Physical Training Run Incident

Rhabdomyolysis Leading to Heat Stroke

Lessons Learned Review

Sequoia and Kings Canyon National Parks

August 2013

The Lessons Learned Review process helps us to maximize learning opportunities presented by unintended outcomes or near miss events. The intent is to improve performance by generating individual, unit, and organizational learning that capitalizes on shared experience by focusing on learning rather than blaming

Contents

1. Leader's Intent

A physical training (PT) run heat stroke/Rhabdomyolysis incident occurred on June 27, 2013 at the Swale Work Center in Kings Canyon National Park. [See Heat Stroke and Rhabdomyolysis definitions on page 8.]

On August 8, 2013, Superintendent of Sequoia and Kings Canyon National Parks, Woody Smeck, authorized a Lessons Learned Review (LLR) of the upstream factors that contributed to the heat stroke event and the post incident medical response.

The Superintendent's Objectives and Expectations directed the LLR Team Leader to conduct a review that:

- Determined lessons learned and enhanced the Park's ability to better manage risk into the future
- Focused on three specific issues for organizational learning 1) upstream factors that contributed to the heat stroke event, 2) the post incident medical response, and 3) recommendations for park staff and others to prevent such an event in the future.
- Pursued other lessons learned and other avenues of learning if they arose

The Superintendent directed the LLR Team Leader to terminate the LLR if the team uncovered information leading the team to believe that the accident resulted from a reckless and willful disregard for human safety, and stipulated that no punitive actions would be taken against any employee as a result of information provided to any member of the LLR team.

2. Sequence of Events

During the second week of August, 2013, the LLR Team members interviewed the employee who collapsed and was medically evacuated during a physical training run, his crew, the Park Medics and CHP Paramedic who treated him, friends, and members of his family.

June 15 – June 23, 2013

William [not the injured employee's actual name] graduated from college on June 16, 2013. Graduation weekend included celebrations involving consumption of alcoholic beverages. Activities during the ensuing ten days included moving from his college apartment in a town on the coast and getting established in a new apartment near the Park at approximately 825' above mean sea level. On the weekend prior to William's reporting date, he attended a friend's bachelor party. Between college graduation, moving, and the friend's bachelor party, William was getting less sleep than usual and interrupted his PT routine. Prior to his college graduation weekend, William had been running an hour per day, hiking some hills, and going to the gym. In all, he was working out one to one and one-half hours per day at least five days per week.

Monday, June 24, 2013

On the first day of employment, in addition to routine check-in procedures and paperwork, William both accompanied the crew on a strenuous PT run and took the Work Capacity (Pack) Test. William felt that the run, conducted at approximately 1700' above mean sea level, was one of the hardest he had ever done while on the crew. Other crew members had been on-duty for between one week and one month, but William stayed relatively close to everyone and felt he performed adequately on the run. The PT run and the pack test were separated by a one and one-half to two hour break, during which William ate lunch. Weather conditions, measured at a nearby remote area weather station (RAWS), during the 1300 pack test:

Sky/Weather: Overcast

Temperature: Approximately 88 degrees Fahrenheit, with moderate wind gusting to 16 mph.

Relative Humidity: 23%

Heat Index: Risk Level: Caution

Knowing it would be hot during the pack test, William reported drinking what he felt was plenty of water. William has always perspired heavily, and compensates by drinking at least four to six quarts of water per day and mixes in some sports drinks. He also drinks a cup or two of coffee each day, but does not use energy drinks. Following the pack test, William spent the rest of the day training in the station training room. He was tired, but felt fine.

After work, William met family members for dinner at a restaurant outside the park. His girlfriend was also present, as an employee of the restaurant. William appeared extremely tired, drank a substantial quantity of water, ate little, and went straight home and to bed after dinner. However, he experienced difficulty sleeping.

Tuesday, June 25, 2013

On his second day of work, William recalls being sore, but not unusually. However, William's girlfriend reported that early in this week, William began feeling ill including experiencing unusual chills and night sweats, perspiring abnormally, and losing his appetite. William also continued to experience trouble sleeping. He began to use over the counter pain relievers, including Ibuprofen, for general muscle soreness.

On Tuesday, the crew did a "cross-fit" type of PT workout including exercises with packs on and sit-ups and squats with a heavy pipe. William reported that this was the first time he had participated in this type of workout. The crew cleared a trail near the Park housing area. The temperature was very warm, but the work only took about half an hour. The crew then trained in the station's training room the rest of the day. William again experienced difficulty sleeping that night, which is unusual for him. In addition, William began noticing that his urine was very dark, the color of cola. Recognizing dark urine as a sign of dehydration, William continued to drink extra water.

