# Fire Fighter Trainee Suffers Sudden Cardiac Death During Physical Fitness Training - Florida

## Death in the Line of Duty...A summary of a NIOSH fire fighter fatality investigation

F2006-23 Date Released: June 20, 2007

## SUMMARY

On September 17, 2005, a 22-year-old male Fire Fighter Trainee participated in a bunker gear donning drill and a warm up jog. After jogging about 350 yards, the Trainee suddenly collapsed. Crew members and instructors notified Dispatch and began cardiopulmonary resuscitation (CPR). The fire engine company stationed across the street arrived at the scene within 3 minutes, and an ambulance arrived 7 minutes later. Additional advanced life support treatment was begun, and the ambulance transported the Trainee to the hospital. Despite advanced life support and CPR for 50 minutes, the Trainee died. The death certificate and autopsy, completed by the District Medical Examiner, listed “hypertrophic and arteriosclerotic cardiomyopathy” as the cause of death. The physical exertion associated with the Trainee’s physical fitness training probably triggered his sudden cardiac death.

NIOSH investigators offer the following recommendations to potentially prevent similar incidents and to address general safety and health issues:

- Ensure thatfire fighters are cleared for duty by a physician knowledgeable about the physical demands of firefighting, the personal protective equipment used by fire fighters, and the various components of NFPA 1582. Encourage fire fighters to provide accurate medical history information to the Fire Department physician.
- Perform pre-placement medical evaluations consistent with National Fire Protection Association (NFPA) 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments.

Although unrelated to this fatality, the Fire Academy should consider these additional recommendations based on health and safety considerations:

- Provide fire fighters with medical evaluations and clearance to wear self-contained breathing apparatus (SCBA).
- Provide automated external defibrillators (AEDs) as part of the basic life support equipment during physically demanding training.

## INTRODUCTION & METHODS

On September 17, 2005, a 22-year-old male Fire Fighter Trainee died suddenly while performing physical fitness training. NIOSH contacted the affected Fire Academy on July 21, 2006 to obtain further information and to initiate the investigation. On August 28, 2006, a Safety and Occupational Health Specialist from the NIOSH Fire Fighter Fatality Investigation Team traveled to Florida to conduct an on-site investigation of the incident.

During the investigation, NIOSH personnel contacted and interviewed the following people:

- Director of the Fire Academy
- Training instructors
- Trainee's father
- State Fire Marshal's investigator

NIOSH personnel reviewed the following documents:

- Incident report
- State Fire Marshal's investigative report
- Training records
- Standard operating guidelines
- Ambulance report
- Hospital records
- Death certificate
- Autopsy report
- Primary care provider records

## INVESTIGATIVE RESULTS

On September 17, 2005, the Trainee left his home, picked up a classmate at about 0745 hours, and drove to the Fire Academy. En route, the classmate observed the Trainee take "a couple of pills with water." At about 0804 hours, his car ran out of gasoline. The Trainee was observed jogging toward a gas station (while carrying a gas can) and was picked up by another firefighter. The firefighter took the Trainee to a gas station and returned him to his car. The Trainee and his classmate then continued on to the Fire Academy (arriving at 0845 hours), where the Saturday class was due to begin at 0900 hours. Weather conditions that morning included a clear sky with haze, a temperature of 82° Fahrenheit (°F) and 67% relative humidity, giving a heat index temperature of 85.8 °F. [1]

The class of 20 students and four instructors began the day's training activities with a bunker gear donning drill. The drill was a timed event conducted outside for approximately 5 minutes. After that, the students (wearing gym shorts, tee shirts and running shoes) formed two lines, each line carrying a stretched-out section of dry 2½-inch hoseline, and began a slow jog. The hoseline maintained a 5-foot spacing between the students. After making the turn to come back to the training area, a distance of 300-400 yards, the Trainee collapsed (0925 hours). Students called for the instructors to assist and for someone to call 9-1-1. Dispatch, notified by radio and telephone, alerted an ambulance and an engine company (Truck 2), which was located across the street from the Fire Academy.

