1000 FREDERICK LANE, MORGANTOWN, WV 26508 • 304.285.5916

25-Year-Old Recruit Firefighter Dies From Hyperthermia Experienced on First Day of Recruit School – Virginia

Executive Summary

A 25-year-old male career firefighter recruit (FR) collapsed during a physical fitness training run. An instructor, who was running with the FR and his recruit classmates, stopped with the FR and witnessed the collapse. The instructor contacted the dispatch center for emergency medical services (EMS). An ambulance crew was dispatched and arrived to witness the FR deteriorating rapidly with increased shallow respirations and a decreasing level of consciousness. While enroute to the nearest hospital, the FR required respiratory assistance via bag-valve-mask (BVM) and other advanced life support (ALS) measures. On arrival to the emergency department (ED), the FR was intubated and treated for hyperthermia. The FR was admitted to the intensive care unit (ICU) and remained there for 2 days before he died.

The medical examiner's report listed the cause of death as hyperthermia with an enlarged heart and obesity as contributing factors.

Key Recommendations

NIOSH offers the following recommendations to reduce the risk of heart attacks and sudden cardiac arrest among firefighters at this and other fire departments across the country.

- *Key Recommendation #1: Fire departments should ensure all firefighter candidates receive a pre-employment medical examination consistent with National Fire protection Association (NFPA) 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments. Although the FD was compliant with this recommendation and no exclusionary conditions were found in this case, it is being provided here as a reminder of good practice.*
- *Key Recommendation #2: Fire departments should consider refining cadet/recruit communications to clearly state what components are mandatory at the start of their training versus those used as an initial benchmark to measure physical fitness progress over the course of the training program.*
- *Key Recommendation #3: Fire departments should consider providing guidance to incoming cadets/recruits on how to improve their physical fitness capacity prior to the start of their formal firefighter training in a safer, gradual manner to reduce their risks for exertional heat-related illness and/or rhabdomyolysis.*

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- *Key Recommendation #4: Fire departments should consider providing information on heat stroke and other heat related illnesses (HRIs) as part of the materials sent with conditional acceptance letters especially if training start dates will occur in warm or hot weather. Annual refresher training on HRI for training center staff should be provided in early spring immediately prior to hot weather months.*

For further information, visit the program Web site at www.cdc.gov/niosh/fire or call toll free 1-800-CDC-INFO (1-800-232-4636).

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Introduction

On July 1, 2021, a 25-year-old male career firefighter recruit (FR) collapsed after stopping during a physical fitness training run. The FR was initially conscious and alert. An experienced instructor running with the recruit class group who was a certified paramedic, stopped with him and stayed with him until arrival of the medical personnel. During transport his mental status deteriorated, and he went into shock. On arrival to the emergency department (ED) he was intubated and treated for severe hyperthermia, registering a core body temperature of 105.6°F and shock. He was admitted to the intensive care unit (ICU) where he developed disseminated intravascular coagulation (DIC) as a complication of heat stroke and died on July 3, 2021. The U.S. Fire Administration notified the National Institute for Occupational Safety and Health (NIOSH) of this fatality on July 6, 2021. NIOSH contacted the FR's fire department (FD) on July 28, 2021. NIOSH investigators traveled to the FD in April of 2022.

During the investigation, the NIOSH investigator interviewed the following people:

- *Chief*
- *Deputy Chief*
- *Training academy Battalion Chief and staff*
- *Parents and significant other*
- *Recruit school classmates*
- *Medical examiner*
- *Ambulance crew and emergency medical services (EMS personnel)*
- *Fire Marshal*

The NIOSH investigator reviewed the following documents:

- *FD records*
- *EMS patient care report*
- *ED and ICU records*
- *Occupational medical records*

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- *Autopsy report*
- *Death certificate*

Fire Department

The FD responds to approximately 50,000 incidents annually. EMS calls make-up approximately 78% of their call volume. At the time of the NIOSH investigation, the FD consisted of 505 full-time firefighters and officers. Emergency operations maintain a minimum shift staffing level of 125 firefighters. The department operates 4 battalions out of 23 fire stations with 23 engines companies, 6 ladder truck companies, and 19 fire-medic units. Shift supervision includes 1 assistant chief/shift commander, 4 battalion chiefs (BC), and 1 safety officer. Each engine and ladder company are advanced life support (ALS) staffed and equipped. BCs and the safety officer are basic life support (BLS) equipped. The FD serves a population of approximately 370,000 in a geographic area of about 446 square miles.

