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Forensic Response Operations and Heat Stress

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Abstract

Exposure to heat stress is one growing concern with regard to scene safety for the forensic practitioner. Elevated ambient temperatures combined with impermeable personal protective equipment and clothing at crime scenes make conditions ripe for employee overexposure to heat. The purpose of this paper is to define and identify sources of heat stress while discussing the importance of protecting the forensic response practitioner from overexposure. Methods to prevent and detect potential heat stress situations along with techniques which can be used to manage work-related heat stress have been investigated in an effort to provide a comprehensive framework for instituting a heat-related illness prevention program.

Investigative efforts found forensic response personnel are potentially exposed to environmental and metabolic sources which could result in a heat-related illness. Medical surveillance, acclimatization, instituting work/rest cycles, and utilizing core body cooling tools among others were identified as successful prevention strategies against heat stress.

The forensic response practitioner may perform his/her job tasks under a number of challenging conditions, yet must maintain the highest level of accuracy. Heat stress like any factor having the potential to influence job performance, should be addressed, evaluated and prevented in an effort to maintain the utmost confidence in all forensic investigation outcomes. The implementation of a comprehensive heat-related illness prevention program can help to achieve these objectives.

Keywords: *Forensic science; Forensic response; Crime scene response; Heat-shock response; Heat stress; Heat-related illness prevention program*

Introduction

The Federal Bureau of Investigation (FBI) is a worldwide organization with 56 field offices throughout the United States. The FBI has a responsibility to investigate violations of certain Federal laws, as well as serving and executing search and arrest warrants issued by a judge. While each field office maintains an Evidence Response Team (ERT), 24 of the 56 field offices also maintain Hazardous Evidence Response Teams (HERT). ERT personnel are often requested to support the execution of search warrants to search for, collect, and transport traditional evidence. HERT personnel use advanced personnel protective equipment to collect hazardous [chemical, biological, radiological, and nuclear (CBRN)] evidence or traditional evidence contaminated with these materials. The majority of the ERT and HERT personnel serve in these functions as a collateral duty; however they are specially trained to perform these functions.

The FBI Laboratory maintains an advanced forensic response capability for processing exceptionally hazardous or complex crime scenes. Personnel include evidence collection experts, operations and safety personnel, and scientists. Laboratory personnel will deploy to any location to provide expert support in processing crime scenes. Collectively, the FBI Laboratory, ERT, and HERT personnel are termed forensic response personnel.

The FBI forensic response personnel often work in climates and conditions that expose them to excessive heat, such as direct sun exposure, hot environments, and wearing personal protective equipment. The objectives of this research is to:

• identify measures that safety personnel can use to assess for heat stress;

• prevent and manage heat stress to forensic response personnel;
• evaluate techniques and devices that can detect early onset signs and symptoms of heat stress;
• explore options to manage heat stress risks once personnel exhibit signs and symptoms of exposure; and
• create a framework that can be used for the development of a comprehensive heat stress reduction program for forensic response personnel.

Heat Stress

Heat stress is a broad term used to describe a collection of illnesses caused by the body's exposure to heat. Heat-related illnesses can be divided into four main types (in order of lowest to highest concern): heat rash, heat cramps, heat exhaustion, and heat stroke (Table 1). Additionally, a worker who is directly exposed to the sun's rays may experience sunburn on unprotected skin [1]. Heat stress can also "contribute to low morale, irritability and fatigue, all of which can lead to taking shortcuts or skipping procedures. All of these can in turn create a safety hazard" [2]. Between 2008 and 2014, the Occupational Safety and Health Administration (OSHA) received 109 heat-related fatality reports with regard to the nation's total workforce [2].