Instructors arrived within 45 seconds and assessed the Trainee, finding him unresponsive with a weak pulse and shallow breathing with long pauses. Oxygen was administered, but the Trainee soon stopped breathing and became pulseless; CPR (chest compressions and assisted ventilations with a bag-valve-mask) was begun.

Truck 2 arrived on the scene at 0927 hours. Fire Fighter/Emergency Medical Technicians inserted a combi-tube (a breathing tube placed into the trachea) and attached an AED, which advised to deliver a shock. Within the next 5 minutes, five shocks were administered with no positive change in the Trainee's heart rhythm; CPR continued.

The ambulance arrived on the scene at 0934 hours and found the Trainee unresponsive, not breathing, and pulseless with CPR in progress. A cardiac monitor was attached to the Trainee, revealing asystole (no heart beat). An intravenous line was inserted and cardiac resuscitation medications were administered. The Trainee's heart rhythm changed to ventricular fibrillation and a shock was administered. Cardiac pacing was attempted with no electrical capture; his heart rhythm reverted to asystole. CPR continued and additional cardiac resuscitation medications were administered with no positive change in the Trainee's condition. Combi-tube placement was verified by auscultating bilateral breath sounds and end tidal carbon dioxide testing. The Trainee was loaded into the ambulance, which departed the scene at 0946 hours.

The ambulance arrived at the hospital's Emergency Department 8 minutes later (0954 hours). Inside the Emergency Department, the combi-tube was removed and the Trainee was intubated with an endotracheal tube. His rectal temperature was 98.7 °F (normal). Additional cardiac resuscitation medications were given and CPR continued, but no positive change in the Trainee's heart rhythm or condition occurred. At 1015 hours, 50 minutes after the Trainee collapsed, he was pronounced dead by the attending physician; resuscitation measures were discontinued.

Medical Findings. The death certificate and autopsy, completed by the District Medical Examiner, listed "hypertrophic and arteriosclerotic cardiomyopathy" as the cause of death. Pertinent findings from the autopsy, performed on September 18, 2005, included the following:

- Arteriosclerotic cardiovascular disease
- Severe calcific narrowing (95%) of the left anterior descending coronary artery
  - Total noncalcific narrowing (100%) of the right coronary artery
  - Noncalcific narrowing (50%) of the circumflex coronary artery
  - All of the coronary arteries are thick walled and exhibit recanalization
- Hypertrophic cardiomegaly (enlarged heart: heart weighed 600 grams [g] [normal is <400 g])[2]
- Concentric hypertrophy of the left ventricule
- All of the coronary arteries are thick walled and exhibit recanalization
  - Concentric hypertrophy of the left ventricule
- Acute pulmonary edema
- No blood clots in the lungs
- Negative drug and alcohol tests

According to his father, the Trainee was hospitalized as a child and was diagnosed with Kawasaki Disease (described in the Discussion Section below). Medical records for this hospitalization or any subsequent primary care physician medical follow-up were not available to the NIOSH investigator. The Medical Examiner was aware that the Trainee had a history of Kawasaki Disease during childhood, but there was no mention of it on the autopsy report. The Trainee also had a history of high blood pressure but was not prescribed blood pressure-lowering medication. According to witnesses, the Trainee also had a history of asthma, for which he was prescribed an inhaler.

On autopsy, the Trainee weighed 304 pounds and was 72 inches tall, giving him a body mass index of 41.22 kilograms per square meter ($kg/m^2$). A body mass index >30.0 $kg/m^2$ is considered obese;[3] >40.0 $kg/m^2$ is considered extreme obesity.[3] In addition to Kawasaki Disease, the Trainee had three coronary artery disease (CAD) risk factors: male gender, high blood pressure (hypertension), and obesity.