The fire department has written policies and procedures, which are available to all department members within their stations. These policies and procedures have been implemented, enforced, and include driver safety training, out-of-service criteria for apparatus, safe placement of apparatus, and vehicle maintenance and repair reporting. This FD's policies also cover topics such as health and safety, incident management and response, standard company operations, maintenance and repair, incident reporting, and management and administrative functions.

Membership and Training

Applicants must be at least 18 years of age, have a high school diploma or equivalent, possess a valid driver's license, and be a resident of the state. Potential members complete an application and must pass a written assessment. Candidates are then interviewed by a panel consisting of firefighters, officers, and chief officers. Successful candidates progress to a FD designed physical ability test (PAT). The PAT consists of eight skills stations representing common physical tasks required by firefighters. The first six stations are continuous and timed. A time of seven minutes or less must be achieved to move on to skill stations seven and eight. These last two stations are individually accomplished and are not timed. Contingent offers are made based on a background check and successful completion of a medical evaluation.

Preplacement Medical Evaluations

The FD requires pre-placement medical evaluations for applicants and annual medical evaluations for incumbents. Components of the medical evaluation are consistent with National Fire Protection Association (NFPA) 1582 Standard [NFPA 2022].

Medical evaluations are conducted by an occupational health physician through a local occupational health group contract or the county's employee medical center upon receipt of the conditional offer of employment. The FR received his offer of employment on April 29, 2021 "contingent upon his successful completion of a physical by the department's contracted physician". The FR completed his physical examination on May 13, 2021, while on site as part of an orientation program for his recruit class.

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Wellness/Fitness Programs

The FD has a contract vendor that provides fitness programming. Participation in this programming begins with two voluntary fitness sessions offered to recruits prior to the start of recruit school. The FD has fitness equipment available to firefighters at all 23 stations through the wellness/fitness program offered by the county. The FR participated in 1 of the 2 voluntary fitness sessions offered prior to the start of recruit school. For incumbent firefighters, the FD only requires those currently or who may be assigned to operations to participate in the wellness/fitness program managed by the vendor.

Weather Conditions

The weather was clear, dry, and sunny the day of the incident. A temperature of 79°F was recorded by a mobile device application being used by the lead instructor just prior physical activity that morning. Relatively humidity and dew point numbers were not captured by the FD device that day. On July 1, 2021, at 0800, the National Weather Service (NWS) recorded data from a county airport 3.5 miles from the training location as having an air temperature of 79°F and a dew point of 73°F. The heat index was calculated using the air temperature and dew point calculator from the NWS Heat Index Calculation (noaa.gov) and showed a heat index of 82.3°F.

Investigation

On May 13, 2021, incoming cadets were scheduled to complete mandatory medical exams followed by uniform fittings at a FD building. At the uniform fitting, information about general fitness expectations was verbally communicated by an academy instructor. Through interviews with the recruit class and academy staff, it was found that this was the first time the incoming cadets were made aware of the 2-mile run that was planned to start their first day of physical activity that would occur immediately following the first 3 administrative days of the recruit school. The run was somewhat traditional in nature for FD recruit classes and was changed from a 3-mile run to a 2-mile run several years ago, the exact date or reason for shortening the run was unknown. The recruits would receive the first written communication about the run in an email on May 26, 2021. That communication also included information on the general physicality of the recruit school. This email required an acceptance response which the FR completed. A second written communication was emailed on May 28, 2021, mentioning the run and included information on 2 optional workouts sponsored and administered by physical fitness personnel contracted by the county in April and May 2021. No acceptance response was required by the FD for this second email. The FR attended the April offering only. Neither optional workout included a run of any length.

The 2-mile run course was a loop that began and finished at the training facility, moving along streets and sidewalks in that general vicinity. The lead instructor for the cadre (Instructor 1) would lead the group during the run and set the pace. A second instructor (Instructor 2) was assigned to the rear of the running group to act as an observer and stay back with recruits that fall off the pace. The other two instructors mixed with the group and acted as observers during the run. A FD service van also followed the group carrying a videographer. The van was driven by the FD Recruit school logistics officer. The video was going to be used for a traditional video presentation at recruit graduation to highlight their improvement over the course of their recruit training. The video would start with showing their first attempt at the 2-mile run.

