recent surgery, some tenderness and swelling would be considered normal. In addition, the FF/E did not report any symptoms consistent with a PE which would have been sudden shortness of breath, and pleuritic chest pain (pain that is exacerbated by deep breaths).

On November 30th shortly after 0100 hours, the FF/E was awoken from his sleep with extreme shortness of breath and chest pain. An ambulance was called and arrived on-scene at 0136 hours. The paramedics found the FF/E sitting on the side of his bed in extreme respiratory distress complaining of chest pain. He was in a cold sweat (diaphoresis). Vital signs revealed a rapid breathing rate of 36 breaths per minute, a rapid carotid pulse at 128 beats per minute, and they could not measure a blood pressure. An electrocardiogram (EKG) was hooked up which showed sinus tachycardia (a fast heart rate) and some ST segment depression in lead three. His



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pulse oximeter was 88% (normal >95%) suggesting reduced blood oxygen. He was given oxygen via a non-rebreathing mask, and intravenous (IV) fluids started. They departed the home at 0148 hours, and arrived at the hospital's ED at 0152 hours.

In the ED the FF/P was alert, anxious, complaining of chest pain and shortness of breath. Vital signs at this time showed a pulse of 140 beats per minute, respiratory rate of 40 per minute, and a blood pressure of 90/60 millimeters of mercury. On physical examination his lungs were clear to auscultation and percussion and his right leg did not show any signs of a DVT. An EKG at 0200 hours showed sinus tachycardia, a conduction disturbance (incomplete right bundle branch block), and some ST segments abnormalities suggesting a possible heart attack. Due to his recent surgery, the ED physicians astutely suspected a PE due to a DVT, rather than assuming a heart attack was occurring. While "clot dissolving" drugs were being ordered (tissue plasminogen activator otherwise known as tPA), an echocardiogram was performed which was reported to show right ventricular strain (a finding consistent with a large PE).

Despite being given ALS medications via IV, the FF/E's condition began to deteriorate. He was intubated (a breathing tube placed into the windpipe) at approximately 0215 hours and a portable chest X-ray confirmed its location in the trachea. At about this same time his heart stopped beating and CPR was started. At approximately 0222 hours the tPA was administered followed by a second bolus at 0230 hours. The FF/E regained a pulse briefly at 0230 hours, but then reverted to pulseless electrical activity. CPR and ALS continued for another 22 minutes at which time he was pronounced dead (0252 hours) and resuscitation efforts were discontinued.

Medical Findings. A pathologist from the County's Office of the Medical Examiner

conducted an autopsy. The cause of death was listed as massive pulmonary embolism due to right deep leg vein thrombus due to knee injury that was treated surgically. The autopsy was significant for:

Acute Pulmonary Embolus as evidenced by:

- A large blood clot in the artery to the lungs [Recent (pre-mortem) blood clot (thrombus) occluding the pulmonary trunk and right and left main pulmonary arteries measuring approximately 1.1 centimeters (cm) in diameter. This clot extended down into the lobar and segmental branches bilaterally. Microscopic examination of this clot did not show any organization (i.e. it was recent)]
- Smaller blood clots in the right pre-mortem clots (thrombo-emboli) scattered in the right lung periphery

Remote Pulmonary Emboli (at least two weeks old) as evidenced by:

- Focal organized adherent clot within branch to right and left lower lobes. Microscopic examination of this clot showed it was well organized, adhered to the artery wall with fibrous tissue, and re-endothelialized

Deep Vein Thrombosis in the right leg

Evidence of hypertensive cardiovascular disease as demonstrated by:

- An enlarged heart of 500 grams (normal less than 400 grams)
- Mild concentric left ventricular hypertrophy measuring 1.5 cm in thickness (normal <1.5 cm)

Severe focal atherosclerotic coronary artery disease as evidenced by:

- 85% blockage of the left anterior descending coronary artery



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Blood samples taken at autopsy revealed no ethanol (alcohol) or salicylates (aspirin) detected. The FF/E had no previous history of DVTs or PEs or clotting disorders.

**DESCRIPTION OF THE FIRE
DEPARTMENT**

At the time of the NIOSH investigation, the Fire Department was comprised of 908 uniformed personnel and served a population of 613,000 residents, in a geographic area of 268 square miles. Each engine and ladder company is staffed with an officer and at least three fire fighters. There are 35 fire stations where fire fighters work 24-hour shifts starting at 0800 hours according to the following tour: 24 hrs-on, 24-off, 24-on, 48-off, 24-on, 24-off, 24-on, 96-off.