The Trainee worked as a plumber during the day and attended the Fire Academy at night. He had complained of increased fatigue over the 2-3 weeks preceding his death. To combat this fatigue, he had been taking vitamins and caffeine pills. Medical records did not indicate what the dietary supplement was, only that it was a vitamin. There was no evidence that the pill was ephedra, a weight-loss supplement sometimes sold as a "dietary" supplement. Ephedra has been associated with over 90 sudden deaths.[4]

The Trainee had passed his physical agility test and was observed performing physical fitness training 1 week before his death. In addition, he had exercised without difficulty at the Fire Academy fitness center 3 days before his death.

# DESCRIPTION OF THE FIRE ACADEMY

At the time of the NIOSH investigation, this Fire Academy was a State-certified training center and was a division of the County Technical Center. The Academy offers basic firefighting, advanced firefighting, company officer development, and urban search and rescue/technical rescue training programs. The basic firefighting course, also known as the 450-hour minimum standards class, trains the applicant to the Firefighter I, Firefighter II, and First Responder levels. The Trainee was enrolled in the basic firefighting course.

Trainee Selection. The Fire Academy requires all basic firefighting applicants to:

- complete an application
- be at least 18 years of age
- not have been convicted of any felony or of any misdemeanor involving moral turpitude
- possess a valid State driver's license
- possess a high school diploma or equivalent
- pass a medical evaluation within the past 6 months
- be of good moral character
- have hospitalization/accidental medical insurance
- pass a physical agility test

The physical agility test consists of the following:

- Hammer slide: move the weighted block the full length of the sled using a sledgehammer; no time limit.
- Stair climbing: pick up and carry a high rise pack consisting of 100-feet of 1¾-inch hose to the 5 th floor of the training tower.

Then, travel down the interior stairwell to the 3 rd floor, lay down the hose and proceed to the balcony; no time limit.

- Hose hoist: from the 3 rd floor balcony, hoist a rolled section of 2½-inch hose (attached to a rope on the ground) up and over the railing to the balcony, and then lower to the ground. Return to the 3 rd floor and pick up the high rise pack and, using the interior stairwell, return to the ground floor.
- Ladder carry: pick up a 24-foot extension ladder and carry it 25 feet to a ladder rack and place the ladder on the rack, then remove the ladder from the rack and return 25 feet to the starting point; no time limit.
- Rescue dummy drag: drag a 185-pound rescue dummy 120 feet. A rope harness will be attached to the dummy. The drag will be done facing forward, no backing up; no time limit.
- Hose pull: put the end of the 150-foot charged 1¾-inch hose over the shoulder and pull it a distance of 100 feet. There is a 3 minute limit on this station.

The successful applicant is then placed into the 450-hour training program and participates in either the day class or the evening class. Hours for the day class are 0900 hours to 1800 hours, Monday through Thursday, for approximately 12 weeks. Hours for the evening class are 1830 hours to 2230 hours, Monday through Thursday and every Saturday, for approximately 19 weeks. The Trainee passed his physical agility test on August 13, 2005 and was enrolled in the evening Fire Academy class. He was in his 4 th week of training when he died.

Pre-placement Medical Evaluation. A pre-placement medical evaluation is required by the State for all fire fighter candidates. The contents of the evaluation are as follows:

- Complete medical history
- Physical examination
- Vital signs
- Vision screening
- Hearing test (whisper test)
- Urinalysis

- Resting electrocardiogram (EKG)

The candidate's primary care physician performs the medical evaluations and provides the results to the candidate, who provides the information to the Fire Academy, who makes the final determination of clearance for training. The physician is given a description of essential firefighting functions and must complete a State medical evaluation form. Medical clearance for SCBA use is not required. The Trainee completed his pre-placement medical evaluation on July 21, 2005. His weight was listed as 304 pounds and his blood pressure was 149/75 mmHg. An electrocardiogram revealed sinus bradycardia, a slow heart rate of 54 beats per minute. All results were determined by the examining physician to be within normal limits and the Trainee was listed as "medically fit to engage in firefighter training." There was no indication that the physician knew of the Trainee's history of asthma or Kawasaki Disease.