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On Monday, June 28, 2021, the FR reported to the first day of recruit school. The first 3 days of the course were designated administrative and new employee orientation days to complete various FD and County Human Resources' employment paperwork. On Thursday July 1, 2021, at 0730 hours the FR reported to fire department training facility classroom where recruit attendance was accounted. This first day of physical activity for the class would start with a 2-mile run at an approximate 10-minute mile pace. The recruit class gathered in the parking lot and began stretching shortly before 0800 hours. The 4 instructors running with them that morning arrived a short time later and led a more formal stretching and warm-up routine for a few minutes. All recruits were wearing FD issued PT uniform of navy-blue t-shirt and shorts.

The recruit class and the 4 instructors began the 2-mile run at 0804 hours. Noted in the interview with Instructor 1, the first mile of the run marked a 10:00 to 10:10 minute mile pace. The first mile revealed nothing unusual from the FR, nor any of the recruit class as noted by interviews with recruits and instructors. At the approximate 1.4-mile mark, the FR and one other recruit (Recruit 1) were noted to fall off the pace by Instructor 2. This was not an unusual occurrence and Instructor 2 encouraged both recruits to keep up with the rest of the group. Shortly after, at the approximate 1.5-mile mark and 0819 hours, the FR stopped abruptly and fell to his knees. Instructor 2 and Recruit 1 stopped with the FR to investigate the problem and help. The FR tried multiple times to get up and resume running but could not. Recruit 1 was ordered to continue running with the rest of the group by Instructor 2. Instructor 2 reported that the FR's initial complaints were tingling of the hands and feet and his legs feeling tired. Instructor 2 noted that the FR was breathing rapidly although he did not report feeling short of breath. Further questioning of the FR by Instructor 2 would elicit responses from the FR wanting to "collect himself" and a desire to finish the run. The FR would deny chest pain and shortness of breath according to Instructor 2. The FD service van had stopped shortly after seeing the FR drop to his knees. The videographer stayed with Instructor 2 and the FR while the logistics officer left on foot to get emergency medical service (EMS) equipment at the FD training facility that was a short distance away and in view of the location where the FR stopped.

Instructor 2 placed a call to Instructor 1 to update him on the situation. Instructor 2 ended the call and once again focused his attention on the FR. The FR was alert and asked that an ambulance not be called as he wanted to try and finish the run. Once again, an attempt was made to get the FR up on his feet, but he could not bear his weight and collapsed back to the ground. Instructor 2 and the videographer attempted to transfer the FR into the van for transport but were unsuccessful, so the FR was assisted back to the ground. At 0829 hours the FD Emergency Communication Center was contacted, and an ambulance was requested as a jurisdictional "priority 3", which is a non-emergent response.

After FD communications dispatched the ambulance, the FR's level of consciousness declined, and he began to have rapid and shallow respirations. At approximately 0835 two paramedics from the FD training facility arrived at the location of the FR with their equipment, having been alerted by the logistics officer who informed them of the situation when he arrived at the training center to retrieve the EMS equipment. On arriving to the FR's location, the paramedics assumed patient care, performed an initial physical assessment, and applied a cardiac monitor. The dispatched ambulance arrived at 0839 hours. The FR became unresponsive while being packaged for transport. Paramedics attempted intubation while enroute but were unsuccessful, so FR was ventilated using a bag-valve-mask (BVM) throughout the transport. Paramedics also noted the FR to be in shock as he was tachycardic and

hypotensive. One dose of 0.3 milligrams epinephrine was administered intramuscularly enroute to presumptively treat an asthma attack as he had been reported to have had asthma in the past and this was thought to have been a possible cause of his rapid and shallow respirations.

As per protocol, the EMS crew reported to the hospital that the cardiac monitor 12 lead computer interpretation indicated a "STEMI". A STEMI (ST elevated MI) is a type of an acute myocardial infarction (AMI) that is characterized by abnormal elevations of the ST segment of the cardiac tracing. This resulted in the ER staff calling an “AMI (acute myocardial infarction, also known as a heart attack) Alert” so the FR was evaluated by cardiology in the ED. This alert not only ensures prompt evaluation by cardiology but also places other resources such as the cardiac catheterization laboratory, interventional radiology staff, etc. on standby. The cardiologist did not find evidence of an AMI and the alert was cancelled. The elevations of cardiac markers were determined to be due to global hypoperfusion from shock and not a localized blockage in any of the coronary arteries that could cause an AMI.