Signs and Symptoms	Treatment
Heat Rash	
Red clusters of small blisters that resemble pimples on the skin	Stay in a cool, dry place Keep rash dry Use powder, like baby powder, to soothe the rash
Heat Cramps	
Heavy sweating during intense work Muscle pain or spasm	Stop physical activity and move to cool place Drink water or sports drink with electrolyte replacement Wait for cramps to go away before doing any more physical activity
Heat Exhaustion	
Heavy sweating; cold, pale, and clammy skin Fast, weak pulse Nausea or vomiting Muscle cramps Dizziness, headache, tiredness	Move to a cool place Loosen clothing Put cool, wet cloths on the body or take a cool bath Sip water
Heat Stroke	
High body temperature; Hot, red, dry or damp skin Fast, strong pulse Nausea or vomiting Dizziness, headache, tiredness Confusion, loss of consciousness	Call 911 – heat stroke is a true emergency Move person to a cooler place Help lower the person's body temperature with cool cloths or a cool bath Do not give the person anything to drink

Note. From Center for Disease Control and Prevention. (2017). Heat-related illnesses. (1)
Table 1: Signs, Symptoms, and Treatment of Heat-Related Illnesses

Sources of heat stress

Forensic response personnel may be exposed to a number of different sources that can cause heat stress. "Physical work, high ambient temperature and wearing protective clothing can elevate body temperature and cardiovascular strain sufficiently to degrade performance and induce heat-related illness" [3]. Workers, supervisors, and safety personnel must first recognize heat stress sources before they can prevent, detect, and manage worker exposures.

Environmental heat sources

Outdoor air temperature can vary greatly throughout the United States. Forensic response personnel may be called to very hot and humid climates to perform their activities. These high-temperature climates can significantly increase heat stress to the forensic responder. This is even more of a concern when the specific responder is not acclimated to the particular high-temperature environment. However, there is still a risk of heat stress in temperate climates. "The risk of heat stress should not be underestimated in temperate regions, especially when dealing with unacclimatized workers being exposed to heat waves" [4]. It may be necessary to process a crime scene in the middle of a heat wave in a generally temperate climate.

Metabolic heat sources

During work, the body generates heat through metabolism. Higher levels of work produce more heat within the

body. The metabolic equivalent task (MET) is a measure used to estimate the amount of intensity with regard to physical activity. One MET is the amount of energy expended when a worker is sitting quietly. Generic MET values are assigned to different occupations. Crossing guards are assigned a MET value of 2.0, firefighters are assigned a MET value of 5.0, and steel workers are assigned a MET value of 7.5 [5]. The higher the MET value of a task, the more strenuous the activity, which contributes to a higher risk of heat stress. Performing forensic operations involves extensive hand manipulations, occasionally lifting heavy objects and working in personal protective equipment. While there is no specific MET value assigned to a forensic responder, the activities of an electrician (MET value of 3.0) closely resembles typical forensic response workload. However, certain operations like line searching in a landfill will increase the forensic operators working MET value.

Heat loss barriers

During traditional ERT forensic operations, personnel wear coveralls, one or more pairs of gloves, and boot covers. These coverings not only protect the forensic responders from incidental contact with scene contaminates, it also reduces the likelihood that they contaminate scenes with their DNA, fingerprints, hairs, and clothing fibers. While processing hazardous crime scenes, HERT personnel use higher levels of chemical protective clothing and respirators to protect themselves from CBRN hazards. Many of the HERT protective clothing is impermeable. In both ERT and HERT operations, the use of protective clothing increases worker heat burden, increases sweating, and restricts the skin's ability to evaporate perspiration, all of which increase the risk of heat stress [3].

Prevention of Heat Stress

The preferred method to mitigate heat stress is to prevent excessive heat exposure to forensic response personnel. Often, more than one preventative measure is necessary to reduce the heat stress risk to an acceptable level. The Occupational Safety and Health Administration [6] recommends three things employers can do to prevent heat illness: establish a comprehensive heat illness prevention program, provide training to supervisors and employees about the hazards of heat stress and how to prevent them, and provide adequate cool water for workers near the work area. This section will explore a number of different strategies aimed at preventing heat related illnesses in forensic response personnel.

Medical Surveillance

It is important to ensure that employees are medically able to perform work where heat stress is possible. There are a number of medical conditions that can increase the likelihood or severity of heat stress. Some include obesity, cardiac ailments, and diabetes. Certain medications can also increase a worker's risk for heat-related illness. Some medications can increase heart rate, increase sweating, dilate blood vessels, or cause an electrolyte imbalance [7]. These conditions can usually be identified during routine medical surveillance screenings. This also allows a physician or other licensed healthcare provider to render an informed opinion about a particular worker's fit for work where the risk for heat stress may be present.