Wednesday, June 26, 2013

Crewmembers chose their own PT activities on this day, and William participated in a quick, one-half hour, run followed by push-ups, sit-ups, and dips. William recalled that everyone on the crew was sore and wanted to keep PT short. Following PT, the crew conducted chainsaw training in the field for about an hour to an hour and one-half. During this time, William bucked and stacked firewood, expending about three quarters of a tank of chainsaw fuel. Afterward, he maintained chainsaws and participated in classroom training. William's dark urine persisted, and William continued his efforts to re-hydrate. After hydrating, William's urine would lighten, but later return to a dark color. William reported drinking a protein shake Wednesday evening

Physical Training and the Work Capacity Tests

The physical requirement for Wildland firefighters demands a high level of fitness. Physical training (PT) and the Work Capacity Tests (WCT) separate firefighters from other employees based on a level of physical fitness and successful completion of the WCT as a condition of employment. Some individuals believe this division has helped to establish a culture of accepting pain that is potentially produced by PT and the Pack test.
This common acceptance of pain as being part of PT and the Pack Test perhaps leads participants to believe that any post-exercise pain or discomfort must simply be "normal" muscle pain.

Thursday, June 27, 2013

William reported feeling fine on the morning of June 27, actually the best he had felt all week. The crew began its day with a briefing from 0930-1000. After briefing, the crew drove to the Valley Floor prescribed burn unit in the Cedar Grove area at 4600' above mean sea level, arriving at 13:00. From 1300-1330, the crew rehabilitated fireline on the burn unit; an activity that crew members described as "not labor intensive." The crew then drove from the Cedar Grove area to the Swale Work Center, arriving at 15:00. Having missed their PT that morning, the crew brought their PT gear along, intending to run a trail in the area while simultaneously scouting rehabilitation needs on the Swale East 3 prescribed burn unit. The crew boss chose this time and location to conduct PT because, though it was near 6,300 feet elevation and in the afternoon, it was also cooler and had better air quality than the crew's station location at 1200' elevation. The crew boss estimated the heat stress factor to be moderate at this location. In fact, the temperature at Grant Grove was more than 20 degrees Fahrenheit cooler and the heat index lower than at Ash Mountain at the time of the PT run. A total of eight people participated in the run, and the intent was quick PT before making the extended drive back to their station.

The PT Run

The crew conducted its PT run on a maintained trail south of the Swale Work Center. Trail conditions are moderate, not exceeding a 5% grade at any point and on a well-maintained trail tread.

Weather conditions, measured at a nearby RAWS, at the time of the PT run:

Sky/Weather: Sunny

Temperature: Approximately 76 degrees, with a slight breeze.

Relative Humidity: Approximately 60%

Trail on Which the PT Run Was Conducted

The crew has a Job Hazard Analysis (JHA) for PT, which they review during pre-season training. On the day of the incident, the crew commenced its PT run at 15:15. The crew runs as a group, with either the crew boss or the assistant crew boss taking the lead and the other bringing up the rear. On this day, the crew boss led the run on the way out and, after reversing tool order, the assistant crew boss led the run on the way back while the crew boss ran at the back of the group.

PT Run Performance

The PT run unfolded without incident up to the point where the crew turned around. After turning around and starting back, at around 15:35, William stopped to urinate. Around 15:50, William fell back, then broke off from the group, at which time the crew boss asked William if he was OK. William responded that he couldn't catch his breath. The crew boss instructed William to walk, and William walked for a minute. William continued to try to run after taking brief breaks during which he rested in a standing position with his hands on his knees. According to both William and the crew boss, William's goal was to try to catch back up to the crew. The crew boss continued to accompany William. Up to this point, William was thinking that he was struggling because this was his first run at elevation for the year, and he did not consider his struggles particularly unusual. However, William was also thinking that he was slacking off by being behind and felt he needed to pick his performance up because he is normally one of the stronger people on the crew. William appeared to get a second wind, caught up to the crew as they circled back to his location, and around 15:56 William sprinted the last 200 feet, past the crew to finish the PT run at the lower loop of the parking lot at the Swale Work Center.

Following the PT Run

Immediately following the PT run, William appeared wobbly, had a pale color and bluish lips, had trouble speaking, was out of breath, asked for water, and reported that he felt cognitively impaired. A crew member reported that as he supported him, William felt hot to the touch.