Upon arrival at the hospital’s Emergency Department (ED) at 0912, FR was noted to be unresponsive with agonal respirations and by 0915 the FR was intubated. He was still hypotensive, and his initial core body temperature was 105.6°F. Multiple vasopressors were started for blood pressure support and cooling measures were initiated with placement of Arctic Sun™ cooling pads, cold saline infusion, and gastric lavage with cold saline. At 1124, the FR was transferred to the ICU with admitting diagnoses of shock due to exertional heat stroke and respiratory failure.

Initial laboratory results revealed that FR was in acute kidney failure, so nephrology was consulted, and hemodialysis was started. Shortly after arrival into the ICU, the FR developed disseminated intravascular coagulation (DIC), a coagulation disorder where clotting factors are rapidly used up that can result in bleeding throughout the body. The FR’s initial head and chest CTs did not show any acute conditions that would account for his refractory shock. Several rounds of blood products and clotting factors were given to address the DIC. The FR was also started on antibiotics in case shock was due to sepsis (bacterial infection that has spread through the bloodstream) but this was subsequently ruled out.

The FR’s core body temperature was monitored via a probe attached to the tip of the Foley catheter placed in the bladder. The FR’s body temperature dropped to 95.7°F by 1855 and active cooling measures were discontinued. His temperature rebounded to 97.1°F at 2100, 97.9°F at 2300, 98.5°F at midnight on 7/2/21, and over the next several hours his core temperature varied between 98.6°F–99.7°F.

The FR remained in shock, DIC, and renal failure. On the afternoon of 7/2/21, the FR developed intra-abdominal hypertension and an emergency surgical decompression was performed. Despite aggressive administration of blood products for DIC, FR continued to have internal bleeding and oozing around his vascular access sites. He remained in kidney failure requiring dialysis and required 4 different medications for blood pressure support. At this point, ICU staff advised the FR’s family of his poor prognosis, and they decided to transition to comfort care. The FR passed the next morning at 0644.

Cause of Death/Autopsy/Medical Findings

The medical examiner listed the cause of death as hyperthermia with contributing factors of cardiomegaly, hepatomegaly with macrovesicular steatosis, and morbid obesity (BMI > 40).

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Discussion

Exertional Heat Stroke

Heat stroke is a clinical diagnosis, meaning that there is no specific test for it. It is a presumed diagnosis when there is any change in mental status while in a hot environment. This mental status change can vary from being confused, having difficulty performing routine tasks, etc. to loss of consciousness, seizures, and death. Although heat stroke is associated with a core body temperature over 40.5°C (104.9°F) this is not a requirement for diagnosis as it can occur at lower core body temperatures. Occurrence of heat stroke indicates the net heat load has exceeded the body's capacity to dissipate heat leading to dysfunction of the central nervous system along with other body systems [Danzl 2022; Garcia et al. 2022]. The net heat load is the total amount of heat the body experiences and can include but is not limited to heat from direct sources such as a fire, ambient heat from the environment, and heat generated by muscles during exertion. The body's primary mechanisms for dissipating heat are evaporative heat loss through sweating and direct heat exchange with the environment via dilating blood vessels under the skin and increasing heart rate to bring blood from the body's core areas with the highest temperature to under the skin surface where heat dissipation to the environment can occur. Although not applicable in this case, the effectiveness of these heat dissipation mechanisms may be disrupted by wearing turnout gear that traps heat. Use of medications/substances that impair these mechanisms such as beta blockers that artificially keep the heart rate down or vasoconstrictors like caffeine that block dilation of peripheral blood vessels. At the time of the initial ambulance dispatch, the FR had not shown any change in mental status as he was awake, speaking with the instructor, and asking to complete the course so heat stroke may not have been considered at that time. However, once his level of responsiveness decreased, it was immediately recognized and appropriately treated.