Health/Wellness. Physical fitness training is mandatory and occurs daily, except for the first 2 weeks of training. Exercise equipment (strength and aerobic) is available at the Fire Academy, and trainees are urged to exercise while off-duty.

A return-to-duty medical clearance is required from the trainee's primary care physician for duty-related injuries and non-duty-related illnesses that prevent fire fighters from performing their training. The trainee may sit out one class for a non-debilitating injury or illness without obtaining a medical clearance. All clearances are reviewed by the Fire Academy, who makes the final clearance decision.

## DISCUSSION

Kawasaki Disease. Kawasaki disease, also called Kawasaki syndrome or mucocutaneous lymph node syndrome, is the leading cause of acquired heart disease in children.[5,6] It is an acute systemic vasculitis of unknown cause. It primarily affects children under 5 years of age. It was first described in Japan in 1967 and has been occurring in the United States since at least 1971.[5,7]

The clinical findings in persons with Kawasaki disease are nonspecific and are commonly found in many pediatric infectious and immunologic diseases. Further complicating the diagnosis is the fact that these clinical features may be absent or may evolve over many days after fever onset.[5] The important acute complication is coronary artery aneurysm.[6,8] Although most aneurysms resolve over time, patients can go on to develop coronary artery stenosis, ischemic heart disease, premature atherosclerosis, myocardial infarction, and sudden death.[6,8,9] The findings on the Trainee's autopsy are consistent with these sequalae.

Long-term management of patients with Kawasaki disease includes low-dose aspirin therapy.[5,8] Patients with cardiac complications should be followed regularly with serial echocardiograms, exercise stress tests, and myocardial imaging. Results of these tests will direct the need for coronary angiography and/or surgical transcatheter intervention.[8]

CAD and the Pathophysiology of Sudden Cardiac Death. In the United States, CAD (atherosclerosis) is the most common risk factor for cardiac arrest and sudden cardiac death.[10] The Trainee had severe CAD, but did not report symptoms of angina (e.g., chest pain on exertion) prior to his collapse or in the months/years prior to his death.

Patients with severe CAD are at risk for heart attacks. Heart attacks occur with the sudden development of complete blockage (occlusion) in one or more coronary arteries that have not developed a collateral blood supply.[11] This sudden blockage is primarily due to blood clots (thromboses) forming on the top of atherosclerotic plaques. Blood clots in coronary arteries are initiated by disruption of atherosclerotic plaques. Certain characteristics of the plaques (size, composition of the cap and core, and presence of a local inflammatory process) predispose the plaque to disruption.[11] Disruption then occurs from biomechanical and hemodynamic forces, such as increased blood pressure, increased heart rate, increased catecholamines, and shear forces, which occur during heavy exercise.[12]

Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks.[13-16] The Trainee participated in a bunker gear donning drill and jogging. This is considered a moderate level of physical exertion.[17,18] The physical stress of performing physical fitness training and the Trainee's underlying CAD could have caused a heart attack which caused a heart arrhythmia and sudden cardiac death.

Hypertrophic Cardiomyopathy and Left Ventricular Hypertrophy. The Trainee also had a history of hypertension and cardiac ischemia. These two factors contributed to the development of his hypertrophic cardiomyopathy and left ventricular hypertrophy. Both conditions increase the risk for sudden cardiac death.[19-21] Therefore, the Trainee's sudden cardiac death

could have been due to either a heart attack (as discussed above) or his hypertrophic cardiomyopathy and left ventricular hypertrophy.