All ERT and HERT personnel must complete routine medical surveillance requirements. The specific content, frequency, and action thresholds vary based on function, such as special agent or professional staff. However, all types of medical surveillance should include screening for heat stress risk factors.

Job Planning

Crime scene operations may be categorized as spontaneous or planned. Spontaneous events, such as the Boston Marathon Bombing, do not allow for discretionary time to provide proper planning to reduce heat stress risks. Often decisions about worker health and safety are made quickly and usually in response to a threat that is suddenly encountered. Usually, it takes eight hours to a day or more to start proactive planning.

The service of a search warrant and similar planned events often have some amount of discretionary time to perform a thorough risk assessment and consider the concern of heat stress. When supervisors or safety personnel determine the risk of heat stress is unacceptable, they can then implement one or more actions to reduce the risk of heat stress. These planning elements are designed to prevent heat stress in forensic response personnel.

Employee medical monitoring plan

While medical surveillance is performed well in advance of an employee working in hot environments, medical monitoring occurs within 24 hours of work at a specific scene (usually within hours of the work). Medical monitoring

can identify the current health status of a specific worker and address specific problems medical surveillance may miss. For example, medical monitoring may identify a worker who is suffering the common cold and is taking over the counter medications. This condition may place them at higher risk to suffer a heat related illness or emergency than what was identified during their medical surveillance physical. Medical monitoring ensures a particular employee is fit for work just before the work is to commence. A properly trained paramedic can perform this screening function and provide recommendations for specific employees to their supervisor or site leader. Implementing medical monitoring at a particular site is an essential part of the job planning process.

Acclimatization

Garvey [2] states, "acclimatization can be critical to worker safety". He further states most people can acclimate in 7 to 10 days. It is generally not feasible to provide worker acclimatization during the initial stages of a spontaneous event. However, when a planned event is scheduled to take a week or more to complete, worker acclimatization is another tool employers can use to prepare their workers for hot environments. Forensic response personnel can deploy to the general geographical location of the anticipated work several days in advance of the work and undergo conditioning exercises, like running, jogging, or other tasks to prepare their bodies for work in that particular climate. While 7 to 10 days of acclimation is not always feasible, even a few days of acclimatization for short term work is beneficial [4].

Work/rest cycles

OSHA and the National Institute for Occupational Safety and Health (NIOSH) both recommend workers take frequent breaks to prevent heat-related illness [2,6]. Breaks allow the body time to reduce the metabolic load, offload excessive heat, and provide the worker a chance to rehydrate with fluids [2]. Several charts are available that use the wet bulb globe temperature (WBGT) to determine proper work/rest cycles.

The WBGT is an adjusted ambient temperature used as an assessment tool for heat stress. The measure takes into account four different atmospheric attributes: temperature, humidity, wind speed, and radiant heat. This tool is widely used and is referenced in a number of standards, including the International Organization for Standard (ISO) 7243 Ergonomics of the Thermal Environment–Assessment of Heat Stress using the WBGT Index [8]. Table 2 presents the American Conference of Governmental Industrial Hygienists' (ACGIH) screening criteria for threshold limit values (TLV) used to evaluate the potential for heat stress based on WBGT, workload and work/reset regimen as adopted by OSHA and NIOSH. Supervisors and safety personnel should consult this table when planning work, taking into account these non-working rest periods.