Exertional heat stroke is the term given to heat stroke where the primary heat load is generated by the body's skeletal muscle as it is engaged in physical activity. Exertional heat stroke in the fire service is a known issue due to the risk factors for it that are inherent to the job i.e., engaging in strenuous physical activities in proximity to a live heat source, engaging in fire suppression activities while wearing 40–60 pounds (lbs) of equipment including heat trapping turnout gear, and depending on geographic location and time of year, engaging in these activities in a hot ambient environment. NIOSH has conducted prior investigations on heat stroke deaths in firefighters during actual fire responses as well as during training events and a few examples are summarized below.

One common misconception is that heat stroke can only occur in hot weather and often the contribution to the net heat load by exertion is underestimated. Fire training academies often compensate for the expected heat generated by exertion by keeping indoor training areas at a cooler temperature but even this intervention cannot completely prevent exertional heat stroke as shown by a 25-year-old cadet who died of exertional heat stroke while engaged in an indoor maze course whose thermostat was set to 66°F. Within 30 minutes of entering the maze in full turnout gear with a self-contained breathing apparatus (SCBA) in place, he became unresponsive, and his PASS alerted. The cadet was immediately removed from the maze and was found to be pulseless and hot to the touch. CPR was started and on arrival to the ED, he was found to have an initial core body temperature of 107.2°F [NIOSH 2018].

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Recruits have died from exertional heat stroke in outdoor based training events as described in the following examples of previous NIOSH investigations:

- 35-year-old collapsed 20 minutes after starting a consumption course held the second week of recruit training course. This course requires cadets to complete 10 firefighting tasks while in full turnout gear and wearing SCBA and is designed to help cadets practice managing their use of supplied air. At that time, the outdoor temperature was 81°F with a relative humidity of 65% resulting in a heat index (how hot it feels when accounting for humidity) of 84°F. The cadet was unable to finish the course after using up his air. He had to be assisted to the rehab area, found to have a decreased level of consciousness and then went into cardiac arrest. CPR was started and on arrival to the ED, he had a core temperature of 103.8°F [NIOSH 2020a]
- 22-year-old recruit collapsed while completing a run at the end of a training day that started at 0700. The training included breaks for rest and lunch. At 1600 with an ambient outdoor temperature of 79°F, an instructor led stretches, "light aerobics", and then took recruits on a 2.5–3-mile run. On arrival to the ED, he had a core body temperature of 108.6°F. He was transferred to the ICU and died nine days later [NIOSH 2006].
- Exertional heat stroke also occurs in wildland firefighters. Due to the remote locations of many wildfires and the locations used to train for these events, prolonged times for transport to definitive medical care often adds to the risk of an adverse outcome. A 29-year-old seasonal wildland firefighter collapsed while on a 1.45-mile hike. The ambient temperature during the hike was 73°F–78°F with 63% relative humidity, resulting in a heat index range of 73°F–78.5°F. This hike went through steep terrain while wearing their Nomex shirts and pants, hardhat helmet, and boots while carrying standard gear weighing approximately 25 lbs. His mental status quickly deteriorated from awake but stumbling and losing his balance to sitting down and not being able to get up, so a helicopter was called to evacuate him for further medical care. He was uncoordinated and could not remove his gear without assistance. The cooling measures his team had available at their remote location included pouring water over his head and using a jacket to create a shaded area. Approximately 70 minutes after starting the hike, this firefighter was described as "breathing but not alert or oriented". The initial air transport team arrived 30 minutes later and initiated advanced resuscitation measures, but he was pronounced dead on arrival at the closest hospital where his core body temperature was recoded as 107°F [NIOSH 2020b].

Although prevention of exertional heat stroke may not be possible, there are ways to reduce its risk including but not limited to:

- Allow an acclimatization period of at least 14 days when moving to/starting outdoor work in a new climate.
- Gradually increase level of exertion through progressive physical fitness training regimens. This will also help reduce the risk of developing rhabdomyolysis, muscle breakdown.
- When possible, avoid concurrent use of substances that can impair the body's heat loss mechanisms such as vasoconstrictors like caffeine, decongestants, etc.

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- Keep up water intake as the body cannot generate adequate sweat for cooling if it is dehydrated.

