Fireground Rehab Evaluation (FIRE) Trial

Executive Summary

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*Background & Introduction*

For two years, researchers at the University of Pittsburgh Department of Emergency Medicine Emergency Responder Human Performance Laboratory (ERHPL) studied two crucial components of on scene rehabilitation, hydration and cooling, in order to decrease the short and long term negative health effects working on the fire scene may have on the firefighter.

It is readily apparent to most firefighters and to the general public that firefighting is an inherently dangerous profession. What is not so obvious is the fact that the greatest harm to these public safety professionals does not come from the slips, trips, falls, or burns that are the obvious dangers to the firefighters, but instead are from sudden cardiac death (SCD) that is precipitated by the extreme physiological stress induced while working in thermal protective clothing. Firefighters get extremely hot, dehydrated, and must work at their cardiovascular limits when fighting fires in thermal protective equipment. The gear that is designed to prevent harm from the environment, ultimately places a significant amount of weight (40-50 lbs) that needs to be carried creating additional work, and does not let out the internal heat that is generated by the working firefighter. This combination of extra cardiac strain, high temperature, and dehydration can lead to several severe medical conditions, such as heat stroke and SCD, and to the potential for long term risks for other medical conditions, such as heart disease and stroke.

Since these internal conditions are known to exist during and after firefighter activities at the scene, it is very important to decrease the chance that the hyperthermia and inflammation initiated during the work are mitigated as soon as possible. The most rational approach to doing this is to ensure that on scene rehabilitation is initiated, and utilizes the best available rehabilitation methods based on scientific research performed on firefighters for firefighters.

Therefore, we sought to provide evidence-based guidance through the FIRE Trial. We investigated multiple methods to hydrate and cool firefighters during a simulated rehabilitation period following work in thermal protective clothing at the ERHPL.
**FIRE I – A study on hydration**

During this laboratory phase of the study, it was our goal to identify the best fluid for hydration during a 20-minute rehabilitation period and also determine the best route (oral vs intravenous) of administration to not only return a firefighter to physiological normal parameters, but to see if when returned to work, which fluid and route of administration allowed the firefighter to work the longest.

We chose water and a sports drink due to availability and current use within the fire service. The possible routes of administration were oral, for the water or sports drink, and intravenous, for normal saline fluid used to directly expand the blood volume.

Initially, hydration with water, sports drink, and intravenous fluid were deployed during the simulated rehabilitation period to see which one improved all the physiological derangements that occurred during the work. These negative effects included increased heart rate, high body core temperature, and subjective sensation of comfort.

Despite all the potential benefits of each hydration method, after the initial portion of the trial, it was determined that *no method of hydration was better than another when fluid was replaced kilogram for kilogram, ounce for ounce* to return heart rate below 100 beats per minute. Furthermore, all groups cooled equally but incompletely at the end of the 20-minute rehab period. This means that hydration with ANY fluid is going to get the firefighter where they need to be, hydrated and comfortable. It is also important to be sure firefighters drink enough fluid during rehab. In both our field and lab studies, firefighters lose nearly one liter of body water from sweating. In some conditions this amount may be higher.

For the second analysis of the hydration trial, we wanted to determine if the different hydration methods improved the firefighters’ performance on a second bout of work. Potentially resting and hydrating well should make the firefighter better able to handle going back into the fire for a second round of work. Again, despite the potential benefits for each method of hydration, no one method helped the firefighter work harder or longer during the bout of work that followed rehab.

Although this again supports the use of any fluid for hydration during rehab, an interesting and unexpected finding to come out of the FIRE I trial was that despite providing full rehydration before the trial and during rehab, no firefighter could complete the 50-minute, heavy work load representing “2 cylinders before rehab” on either bout of work. Furthermore, no firefighter returned to a baseline temperature after 20-minutes of rest in spite of receiving full rehydration and removing their turnout gear.

Our conclusions from the FIRE I trial are simple.

- Hydration is important, but the route of administration and the type of fluid is less important than making sure the firefighter takes in at least the same amount of fluid they lost from sweat.
Total fluid replacement is best assured by making sure firefighters have accurate weights before and after work, and then fluid losses can be determined exactly. Since this may not be possible on the scene, a rule of thumb of at least 20 – 34 ounces (0.6 – 1.0 liters) of fluid should be consumed after two cylinders of work. Another 20-34 ounces should be consumed after returning to quarters.

Twenty minutes may not be sufficient to assure complete return to baseline vital signs and temperature. Firefighters should be closely monitored for signs of heat stress.

Furthermore, due to the inability to complete the “2 cylinders before rehab” of simulated heavy work in laboratory, it may be necessary to shorten the work limits of firefighters on scene to ensure that work periods are not excessive and will not push firefighters over their physiological edge.

**FIRE II – A study on cooling**

During this laboratory phase of the study, it was our goal to study the best cooling technique to employ during a 20-minute rehabilitation period to not only return a firefighter to physiological normal parameters, but to see if when returned to work, which method allowed the firefighter to work the longest.