In fiscal year 2003 (7/1/02 to 6/30/03), the FD responded to 73,036 alarms: approximately 48,000 emergency medical service, 11,000 good intent, 5,000 service calls, 2,300 HAZMAT, 2,300 fire alarms, 2,000 false alarms, 1,100 other incidents, 900 overpressure, and 40 natural disasters. The ambulance service (ALS) is provided by the County.

Training. The FD provides all new hires with an 18-week training to become State-certified at the National Fire Protection Association (NFPA) Fire Fighter II level. All are State-certified EMT-d and are certified in CPR, AED use, and hazardous materials operations level (24 hour). The victim had 21 years of fire fighting experience and during that time was promoted from a FD level FF I, to a FD level FF II, then to an Engineer.

Pre-employment/Pre-placement Evaluations. Candidates are required to complete a Candidate Physical Ability Test; a timed performance evaluation of essential fire fighting duties.¹ The candidate has an opportunity to practice the CPAT up to eight weeks

before their actual test. Candidates who do not complete the task within the allotted time are dropped from the Candidate hiring pool. Once hired, recruits are also required to pass a physical fitness examination administered at the beginning, middle, end of the training period, and at the end of the first year probationary period.

Candidates are also required to pass a urine drug test used to detect illicit drug use. If the Candidate passes the drug test, they undergo a pre-placement medical evaluation for all new hires, regardless of age. Components of this evaluation include:

- A complete medical history
- Height, weight, and vital signs
- Physical examination
- Blood Tests: Complete blood count (CBC), SMA 6, liver function tests, lipid test, and Hepatitis B antibody and antigen titer testing
- Urine dipstick test
- Chest X-ray
- Resting EKG
- Pulmonary function tests/spirometry
- Audiometry
- Vision Test
- Tetanus booster (if appropriate)

These evaluations are performed by the FD contract physician, who makes a decision regarding medical clearance for fire fighting duties. The FD is notified of any condition requiring modification or restriction. Results of the medical examination are kept confidential by the contract physician and only the clearance status is reported to the FD.

Periodic Evaluations. From 1980 until approximately 1992, the FD required annual medical examinations for fire fighters over the age of 40 years. Since 1992, however, the FD medical examinations became optional and included a \$25 to \$30 co-payment. Consequently, few fire service personnel participated in these annual medical evaluations;



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instead they received their medical care through their personal physicians. Hazmat personnel, on the other hand, continued to receive their annual medical examinations per the State OSHA Standard.^{2,3}

If a fire fighter is injured at work or has missed work due to non-work-related illness for 30 or more days, he/she must be cleared for “return to work” by their treating physician(s). This clearance requires the signature of the treating physician on a FD “medical clearance form.” This form includes a “physical job description” that lists many of the physically challenging job duties required during fire suppression or rescue work. This information is then forwarded to the FD’s contracted occupational medicine physician who has the final authority regarding return to duty.

Since 1980 the FD has had a mandatory physical fitness program designed to meet the guidelines of the Joint Labor/Management Wellness-Fitness Initiative.⁴ The program consists of an individualized exercise program developed by the Physical Fitness Coordinator based on a physical fitness evaluation. Each fire fighter is required to devote one hour to physical fitness training during each 24-hour shift (Sundays and Holidays optional). All fire stations are equipped with exercise (strength and aerobic) equipment.

The evaluation portion of the program, known as “Physical Fitness Qualification (PFQ),” requires an annual physical fitness test. The test scores fire fighters in four areas: aerobic capacity, muscle strength, flexibility, and muscle endurance. The scores are weighted to generate a total/overall score. The total score is categorized into five groups: unacceptable, marginal, performance achieved expectations, performance exceeded expectations, and exceptional performance. The total scores needed to achieve each category are stratified by age (less than 40 years and 40 or more). If a member

receives an unacceptable rating, a number of events are triggered:

1. A required counseling session with the Physical Fitness Coordinator
2. Immediate removal from operations duty assignment; assigned light duty if necessary
3. A medical examination with the FD contracted occupational medicine specialist
4. Retest within three months after clearance by the FD contracted physician

If the retest results in an unacceptable rating again, it is noted in their personnel performance appraisal and a Job-Related Physical Agility Test (JRPAT) is scheduled within one week. If the fire fighter fails the JRPAT, they are immediately removed from operations duty assignment. The Physical Fitness Coordinator reviews their exercise regimen and the fire fighter must retake the JRPAT or the PFQ within 30 days. Failure to pass either of these tests will result in suspension without pay for up to 30 days and possible termination.