Other risk exertional heat stroke reduction measures should occur prior to training events on hot environments including:

- Prescreening applicants for conditions and/or use of medications that would place them at increased risk for heat stroke such as use of beta blocker medication or sweat (apocrine) gland dysfunction.
- Having a program plan requires ambient heat and humidity to be assessed when scheduling outdoor training events (i.e., postponing these training events when the heat index reaches a certain value) and a clear outline of what heat indices may result in rescheduling the outdoor activity due to the heat.
- Schedule outdoor training events for early morning or late evening
- Ensuring all staff are aware of protocol to follow when heat stroke is identified that includes immediate initiation of cooling measures and notification of EMS either through use of standby units or calling 911 [NIOSH 2016, 2019, 2022].

Early identification of heat stroke signs and symptoms is crucial so that cooling measures can be started, and medical interventions can be initiated promptly. The buddy system facilitates this early identification of heat stress by deliberately assigning pairs to watch over each other. While it is helpful to have instructors keep an eye on a group of trainees, the ability to spot early heat stroke may be limited in that situation. In this case, the FR had remained with the instructor in the back of the group for the entire run so the instructor was able to quickly note when he began to have difficulty.

Discussions with FR's family revealed that he had been working on slowly building up his run capacity in the weeks preceding the start of his training course. As part of his application to the FD's training course, the FR underwent a medical evaluation as outlined by the NFPA 1582 standard which would have addressed the components of a medical screening for conditions that would place him at increased risk for heat-related illness (HRI). The only findings noted was slight elevation of his creatinine, a measure or kidney function, and Hemoglobin A1c, a marker for long-term glucose control. These items were noted to be followed-up but did not reach exclusionary levels.

During the interviews we inquired about intake of energy drinks prior to the run but none of his classmates could confirm if the FR drank any of these products that day. These energy drinks contain a high amount of caffeine and may have impaired his ability to dissipate heat generated by his muscles during the run due to their vasoconstrictive effects.

Documents provided by the FD showed that they did have a heat monitoring process as part of their operations procedure, and this included clear work/rest times for various environmental conditions along with cutoffs where all outdoor training activities would be cancelled.

Identification of heat stroke should prompt immediate initiation of cooling measures such as:

- Removing individual from the hot environment to a cooler one with air conditioning if possible or by providing a shaded area if there is no indoor air-conditioned facility nearby.

- Removing excess clothing.
- If the individual is awake and alert, encourage them to drink cool liquids. However, if heat stroke has resulted in an individual being somnolent/difficult to rouse, do NOT attempt to give them fluids orally as this may result in the fluid going into their lungs (aspiration) instead of down their esophagus. Aspiration pneumonia itself can be fatal.
- Encourage evaporative heat loss by pouring water on patient or using misting fans.
- Ice packs to neck, axilla, and groin or immersion in a cold water or ice bath [NIOSH 2022; Santinelli et al. 2014].

EMS personnel may initiate cooling measures such as cooled saline administered intravenously and on arrival to a hospital, other measures such as gastric lavage (rinsing the stomach via nasogastric tube) with cooled saline and placement of a cooling system such as the Arctic Sun™ used in this case which pumps chilled water through pads placed around the patient's chest, abdomen, and thighs to achieve a preset core body temperature via automated feedback from a core body temperature sensor [BD 2021].

Potential Consequences of Heat Stroke: Shock, DIC, Kidney failure, and Intra-abdominal hypertension

Shock is defined as "a state of insufficient perfusion and oxygen delivery to the tissues" [Wacker and Winters 2014]. The circulatory system delivers oxygenated blood and nutrients to all the tissues in our body and can be compared to a closed system containing a pump (the heart), a tank (volume contained within the system), and the pipes (blood vessels). Failure of any one or a combination of the components can result in shock which if not corrected, can result in death. Treatment of shock depends on its cause [Richards and Wilcox 2014]. Measures of shock include a systolic blood pressure < 90 millimeters of mercury (mmHg) and the FR was already in shock by the time EMS made first contact with him and he remained so despite being given IV fluids and multiple medications to raise his blood pressure.