Occupational Medical Standards for Structural Fire Fighters. To reduce the risk of sudden cardiac arrest or other incapacitating medical conditions among fire fighters, the NFPA developed NFPA 1582.[22] According to NFPA 1582, the Trainee had several medical conditions which could have precluded him from participating in the Fire Academy: 1) cardiac complications from Kawasaki Disease, 2) hypertrophic cardiomyopathy, 3) left ventricular hypertrophy, and 4) asthma. It is unclear why these conditions were not identified on the Trainee's medical evaluation in July 2005.

## RECOMMENDATIONS

NIOSH investigators offer the following recommendations to potentially prevent similar incidents and to address general safety and health issues:

**Recommendation #1: Ensure thatfire fighters are cleared for duty by a physician knowledgeable about the physical demands of firefighting, the personal protective equipment used by fire fighters, and the various components of NFPA 1582. Encourage fire fighters to provide accurate medical history information to the Fire Department physician.**

Guidance regarding the content and frequency of pre-placement and periodic medical evaluations and examinations for structural fire fighters can be found in NFPA 1582 22 and in the report of the IAFF/IAFC Fire Service Joint Labor Management Wellness/Fitness Initiative.[23]

This medical evaluation could be conducted by the fire fighter's primary care physician. However, the results must be communicated to the State-approved physician, who makes the final determination for clearance for duty.

The Fire Academy provides a medical examination form to the physician conducting the medical evaluation. The form contains a description of essential firefighting functions which students are expected to perform including wearing personal protective equipment that weighs approximately 50 pounds, working in extreme temperatures, climbing ladders, and wearing positive pressure breathing equipment. It is unclear if the physician completing the Trainee's medical clearance was aware of the Trainee's history of Kawasaki Disease in childhood.

Fire fighters should be encouraged to accurately report any medical condition, both past and present, that could hinder their ability to perform fire fighting duties. Had the physician been notified of the Trainee's childhood Kawasaki Disease, asthma, and hypertension, the Trainee could have been referred for further medical follow-up and perhaps precluded from performing such physically demanding tasks as fire fighting and training duties.

**Recommendation #2: Perform pre-placement medical evaluations consistent with NFPA 1582.**

Guidance regarding the content of medical evaluations and examinations for fire fighters can be found in NFPA 1582[22] and in the International Association of Fire Fighters (IAFF)/International Association of Fire Chiefs (IAFC) Fire Service Joint Labor Management Wellness/Fitness Initiative.[23] The Fire Academy is not legally required to follow this guidance.

Although unrelated to this fatality, the Fire Academy should consider these additional recommendations based on health and safety considerations:

**Recommendation #3: Provide fire fighters with medical evaluations and clearance to wear SCBA.**

The Occupational Safety and Health Administration (OSHA)'s Revised Respiratory Protection Standard requires employers to provide medical evaluations and clearance for employees using respiratory protection.[24] Such employees include fire fighters who utilize SCBA in the performance of their duties. These clearance evaluations are required for private industry employees and public employees in States operating OSHA-approved State plans. Florida is not a State-plan State; therefore, public sector employers are not required to comply with OSHA standards. However, the NIOSH investigator recommends voluntary compliance.

**Recommendation #4: Provide AEDs as part of the basic life support equipment during physically demanding training.**

AEDs have caused the cardiac arrest survival rate to increase from 7% (CPR performed only) to 26%.[25] When defibrillation is provided within 5-7 minutes, the survival rate is as high as 49%.[26] To provide emergency medical care, adequate supplies and equipment should be available to treat bleeding, fractures, cardiac arrest, etc.[26,27] Even though a staffed fire station was located just across the street from the Fire Academy, having AEDs available during training would allow the Fire Academy to provide a greater level of emergency medical care to the trainees and instructors. In this incident, the AED was attached to the Trainee within 3 minutes of his collapse. Therefore, it is unlikely this recommendation would have prevented this Trainee's death. We commend the Fire Academy for purchasing an AED after this incident.

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This page was last updated on 11/27/2007.
Page last reviewed: November 18, 2015