DISCUSSION

A deep vein thrombosis (DVT) is a blood clot (thrombus) that develops in a deep vein, usually in the leg. It is more commonly seen in adults over age 60 but can occur in any age group. Risk factors for its development include prolonged sitting, bedrest or immobilization (such as on long plane or car trips), recent surgery or trauma (especially hip, knee or gynecological surgery), fractures, childbirth within the last 6 months, use of medications such as estrogen and birth control pills, polycythemia vera, malignant tumors, and inherited or acquired hypercoagulability (changes in the levels of blood clotting factors making the blood more likely to clot).^{5,6}

Recent studies have reported incidence rates of DVT and thromboembolic events following arthroscopic knee surgery to be 18% and 12%, respectively.^{7,8}



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The latter study reported a 12% incidence despite treatment with low-molecular-weight heparin (a blood thinner) for an average of four days post-operatively. Symptoms of a DVT can include swelling of the leg, warmth and redness of the leg, or pain exacerbated by standing or walking.^{5,9} Unfortunately, many DVT patients do not experience these symptoms.^{9,10} Equally discouraging is the lack of signs on physical examination (swelling, erythema, tenderness, superficial venous dilation, appearance of prominent venous collaterals, a palpable “cord,” or a positive Homan sign).^{6,9} Therefore, it is generally accepted that clinical signs are unreliable and the lack of physical findings does not rule out a DVT.¹¹

Diagnosing a DVT is important so treatment can be initiated before complications develop. Treatment with blood thinners can help prevent the clot from becoming larger, new clots from forming, development of post-thrombotic syndrome, and, most importantly, the blood clot from breaking loose and traveling to the lungs [pulmonary embolus (PE)].^{5,12} Symptoms of a PE include shortness of breath, pleuritic chest pain, and coughing up phlegm, possibly flecked with blood. Depending on the size of the clot, a PE can be a life-threatening. With appropriate treatment (e.g. blood thinners) it is rare for a DVT to lead to a PE.¹²

For the FF/E the most likely risk factor for his DVT was his recent arthroscopic knee surgery. From the records provided to NIOSH, the FF/E did not appear to receive any heparin (one type of anti-coagulant) pre- or post-operatively. Another type of “blood thinner” is aspirin, or aspirin like products (e.g. ibuprofen or another non-steroidal anti-inflammatory agent). These medications have anti-coagulant effects by interfering with platelet function which is one part of the body’s clotting mechanism. According to the FF/E’s spouse, aspirin was recommended as part of his discharge instructions,

but she thought this was for their analgesic (pain relief) properties, not their anti-coagulant properties. In either case, these instructions were either not provided at the time of discharge or not pick-up by the family as they left the hospital. Instead, they were mailed to the patient and, according to the FF/E’s spouse, were received somewhere between seven and ten days later.

The autopsy findings confirmed the presence of a large pulmonary embolus and the presence of a DVT in the right leg. In addition, the autopsy found evidence of several smaller PE’s that had occurred at least two weeks earlier based on their histologic (microscopic) appearance.

RECOMMENDATIONS AND DISCUSSION

Given the cause of death, it is unlikely the Fire Department could have done anything to prevent the tragic and untimely death of this fire fighter. Therefore, the following recommendations address general health and safety issues identified during the NIOSH evaluation. This list includes some preventive measures that have been recommended by other agencies to reduce the risk of sudden cardiac arrest and or death among fire fighters. These recommendations have not been evaluated by NIOSH, but represent research presented in the literature or of consensus votes of Technical Committees of the NFPA or labor/management groups within the fire service. This strategy consists of: 1) minimizing physical stress on fire fighters; 2) screening to identify and subsequently rehabilitate high risk individuals; and 3) encouraging increased individual physical capacity. Issues relevant to this FD include:

Recommendation #1: Provide annual medical evaluations to fire fighters to determine their medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others. The Department



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and Union should negotiate the content and frequency to be consistent with NFPA 1582.

Since the FD's mandatory annual medical examinations were discontinued in 1992, the FD has approached the City regarding resurrecting that program. The program was not restarted due to cost concerns; costs not only for the fire fighter examinations, but also the perceived need to offer similar examinations for all other City employees. It should be remembered, however, that fire fighters are public safety employees. Their job requires entering environments that are immediately dangerous to life and health (IDLH). Sudden incapacitation in an IDLH environment not only jeopardizes the life of that individual, but also his/her peers and the civilians they have sworn to protect. Most other city employees are not operating in IDLH environments, nor do they have the physical demands of fire fighting. Providing mandatory annual medical evaluations to ensure fire fighter can safely perform their duties is consistent with their job requirements.