While three crew members retrieved crew vehicles, other crew members sat William down, moved him into the shade, removed his shirt, and gave him a sip of Gatorade, which he spat out. At this time, William was responsive, but not alert, and could not speak well.

Approximately five minutes after finishing the PT run, crew members laid William flat on the ground, took his vital signs and administered Oxygen. Approximately seven minutes after completing the run, William's pulse was 140 beats per minute; his respirations were 80 per minute; and he was conscious, but not alert and trying to sit up.

Having no ice packs in the first aid kit on scene, a crew member was sent to the upper parking lot at the Swale Work Center to retrieve ice packs from a second first aid kit. The crew member quickly returned with ice packs, but those ice packs malfunctioned. It appeared that ice packs in both first aid kits had been activated while in storage within the kits. The crew had noted the absence of functioning ice packs when they inspected the first kit, and had ice packs on a list for purchase. Two crew members returned to the Swale Work Center to try to get ice from the kitchen, but were unfamiliar with the station and unable to make entry to the kitchen.

The crew boss and assistant crew boss left the scene to drive five to seven minutes to a nearby ranger station to get an EMT. The crew boss reported a reluctance to call on the radio because he was aware of radio traffic related to other medical calls. When he left, the crew boss left a crew member in charge, with instructions to use the radio in the truck to contact him as necessary. At the ranger station, the crew boss made contact with the Sub-district Ranger who is also a Park Medic and the Park's EMS Coordinator. Suspecting that the injury may be more severe than initially indicated, the Sub-district Ranger requested that another ranger respond with the NPS ambulance as a precaution and immediately responded in her patrol vehicle. The District Ranger, who is also a Park Medic, upon hearing the ambulance respond, also proceeded to the Swale Work Center.

NPS Ambulance **5 – King's Canyon NP**

Approximately thirteen minutes after completing the run, William became unresponsive. A crew member who had taken EMT training in the past continued to check William's responsiveness and circulation, but got no response.

From 16:05 through 16:18 (from eight minutes after completing the PT run until 21 minutes after completing the PT run), crewmembers continued talking to William to elicit a response from him. Crew members report that William tried to sit up a few more times and gripped/held the hands of crewmembers. William remained slightly responsive, and never lost consciousness. Crew members took an additional set of vital signs. At that time, William's pulse was 128 beats per minute and his respirations 60 per minute. Around 16:15 (18 minutes after completing the PT run), William became slightly more responsive, could nod his head in response to questions, and make sounds but his speech remained impaired.

At 16:22 (25 minutes after completing the PT run) the Sub-district Ranger arrived on scene, and crewmembers relayed both sets of vital signs to her. William appeared cognitively altered, his pupils were dilated; he was drenched in sweat, and cool to the touch. At this time, William was able to respond verbally to questions, but with pronounced speech impairment. The Medic immediately administered oral glucose to William, which produced little noticeable improvement, and took his vital signs again. The second Park Medic arrived around 16:23. At this time, William's legs began to cramp. The NPS ambulance arrived around 16:25, at which time William was immediately loaded into the ambulance and transported to a nearby permanent helispot.

Twelve minutes after arriving on-scene, given William's deteriorating condition, the first arriving Park Medic decided to order air medical evacuation. Once inside the ambulance the attending medics prepared for both cardiac arrest and seizure. Very shortly after entering the ambulance, William did experience his first seizure, and the attending medics administered anti-seizure medication, which seemed to stop William's seizure activity. At this time, one of the medics noted that William's pupils were both dilated and unequal, a sign of serious condition.

CHP Helicopter 40

The NPS EMS personnel transferred William to a California Highway Patrol (CHP) helicopter which arrived shortly after they reached the helispot. On the helicopter, the CHP paramedic determined that William's condition dictated transport to a trauma center, and the trauma center was actually the closest hospital from the pickup point as well. Based on William's behavior, CHP personnel suspected bleeding in the brain, and confirmed that the Park Medics had rendered appropriate care, stopping William's seizures before transfer to the helicopter. William was on the CHP helicopter approximately one hour and fifteen minutes after collapsing, and at Community Regional Medical Center, a Level I trauma center, in Fresno within one hour and thirty three minutes of his injury.

At the hospital, William was diagnosed with exertional heat stroke with Rhabdomyolysis. His medical team also expressed concern that he might experience compartment syndrome. The Chief of Medicine described William's condition to his parents as "…a profoundly sick young man, who may not make it."

What is Heat Stroke?