Heat stroke can result in shock through 2 different types of dysfunctions involving the tank: loss of intravascular volume due to sweating and due to bleeding from a condition called disseminated intravascular coagulation (DIC). DIC has been a recognized as a potential complication of heat stroke for over 60 years, but it has remained a difficult condition to treat [Meikle and Graybill 1967]. It is a condition of refractory bleeding that results when the body quickly uses up its available clotting factors and cannot replace them at all or fast enough to stop internal bleeding. One mechanism proposed for heat stroke-related DIC is that heat damage to the liver, where many of the clotting factors and proteins are produced, can contribute to the difficulty of treating this condition resulting in continued need for the patient to be given these clotting factors along with the blood to replace what they are losing [Matsumoto et al. 2019; Mustafa et al. 1985]. DIC measures along with markers of liver and kidney damage can predict survival in patients with exertional heat stroke and the worse these markers are, the lower the chances of survival [Liu et al. 2022].

It was noted that on arrival to the ED, the FR showed severe damage to his kidneys and was not making any urine even with fluid resuscitation. He was immediately started on hemodialysis, the process where machines perform the blood filtration function for kidneys that are not working properly. It is estimated about 30% of patients with exertional heat stroke may present with kidney

failure due to acute tubular necrosis or direct heat damage to the kidney's filtration structures in combination with decreased blood flow to the kidneys due to shock. Kidney damage in heat stroke may be compounded by rhabdomyolysis, breakdown of skeletal muscle that can release substances toxic to the kidneys. but there is no evidence that rhabdomyolysis played a role in the FR's situation [Department of the Army 2022; Kruijt et al. 2023; Wolfson 2017].

The FR developed a third reason for shock involving a tank issue likely due to a pipe problem. Sometimes during resuscitations in patients with certain underlying causes of their shock that require the administration of a high volume of fluids (saline, blood, clotting factors, etc.), blood vessels can become "leaky" causing fluid to build up in the tissues surrounding them resulting in localized swelling, also called edema. If this occurs in the abdomen, it can lead to abdominal compartment syndrome where the pressure inside the abdomen rises higher that the pressure of the blood trying to enter the abdomen. In this situation the "tank" appears empty to the abdominal organs resulting in loss of blood supply to the abdomen and all its organs such as the gut, liver, pancreas, and kidneys [Khorsand et al. 2023; Rogers and Garcia 2018].

Progressive Conditioning

The FR would eventually succumb to an event that hospitalized him on day one of physical activity in recruit school. This event calls for identifying possible contributing factors associated with "preparation" for firefighting training. The FD's department policies and culture associated with wellness and fitness for day-to-day employment are progressive and informative. FD documents provided to accepted recruit candidates clearly call for run preparation but give no guidance on how to go about this is a safe manner. The hiring process of this FD does not require an applicant to complete a run of any distance, so FD staff have never seen any recruit run prior to this traditional 2-mile run. This contrasts with other departments that require applicants to complete a fitness test as part of the application process which for some, does include a run. In addition to the physical preparation distance running takes, the tone of the communication of the run does seem to create some stress/angst among recruits and there appeared to be some confusion on the consequences of not being able to complete the 2-mile run on their first attempt. Additional clarity regarding the run could alleviate some of that stress.

Although the FD offered 2 voluntary fitness sessions leading up to the start of the training course, progressive conditioning programs starting at least 3-4 months prior to first run of recruit school could provide recruits additional guidance on engaging in a safer, gradual increase to the length and intensity of their physical fitness training. Examples of these include the Indiana Law Enforcement Academy training plan developed by early studies in the Cooper Institute, TX which provides a schedule for recruits to follow over a 12-week period to prepare for a 1.5 mile run. This schedule assumes a start from a sedentary lifestyle and begins with walking intervals that slowly increase to completing the distance at a running pace. Exercise physiologists have been utilized by FDs to help design physical fitness programs for incumbents and can also be a resource to provide safe training information to recruits [NIOSH 2019].

Contributing Factors

Occupational injuries and fatalities are often the result of one or more contributing factors or key events in a larger sequence of events that ultimately result in the injury or fatality. As in many cases of

heat stroke, it is unclear as to why the FR incurred this injury that led to his death when he had been slowly training for the run, the FD had been appropriately monitoring environmental conditions leading up to the run, staff quickly identified the occurrence of heat stroke in the FR, and immediately obtained medical assistance. Although there is no evidence that the following recommendations would have prevented this fatality, they are being provided as a reminder of a good practice.

Recommendations

Recommendation #1: Fire departments should ensure all firefighter candidates receive a pre-employment medical examination consistent with National Fire protection Association (NFPA) 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments.