Guidance regarding the content and frequency of medical evaluations for fire fighters can be found in NFPA 1582,¹³ and in The Fire Service Labor Management Wellness/Fitness Initiative.⁴ Applying NFPA 1582 involves legal and economic repercussions and must be carried out in a nondiscriminatory manner. Appendix B of NFPA 1582 provides guidance for FD Administrators regarding legal considerations in applying the standard.

Economic repercussions go beyond the costs of administering the medical program. Department administrators, unions, and fire fighters must also deal with the personal and economic costs of the medical testing results. NFPA 1500 addresses these issues in Chapter 8-7.1 and 8-7.2.¹⁴ The success of medical programs may hinge on protecting the affected fire fighter. The department should provide alternate duty

positions for fire fighters in rehabilitation programs, if possible. 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 Department.

Recommendation #2: Following an injury/illness, the final determination of a fire fighter's return-to-work status should be made by the fire department physician who is knowledgeable about the physical demands of fire fighting, the medical requirements of fire fighters, and the various components of NFPA 1582. Only after requesting, receiving, and reviewing all relevant medical information should the fire department physician clear fire fighters for full duty.

Physicians providing input regarding medical clearance for fire-fighting duties should be knowledgeable about the physical demands of fire fighting and that fire fighters frequently respond to incidents in IDLH environments.¹⁵⁻¹⁷ They should also be familiar with the consensus guidelines published by NFPA 1582, *Standard on Comprehensive Occupational Medicine Program for Fire Departments*.¹³ To ensure physicians are aware of these guidelines, we recommend that the Fire Department provide the contract and other private physicians with a copy of NFPA 1582. In addition, we recommend the fire department physician consider, but not "rubber stamp" the opinions of the treating physician regarding return-to-work. This decision requires knowledge not only of the medical condition, but also of the fire fighter's job duties. Personal physicians may not be familiar with an employee's job duties, or guidance documents, such as NFPA 1582. In addition, they may consider themselves as patient advocates and dismiss the potential public health impact of public safety officials who may be suddenly incapacitated. Therefore, we recommend that all return-to-work



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clearances be reviewed by the department contracted physician. The final decision regarding medical clearance lies with the FD physician with input from many sources including the fire fighter's private physician.

Recommendation #3: Fire fighters should be medically cleared prior to participating in the FD's Physical Fitness Qualification (PFQ) test, specifically, the aerobic capacity (treadmill) test.

During PFQ tests, fire fighters are required to measure their aerobic capacity on a treadmill. When on the treadmill, fire fighters can exercise to the point of maximum heart rates and metabolic work of up to 15 METS. The heavy physical exertion can trigger heart attacks in susceptible individuals.¹⁸⁻²¹ Therefore, prior to participating in the treadmill test, we recommend fire fighters receive medical clearance.

Recommendation #4: Provide fire fighters with medical evaluations and clearance to wear SCBA as required by OSHA.

OSHA's revised respiratory protection standard requires employees to provide annual medical evaluations and clearances for employees using respiratory protection.²² These clearance evaluations are required for private industry employees and public employees in States operating OSHA-approved State plans. Since North Carolina is a State-plan State, public employees, including FD must comply with this Standard.

Recommendation #5: Complement the impressive mandatory fitness program with a mandatory, rather than voluntary, wellness program. Specific programs that can reduce modifiable CAD risk factors include smoking cessation, weight control, and low fat/ low cholesterol diets.

The International Association of Fire Fighters (IAFF) and the International Association of Fire Chiefs (IAFC) created the Fire Service Joint Labor Management Wellness/Fitness Initiative to strengthen fire fighters' mental, physical, and emotional capabilities.⁴ NFPA 1583 Standard on Health-Related Fitness for Firefighters prescribes similar department-wide programs to enhance physical fitness and reduce modifiable cardiac risk factors in firefighters.²³ Both documents stress the importance of regular aerobic and strengthening exercise, nutrition and weight control, and smoking cessation.