%Work	Workload			
	Light	Moderate	Heavy*	Very Heavy*
75 to 100% (continuous)	31.0°C	28.0°C	N/A	N/A
50 to 75%	31.0°C	29.0°C	27.5°C	N/A
25 to 50%	32.0°C	30.0°C	29.0°C	28.0°C
0 to 25%	32.5°C	31.5°C	30.5°C	30.0°C

Note: From American Conference of Governmental Industrial Hygienists (ACGIH). *Heat Stress and Strain: TLV® Physical Agents 7th Edition Documentation (2017).* TLVs and BEIs with 7th Edition Documentation, CD-ROM, Cincinnati, OH, 2017 as cited by OSHA (2017). OSHA technical manual: Section III: Chapter 4 (14).
Table 2: ACGIH Screening Criteria for Heat Stress TLV

Vega-Arroyo *et al*. [9] conducted an investigation among 259 farmworkers in California. Using an increase in core body temperature as an indicator, investigators hypothesized variables such as work rate, clothing, and hydration along with environmental factors would be associated with the risk of heat related illnesses. Work rate data was collected via accelerometer which assessed the total activity counts per minute (cpm). The medical scale Seca™ Model 874 (Seca GMBH & CO. Hamburg, Germany) was used to assess participant hydration status. A clothing inventory was taken for all study participants before and after each work shift. While environmental factors were measured using the WGBT and heat indices [9]. Table 3 represents investigative findings showing work rate to have the greatest association to the risk of heat related illnesses.

Shade or climate control

During the planning of any operation, considerations must be made to provide shade and/or climate-controlled environments that can be used by forensic response personnel for on-scene rehabilitation. Simple canopy tents can reduce worker exposure to direct sun and radiant heat [2,10]. Ideally, air-conditioned environments, like vehicles and climate-controlled tents, should be provided to allow a more rapid and effective recovery time.

Variable	Total n=259 (100%) n (column %)	Core body temperature <38 °C n=141 (54.4%) n (row %)	Core body temperature ≥38 °C n=118 (45.6%) n (row %)	*P* value[a]
Hydration defined by weight loss				
<1.5% body weight loss	222 (85.7)	124 (55.9)	98 (44.1)	.26
≥1.5% body weight loss	37 (14.3)	17 (46.0)	20 (54.0)	
	Mean (standard deviation)	**Mean (standard deviation)**	**Mean (standard deviation)**	***P* value[b]**
WBGT (°C)	25.6 (3.8)	24.9 (3.8)	24.9 (3.8)	.0006[c]
Heat index (°C)	29.2 (4.0)	28.4 (3.7)	28.4 (3.7)	.0007[c]
Daily activity counts per minute	360.9 (243.7)	315.7 (228.4)	315.7 (228.4)	.001[c]
Clothing ensemble insulation heat gain (Watts)	79.1 (13.7)	79.3 (13.1)	79.3 (13.1)	.85
Head gear insulation heat gain (Watts)	12.6 (8.3)	12.3 (8.2)	12.3 (8.2)	.50

Abbreviations: CHIPS, California heat illness prevention study; WBGT, wet-bulb globe temperature.
[a]P values for categorical variables were calculated using chi-square test.
[b]P values for continuous variable were calculated using a Student's *t* test. [c]P value is significant at $a<0.05$ level
Note: From Vega-Arroyo AJ, Mitchell DC, Castro, JR, et al. Impacts of weather, work rate, hydration, and clothing in heat-related illness in California farmworkers. Am J Ind Med. 2019;62:1038-1046. https://doi.org/10.1002/ajim.22973
Table 3: CHIPS participants primary variables to assess increased core body temperature (n=259)

When scheduling work outside, supervisors should attempt to avoid the time of day with the most direct sun exposure. Night work or early twilight hour work should be considered, when practical and possible. Opportunities to reduce the temperature of the work environment should also be made, when possible.

Site monitoring

At least one employee should be assigned the responsibility of monitoring conditions and personnel for heat stress. The site safety officer and/or paramedic can be assigned this function singularly or collectively. The site safety officer may be responsible for determining the WBGT and work/rest cycles, whereas the paramedic may be responsible for medical monitoring and post-entry rehydration. Regardless, a plan must be established to identify the site-specific requirements for monitoring. This monitoring plan may be a component of an overarching site-specific health and safety plan.