We chose six methods that are either currently employed by the fire service, or have been developed for possible use in the fire service for cooling at the scene. The methods can either be performed without devices or uses a commercially available device or technique that has been designed for use by firefighters.

The six methods included: (Passive technique) 1. passive cooling in a 75°F (24°C) room, (Active techniques) 2. fan, 3. forearm immersion in cool water, 4. hand cooling grip device, 5. intravenous infusion of cold (4°C) normal saline, and 6. A cooling vest with continuous ice water infusion.

All of the devices had pros and cons for the fire service in terms of ease of deployment, cost, complexity of maintenance, and overall comfort. The most invasive and complex technique was the IV cold saline administration that requires an EMS personnel to provide the venous access, the availability of cold saline, and the ability to monitor the patient’s temperature accurately so not to over shoot the goal of normal body temperature. The easiest was the passive cooling in the moderate temperature room that can be created through the use of air-conditioned vehicles or portable shelters. Many devices required electricity or large amount of ice to operate. Additionally, cost should be considered when deciding to purchase a cooling device for fireground rehab. Will you have enough devices to handle all the firefighters reporting to the rehab sector?

At the end of the first bout of work, the firefighters removed their turnout gear, were cooled with each technique, and then put back to work. The vital signs of interest for determining the success of cooling were the core temperature and heart rate monitoring. The work parameters of interest were the ability to do a second bout of work, and how they could last.

Although some small advantages were shown for IV cooling, forearm immersion, and hand cooling, the study showed that, with the simulated bouts of work and 20-minute rehab periods, no single type of active cooling technique was better than the cooling effect of placing the firefighter in a moderate temperature room. *The overall rate and magnitude of cooling did not differ among the six cooling modalities nor did any technique return the firefighter to baseline temperature in 20 minutes* (see figure). The moderate temperature for passive cooling can be created in the lab very easily, but can also be transported to the scene for firefighter rehab by way of a public bus, or large air conditioned fire truck cab.

IV cooling may have the greatest promise to reduce core temperature if a large enough volume is administered. However, cold saline is very uncomfortable for hyperthermic
firefighters to receive. However, by the end of the rehabilitation time (20 minutes), all the devices and techniques eventually caught up. The fan seemed to be the most comfortable and preferred by the firefighters overall, but again, did not to have a cooling advantage over the other methods.

In summary, the FIRE II cooling study demonstrated that:

- The active and passive cooling methods we chose for the study appeared to be equally effective in reducing most of the most vital signs during the allowed rehabilitation period.
- None of the cooling techniques actually brought the core temperature back to baseline during the 20-minute rehabilitation period. This means that despite aggressive and appropriate use of...
the commercially available techniques, some, if not all firefighters may still be hot when they leave rehab despite using these techniques. This emphasizes the need to be able to monitor the temperature of the firefighters at all times in order to know when they are cool enough to return to the fire.

- The passive cooling environment created in the laboratory may be brought to the field by using air-conditioned vehicles (e.g. large ambulance, bus) or a portable shelter allowing larger numbers of firefighters to remove their turnout gear and receive rehydration and rehabilitation.

The results of the FIRE II Trial were published as: D Hostler, SE Reis, JC Bednez, S Kerin, J Suyama. Comparison of active cooling devices to passive cooling for rehabilitation of firefighters performing exercise in thermal protective clothing: A report from the Fireground Rehab Evaluation (FIRE) trial. Prehospital Emergency Care 14(3): 300-309, 2010

**How to implement fireground rehab**

Fire departments should conduct a careful needs analysis before developing fireground rehab policies and procedures. What are the environmental conditions that you typically face? If temperatures routinely exceed 80 degrees, it will be important to deploy some form of active cooling or have an air-conditioned vehicle available for rehab. An inexpensive, easily deployed alternative for active cooling is to bring 5-gallon buckets of cold water to the rehab sector. Firefighters can sit in a low chair or kneel between buckets and immerse their hands and forearms to create conductive cooling.

If conditions are moderate (cool temperature and low humidity), or an air-conditioned vehicle is available, then passive cooling is acceptable. However, firefighters must remove their turnout coats, helmets, gloves, and be seated to allow for proper recovery. Failure to remove protective clothing will inhibit cooling.

Rehydration is a critical component of fireground rehab. Any fluid can be used for recovery if it is consumed in sufficient quantity. Bottled water should be placed on every emergency apparatus to ensure it is immediately available at an incident. Firefighters often do not realize how much fluid they have lost and should be encouraged to consume as much as they comfortably can.

Finally, fireground rehab must continue even after the incident concludes. Firefighters will not return to baseline heart rate or body core temperature while at the incident. Continued rehydration and recovery time in an air-conditioned structure should be part of the plan to return to service.

In summary, **full rehydration and either active cooling or passive cooling in a moderate temperature are required to partially restore** the firefighter to baseline conditions following work in thermal protective clothing. Additionally measures will be required at the end of the incident to prepare the firefighter for the next incident. A 20-minute rehab
period is likely the minimum and most firefighters would benefit from longer rehab periods when performing heavy work or working in extremes of temperature and humidity. Incident commanders should take this into account when considering the personnel requirements of a particular incident.

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