Discussion: NIOSH recommends that all new and incumbent personnel participate in annual medical evaluations to determine that personnel are healthy enough to participate in strenuous activity and to identify potential injuries or illnesses. Guidance regarding the content and frequency of the medical evaluations for firefighters can be found in Chapter 7 of NFPA 1582. The FR had a pre-employment medical evaluation consistent with NFPA 1582 on May 13, 2021, which was reviewed by the FD's occupational medicine director, a board-certified occupational medicine physician, and found that there were no exclusionary conditions noted.

Recommendation #2: Fire departments should consider how communications may be received/interpreted by cadets/recruits and be clear on what components are mandatory at the start of their training versus those used as an initial benchmark to measure physical fitness progress over the course of the training program.

Discussion: Interviews with FR's family and classmates indicate that he and possibly others may have interpreted the communications from the FD regarding the 2-mile run as its completion being mandatory on their first attempt in order to stay in the FD's training program. This was in contrast to discussions with training program staff who stated that first attempt at the 2-mile run was used as a benchmark to demonstrate their physical fitness improvement over the course of the training program by comparing the time of their initial attempt to their run time tested again at the end of the training program. Staff related that recruits would not be removed from the training program if they were unable to complete the initial attempt at the 2-mile run at the pace set by the instructors. The letter dated May 26, 2021, that the FR received from the FD regarding the training program stated "Be prepared to run at least 2 miles, two days a week at a pace of 9 minutes per mile" but did not mention if there were consequences of not being able to do so. Consider adding language to clarify that failure to complete the initial run at the set pace would not result in removal from the training program but they may be encouraged to work with the FD training staff to improve this aspect of their physical fitness regimen.

Recommendation #3: Fire departments should consider providing guidance to incoming cadets/recruits on how to improve their physical fitness capacity prior to the start of their formal firefighter training in a safer, gradual manner versus more abrupt methods, such as bootcamps, that may incur risks for exertional heat-related illness and/or rhabdomyolysis.

Discussion: This FD had a physical training vendor that conducted the 2 voluntary fitness sessions held before the start of the training course. This vendor also provided incoming recruits a class on nutrition

during the pre-training period. FD staff reported that the training course is designed with the emergency medical technician (EMT) certification course taking place in the first 2 months of the course to provide some extra buffer time for recruits to improve their physical fitness as the EMT course is primary classwork with "minimal physical activity". The FD may consider having the vendor develop personalized training programs for the recruits once they receive their conditional acceptance letter and have them actively engage with the recruits during the EMT course to assess progress and offer tailored recommendations to assist them in their fitness goals.

Recommendation #4: Fire departments should consider providing information on heat stroke and other HRIs as part of the materials sent with conditional acceptance letters especially if training start dates will be occurring in the spring and summer. Refresher training on HRI for training center staff could also be provided at this time.

Discussion: Providing this guidance early on will ensure candidates will be aware of HRI risk factors they can avoid or minimize while engaging in their own physical fitness preparation in advance of starting the FD training. The FD could utilize pre-existing material such as this NIOSH publication Heat Stress: Risk Factors (cdc.gov). This information sheet also includes a reminder that identification of heat stroke should prompt a 911 call for urgent transport to a facility that can provide definitive care. In addition, the FD should advise recruits and incumbents to limit their intake of high caffeine content products as to not impede the body's heat dissipation mechanisms prior to any training or fire response activities.

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25-Year-Old Recruit Firefighter Dies From Hyperthermia Experienced on First Day of Recruit School – Virginia

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Investigator Information

This incident was investigated by the NIOSH Fire Fighter Fatality Investigation and Prevention Program's Medical Team based in the Division of Field Studies and Engineering in Cincinnati, Ohio. This investigation was conducted and this report was co-authored by Judith Eisenberg MD, MS, and Mr. Rob Saunders. Dr. Eisenberg is a board-certified Emergency Medicine physician and Rob Saunders is a Technical Information Specialist. Mr. Saunders retired after 31 years with the Pike Township Fire Department, Indianapolis, Indiana. In addition to having served as a firefighter, paramedic, heavy rescue technician, and rescue diver, he has held the positions of company officer, Division Chief of Emergency Medical Services, Deputy Chief of Operations, and Fire Chief.

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