Employee Obesity and Physical Fitness

Workers who are generally sedentary are at a higher risk of heat stress than those employees who lead an active lifestyle. Additionally, employees with a high body mass index (BMI) have increased peripheral insulation which alters the body's thermoregulation abilities. According to Ramphal-Naley [7], "if individuals are not fit, their tolerance to heat will be inadequate, and they should not be exposed to long periods in the heat before they improve their fitness and cardiac conditioning". Forensic response personnel must be encouraged to maintain a high level of fitness. When permitted by policy or rule, work time should be allocated for employees to exercise in a manner that maintains fitness and reduces obesity.

Hydration and Nutrition

Proper worker hydration and nutrition can contribute to preventing employee heat stress. Many studies, standards, and agencies reinforce the importance of proper hydration in reducing the risk of heat-related illness. OSHA [6] recommends workers drink fluids often, before becoming thirsty, and every 15 minutes to protect against heat stress.

In addition to the threat of increased heat-illness, lack of adequate water intake can also affect worker cognition. According to Piil *et al*. [11], "dehydration at levels commonly observed across a range of occupational settings with environmental heat stress aggravates the impact of hyperthermia on performance in tasks relying on combinations of cognitive function and motor response accuracy". Forensic response personnel must maintain a high level of cognitive function while processing a crime scene to ensure no critical evidence is missed and all procedures are precisely followed. Even mild dehydration can increase the frequency of errors during a monotonous task, like driving [11], which is a concern for forensic response personnel when they must drive significant distances to their lodging location at the conclusion of an operation.

Supervisors must ensure workers have access to water. The ACGIH [2] recommends workers replace fluids at a rate of one cup of water for every 20 minutes of limited exposure to heat and to use a sports drink with an electrolyte replacement for prolonged heat exposures. Further, they suggest that water be between 10 ○C and 15 ○C and be available close to the work site.

Core Body Cooling Tools

Another measure to prevent heat stress is to take steps to keep the body's core temperature within acceptable limits. Using core body cooling tools can assist in keeping the core body at a reasonable temperature, thus reducing heat stress. These devices can be used independently or can be used underneath other personal protective equipment, such as chemical protective clothing. According to Stewart, Minett, Maley, & Stewart [12], "PCS [personal cooling systems] can reduce heat and cardiovascular strain and as a result extend work tolerance time".

During forensic response operations, personnel may wear simple, semi-permeable paper-like coveralls, or they may wear more advanced, impermeable chemical protective suits. Using a PCS has shown to extend work time as much as 24% [12]. A National Fire Protection Agency (NFPA) 1994, Class 3 chemical protective ensemble most closely matches what forensic response personnel would wear while processing a hazardous crime scene. A study by Stewart *et al*. [12] concluded the use of a vest containing inserts of a phase change material (PCM) were superior over other methods of external core cooling when wearing an NFPA 1994, Class 3 ensemble. The PCM inserts are placed into refrigeration or an ice water bath for 20 minutes to permit the material to freeze. The inserts are then placed into a carrier (vest). The user can wear the vest by itself or underneath protective suits. The vest will cool the body's core for approximately two hours until they melt and must be recharged. The vest is designed to reduce core temperature prior to work and/or during work, but not as a post-exposure rehabilitation tool.

Detection of Heat Stress

Preventing heat stress is the ideal method to reduce the likelihood of worker heat-related illness. However, when prevention methods fail, detecting signs and symptoms of heat stress is vitally important so workers can be treated before suffering irreversible harm. Therefore, supervisors and workers must be trained to detect or recognize the early signs and symptoms of heat stress.

Signs and Symptoms of Heat Illness

As discussed earlier, there are multiple illnesses related to heat stress. Some symptoms are unique to a particular illness, while other symptoms may apply to several illnesses. Table 1 provides a summary of the heat-related illnesses of concern, their signs and symptoms of exposure, and treatment for each illness.

Supervisor Awareness

Supervisors and safety professionals share the obligation to determine when the potential for heat stress exists and when and how to implement controls. Garvey [2] recommends front line supervisors use observational indicators to assess heat stress risks. They include: occurrence of heat disorders (occurrence of heat cramps may suggest the potential for more serious illnesses), increased incident rates, complaints of chronic fatigue, and alertness of workers.