Wellness programs have been shown to be cost effective, typically by reducing the number of work-related injuries and lost work days.²⁴⁻²⁵ A similar cost savings has been reported by the wellness program at the Phoenix Fire Department, where a 12-year commitment has resulted in a significant reduction in their disability pension costs.²⁶

REFERENCES

1. International Association of Fire Fighters and the International Association of Fire Chiefs. The fire service joint labor management wellness-fitness initiative's candidate physical ability test. International Association of Fire Fighters, Department of Occupational Health and Safety, Washington DC, 1999.
2. 29 CFR 1910.120 Hazardous waste operations and emergency response. Available at http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9765 Accessed on July 2004.
3. NIOSH [1985]. Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities. Available at <http://www.cdc.gov/niosh/pdfs/85-115-a.pdf> Accessed on July 2004.



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4. International Association of Fire Fighters and the International Association of Fire Chiefs. The fire service joint labor management wellness-fitness initiative. International Association of Fire Fighters, Department of Occupational Health and Safety, Washington DC, 1997.
5. National Institutes of Health. Medlines Plus – Deep Vein Thrombosis. Available at <http://www.nlm.nih.gov/medlineplus/ency/article/000156.htm#Causes,%20incidence,%20and%20risk%20factors> Accessed on July 15, 2004.
6. Gupta R, Stouffer GA [2001] Deep venous thrombosis: A review of the pathophysiology, clinical features, and diagnostic modalities. *Am J Medical Sciences* 322(6):358-364.
7. Demers C, Marcoux, S, Ginsberg J, et al. [1998]. Incidence of venographically proved deep vein thrombosis after knee arthroscopy. *Arch Intern Med* 158(1):47-50.
8. Obernosterer A, Schippinger G, Lipp RW, et al. [1999]. Thromboembolic events following arthroscopic knee surgery. Letter to the Editor. *JAMA* 282(5):431.
9. Leclerc JR, Illescas F, Jarzem P [1991]. Diagnosis of deep vein thrombosis. In : Leclerc JR, editor. *Venous Thromboembolic Disorders*. Philadelphia: Lea & Febiger; p.176.
10. Creager MA, Dzau VJ [2001]. Vascular diseases of the extremities. 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. p1440.
11. Gorman WP, Davis KR, Donnelly R [2000]. ABC of arterial and venous disease. Swollen lower limb-1: general assessment and deep vein thrombosis. *BMJ* 320:1453-6.
12. National Institutes of Health. Medlines Plus – Pulmonary Embolus. Available at <http://www.nlm.nih.gov/medlineplus/ency/article/000132.htm> Accessed on July 15, 2004.
13. NFPA [2003]. Standard on Comprehensive Occupational Medical Programs for Fire Departments. Quincy, MA: National Fire Protection Association. NFPA 1582 – 2003.
14. NFPA [1997]. Standard on Occupational Safety Program for Fire Departments. Quincy, MA: National Fire Protection Association. NFPA 1500 - 1997.
15. Gledhill N, Jamnik, VK. Characterization of the physical demands of firefighting. *Can J Spt Sci* 1992;17:3 207-213.
16. Barnard RJ, Duncan HW. Heart rate and ECG responses of fire fighters. *J Occup Med* 1975;17:247-250.
17. Smith DL, Petruzzello SJ, Kramer JM, et al. Selected physiological and psychobiological responses to physical activity in different configurations of firefighting gear. *Ergonomics* 1995; 38:10:2065-2077.
18. Willich SN, Lewis M, Lowel H, et al [1993]. Physical exertion as a trigger of acute myocardial infarction. *NEng J Med* 329:1684-90.
19. Mittleman MA, Maclure M, Tofler GH, et al [1993]. Triggering of acute myocardial infarction by heavy physical exertion. *NEng J Med* 329:1677-83.
20. Siscovick DS, Weiss NS, Fletcher RH, Lasky T [1984]. The incidence of primary cardiac arrest during vigorous exercise. *NEng J Med* 311:874-7.



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21. 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* 20:1049-55.

22. 42 CFR 1910.134. Respiratory Protection. Available at http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=12716 Accessed in July 2004.

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

24. 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* 1999;41:813-820.

25. Stein AD, Shakour SK, Zuidema RA [2000]. Financial incentives, participation in employer sponsored health promotion, and changes in employee health and productivity: HealthPlus health quotient program. *JOEM* 42:1148-55.

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

INVESTIGATOR INFORMATION

This investigation was conducted in conjunction with a fire / rescue training specialist from the Office of the State Fire Marshal North Carolina. The report was written by Thomas Hales, MD, MPH of the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiovascular Disease Component located in Cincinnati, Ohio. The NIOSH investigator would like the acknowledge the cooperation and assistant provided by the Office of the State Fire Marshal, the crew members and Officers of the effected FD, and the local IAFF staff.