While there is no specific OSHA regulation addressing heat stress, the General Duty Clause has been used to cite employers when exposing workers to excessive heat conditions [2]. NIOSH has established recommended heat stress alert levels (RAL) for unacclimatized workers and recommended heat stress exposure limits (REL) for acclimatized workers. The values take into account the WBGT and the workload of the employee, based on the amount of energy expended. Table 2 generally represents the NIOSH RELs.

Worker Awareness

Since safety is a shared responsibility of all employees, workers also bear the responsibility to understand the hazards of heat stress and the details of heat-related illnesses. Behavioral studies have shown workers may choose not to take advantage of rest and hydration opportunities provided by their employer [9]. However, they should routinely communicate with their supervisor about their health status and offer any suggestions to reducing heat stress. Lastly, workers should follow any recommendations or directives provided by supervisors and safety professionals, such as increasing water intake, work/rest periods, and using shade or climate-controlled environments to rest.

Technology

Technological advances may provide capabilities for supervisors and workers to detect employee heat stress. According

to Pancardo *et al*. [8], "it is necessary to have a system to automatically monitor the heat stress without requiring exhaustive human supervision or artificial testing in a laboratory". Pancardo *et al*. [8] advocate for the use of real-time worker monitoring to detect the initial stages when an employee may be experiencing heat stress. They recommend using a multi-sensor wearable device that simultaneously measures worker heart rate, ambient temperature and humidity, and includes an accelerometer to capture worker movements (general workload assessment). A smartphone application used to run the software would also capture biographical information on the worker, such as gender, age, weight, and height. Collectively, an algorithm uses these data to determine if a worker is approaching a heat stress event. The worker would receive a warning on the device and the supervisor would get an alert on their smartphone.

Detecting when forensic response personnel are starting to feel the effects of heat stress is sometimes difficult to achieve. Workers may try to push through the work to get the job done or wear personal protective equipment preventing a supervisor from visually observing the workers. Wearable technology that assesses worker risk for heat stress may be a valuable tool during forensic response operations.

Managing Heat Stress

As stated earlier, prevention is the preferred control method regarding heat stress. However, workers suffering heat stress must be managed. Some options for managing heat stress also relate to preventative means, like hydration. Hydrating before and during work helps to prevent heat-related illness. Hydrating after doing work helps to mitigate the effects of heat stress. However, some options mainly apply to circumstances where employees are already feeling the effects of heat stress.

It may be necessary to treat workers who are exhibiting signs and symptoms of heat stress. In cases of severe distress, like heat stroke, calling 911 or otherwise getting the employee medical attention is paramount. If the heat-related illness can be treated onsite, there are of number of actions that supervisors and safety professionals can implement to reduce the heat stress effects.

Post-Activity Hydration and Nutrition

Dehydration is about a 2% loss in body weight or when the urine specific gravity is 1.020 or higher [11]. If dehydration is not prevented during work by consuming adequate fluids, additional fluid intake must begin if symptoms of heat-related illness are apparent. According to the ISO, "…replacing the water loss is important and strongly advised" [13]. Fluid intake should be about one cup per 20 minutes until the worker improves, body weight recovers, and urine specific gravity is less than 1.020. Severe dehydration may affect worker mood, cause dizziness and confusion, and possibly lead to death [11]. Severe dehydration is a true emergency and medical care must be sought.

In addition to hydration, workers must ensure they are receiving adequate nutrition. It is not uncommon for supervisors to coordinate group meals during operations to continue crime scene processing. Unfortunately, it is too easy to acquire poor-nutritional value foods, like pizza. This type of food may provide limited energy during the work, but a well-balanced meal after crime scene activities is essential in restoring nutritional health.

Climate Controlled Rest Area

Similar to ensuring adequate rest locations during crime scene processing, employees symptomatic of heat stress must be moved to a climate-controlled location to allow their body temperature to return to normal limits. Simple shade may not be adequate. Air-conditioned environments may be necessary.

Active Extremity Cooling

Passive cooling methods, like rest and air conditioning, may not be sufficient to quickly return a worker's core body temperature to normal. Active cooling methods, like forearm water immersion may assist in more rapidly returning the body to homeostasis. "Arm immersion up to the elbow…may reduce cardiovascular strain by lowering heart rate by 10-25 beats/min and increase work tolerance time by up to 60%" [3]. During critical forensic operations, it may be necessary to quickly mitigate a worker's heat stress condition to reduce the amount of rest time needed and to maximize operational engagement.

In addition to a tool used to manage heat stress, extremity cooling could have utility in pre-cooling the body prior to performing work in high-heat environments, functioning like a prevention tool. Even a short duration of use can provide physiological benefits. "Extremity cooling in cool or cold water can accelerate body (core temperature) cooling from 0.2 to 1.0°C/10 minutes vs. control conditions…" [3]. Implementing extremity immersion cooling in pre-exposure and/or post-exposure environments will likely contribute to reducing forensic response personnel suffering a heat-related illness.

Evaporative Cooling

Sweating is the body's natural cooling system. A worker's sweat evaporates and cools their skin. Fortunately, this mechanism can be optimized by using tools to increase evaporative cooling effects. "Evaporative cooling is a simple, effective, and relatively inexpensive approach that can be used in outdoor and indoor environments, but works best in drier, low-to-moderately humid conditions with sufficient airflow" [14]. Evaporative cooling can be accomplished through use of clothing designed to enhance evaporative cooling or through the use of water-based misting fans. The use of misting fans during rest periods in shade can compound the cooling effects for workers. Forensic response personnel may benefit by using evaporative cooling clothing during crime scene processing in hot and dry environments and by using misting fans during rest periods.

Return to Work

Workers who require on-site or off-site treatment must be evaluated for return to work status. Workers requiring medical attention should receive a release from a medical provider articulating when the employee can return to work, stating specific limitations if any. For workers treated on-site, a paramedic, or other qualified individual, must make a recommendation to the supervisor for return to work status. Occasionally, employees will say they feel better and want to return to work, only to realize their symptoms return quickly and again require treatment.

Program Framework

Organizations placing employees in situations exposing them to excessive amounts of heat should establish a heat-related illness prevention program (HIPP). OSHA provides guidance for establishing a program and emphasizes the importance of management participation in the program in identifying and reducing heat stressors. Further, the program should address how the employer will determine when employees are exposed to heat hazards and include the establishment of policies and/or procedures for controlling those hazards [15]. The first step in establishing a program is to create a broad framework to use as the basis for the program. Organizations can use the following or similar program framework for establishing a HIPP.

Administrative Requirements

Any HIPP requires a section to address administrative and/or introductory requirements. This section may include a company profile, program goals, management statement, roles and responsibilities, scope, and purpose. These elements will provide foundational material for the remainder of the program.

Identification of Heat Sources

In fixed facilities, heat stressors are often predicted with high levels of confidence and can be managed appropriately. It is often difficult for law enforcement organizations to make proper advanced assessments for heat stress in the workplace, considering the transient nature of crime scene processing. However, some general guidelines can be used to identify sources, such as time of year, geographic location of the crime scene, anticipated duration, and personnel work load during the operation. These factors, and others, should be incorporated into the program as potential sources of heat stressors. These factors must be considered during the preparatory stages of any planned operation.

Hazard Evaluation

Evaluating heat hazards for employee exposure risk is an important part of a HIPP. Many factors may contribute to a thorough analysis of a job site to ensure all risks are well understood. Basic environmental information, such as temperature, humidity and wind speed, although easy to acquire, provide only a portion of the overall evaluation. Planners must also consider other parameters in the risk assessment. Critical job information, such as work duration, workload, personal protective equipment use, and employee acclimatization are also important to include in the aggregate risk assessment. Once all of the data are collected and evaluated, a site-specific plan can be established that includes heat exposure control requirements.

During site risk assessments, many tools are available to evaluate heat stress. "Key components of any heat prevention plan are the appropriate choice of indices of heat stress, thresholds of these indices that define critical events, and, most importantly, accurate forecasting of such critical events" [4]. The WBGT should be considered in a risk assessment as it is a widely accepted standard for assessing heat risk. The measurement can be compared to the ACGIH RAL and REL to provide a clearer picture of the actual heat stress risk. In the absence of a WBGT measurement, the National Weather Service Heat Index can be used to provide an alternate guide. According to Heidari *et al*. [13], "…the hygienist needs reliable and applicable tools, methods, and equipment to accurately measure these hazards".

Implementing Control Measures

A critical part of a HIPP should be the identification of various control measures that employers, supervisors, and safety professionals can use to reduce heat stress risks. This section should contain procedures that can be used to pre-screen employees who may be subject to heat stressors, as well as other procedures or tools than can be implemented to reduce the impact of heat. Engineering controls, administrative controls, and personal protective equipment options should be discussed in this section.

It is important to identify engineering controls, or engineering-like control measures in the HIPP. Listing these controls will help supervisors and safety personnel to select appropriate options to implement at crime scenes. Some options include air conditioning work areas and rest areas, misting fans, and extremity cooling devices. These options have shown great success in reducing body temperature. Some of these options require the expenditure of funds. Some are one-time expenses, some have ongoing maintenance requirements, yet others are considered disposable. When choosing engineering control options, employers need to consider both the needs of the worker along with the available organization provisions.

Administrative controls, policies, and procedures can contribute to an overall reduction of employee risk. Making provisions at crime scenes for adequate hydration and nutrition, establishing work/rest cycles, and working during the cooler part of the day are all administrative control options. Other critical administrative controls are the establishment of a site-specific health and safety plan, employee screening requirements, and training.

When an organization requires the completion and approval of a site-specific health and safety plan it forces personnel to consider heat stress as a hazard. Further, the plan helps to guide users in implementing the correct engineering controls, administrative controls, and personal protective equipment. A plan should be completed whenever a site is deemed as high-hazard or complex in nature.

Routine medical surveillance should incorporate an evaluation for heat-related illness stress factors. Physicians should be provided with possible scenarios where heat stress is a concern, allowing the impact to workers' health to be anticipated with regard to these expected scenarios. The physician should consider these potential exposures when rendering an opinion about a worker's fitness for duty. Personal risk factors should also be discussed with the physician. They include, but are not limited to diabetes, hypertension, cardiac disease, use of certain medications, and the use of illicit drugs [16]. Even if an employee is medically qualified to perform in elevated heat conditions, considerations should be made to provide specific screening to employees in advance of a planned event where heat stress is an exceptional hazard.

Training is a natural part of preparing supervisors and employees to identify and control hazards. Training with regard to heat stress should include but is not limited to: environmental assessment techniques, exposure limits, implementation of heat stress control measures, signs and symptoms of exposure, and treatment of affected workers. Regular training in these topics will help to ensure all workers remember the requirements of the heat-related illness prevention plan.

It is well accepted in the safety profession that engineering controls and administrative controls should be considered before the use of personal protective equipment. While this is true for exposure to heat stress, it is not always practical to use, or solely use, engineering and administrative controls. Certain types of personal protective equipment, like evaporative cooling clothing and core body cooling tools (e.g. cooling vests) can add benefit to other methods of controls. A good HIPP will encourage the use of all control methods available, including personal protective equipment, to achieve an acceptable risk of employee exposure to heat.

Program Evaluation and Update

The HIPP should be reviewed regularly and evaluated for its effectiveness in achieving prevention, or at least reduction, of heat-related employee illness. Any time a heat-related illness occurs, the program should be reviewed to determine if any gaps in the program contributed to the exposure and if changes are warranted. As control options are added, or deleted, the program should be updated and employees retrained in the changes of available exposure control options.

Conclusion

Heat stress is often a hazard to forensic response personnel when processing crime scenes. These scenes may be anywhere in the world, which present challenges to those personnel who are not acclimatized to high temperature environments. Forensic response personnel routinely wear different types of personal protective equipment, which

increase their risk for heat-related illnesses. Organizations should work to prevent heat stress from affecting their workers, detect when employees are experiencing symptoms of heat stress, and manage heat stress once indicators are present. The implementation of a comprehensive heat-related illness prevention program can help to achieve all of these objectives.

Disclaimer

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