Heat stroke is the most serious heat-related disorder. It occurs when the body becomes unable to control its temperature: the body's temperature rises rapidly, the sweating mechanism fails, and the body is unable to cool down. When heat stroke occurs, the body temperature can rise to 106 degrees Fahrenheit or higher within 10 to 15 minutes. Heat stroke can cause death or permanent disability if emergency treatment is not given.

What is Rhabdomyolysis?

Rhabdomyolysis is the breakdown of muscle fibers resulting in the release of muscle contents (myoglobin) into the bloodstream. These releases can cause multiple symptoms and, if left undiagnosed, can lead to kidney and muscle damage, and in rare cases, results can be fatal.

For More Information: http://wildfirelessons.net/documents/HRI_HIP_pocket_guide.pdf

June 28-August 15, 2013

William remained in critical care for six days and in the hospital for two weeks. William, who was five feet, eleven inches tall and weighed 205 pounds at the time of his injury, lost 35 pounds, mostly comprised of muscle tissue broken down by Rhabdomyolysis. He underwent kidney dialysis three times a week for seven weeks; reduced to once a week at the time this report was written, and was projected to make a full recovery. William hopes to soon return to light duty work, but cannot do so until he is finished with kidney dialysis treatments.

During this period, an NPS family liaison, as well other Sequoia and Kings Canyon National Parks personnel, were at the hospital each day for the first seven days of William's hospitalization; and intermittently and as needed once he had been released from critical care. NPS personnel assisted both the hospital and William's family in navigating the Office of Worker's Compensation Programs (OWCP) requirements.

> "The support he received and we received was tremendous!" – *William's Mother*

The Park organized a critical incident stress management (CISM) team made up of trained and experienced personnel from within the Park. William's crew participated in a critical incident stress debriefing the week following William's injury.

3. Employee's Apparent Fitness Level and Medical History

Prior to his college graduation two weeks before reporting to work, William had been running an hour per day, hiking hills, and working out in the gym. On average, William was engaged in PT one to one and one-half hours per day at least five days per week. Both William and his girlfriend reported that he had trained more and was even better prepared for the fire season than he had been in the past.

Neither William nor his parents report any medical history that would suggest that William was at elevated risk for heat injury. Risk factors already present when William reported to his first day of work included:

- Fatigue
- Recent alcohol use that could contribute to dehydration
- Relocation from a cool sea-level environ to a relatively hot climate at higher elevation
- Sudden change in PT intensity

4. Team Findings

After interviewing involved personnel and establishing a timeline of events, the LLR Team concluded that William was likely injured early in the week, with symptoms of Rhabdomyolysis appearing on or before Tuesday night. The team cannot name the exact cause of William's injury, which could have been his PT, WCT, the project work in which he participated , or a combination of two or more of those events. As noted above, other risk factors associated with Rhabdomyolysis were present when William reported to work. However, the LLR Team does believe that William exhibited symptoms of Rhabdomyolysis as early as Monday evening, June 24. William's heat injury on Thursday, June 27, 2013 likely occurred as a result of a chain of events.

While the diagnosis at the hospital was exertional heat stroke induced Rhabdomyolsis, it is the opinion of the LLR Team's subject matter expert that William's Rhabdomyolysis actually preceded his heat stroke. Recent research indicates that muscle damaging exercises can increase heat strain during subsequent exercise.

5. Lessons Learned from Participants

Sustain

An established protocol for injured staff that is reviewed, updated and communicated to supervisors annually; helps the program manager, duty officer, and supervisors make decisions under stress and facilitate successful navigation of OWCP and other administrative requirements. The fire program at Sequoia and Kings Canyon National Parks maintains such a protocol, included as an appendix to this report.

Providing a consistent and appropriate agency point of contact as a liaison to an injured employee's family is important. Personnel filling the role of agency point of contact and liaison to an injured employee's family should have a working knowledge of the injured employee, their injury, their job responsibilities, their co-workers, supervisory relationships, and OWCP requirements.

Quick recognition and first aid action can prove critically important when heat injuries occur. The members of William's crew were trained to recognize the signs and symptoms of heat injury, and quickly realized the potential for both heat injury and shock. The attending Park Medics noted that the crew took appropriate first aid actions for the situation.

Management recognized the need for critical incident stress management (CISM) early. CISM activities, including critical incident stress debriefings (CISD) must extend beyond personnel proximate to accident; to include personnel linked to previous incidents as necessary. Management must assure that they follow up with affected employees on a continuing basis.

The Park had job hazard analyses (JHA) for both PT and the WCT, and the crew had reviewed them in pre-season training.

EMS personnel maintained a low threshold for intervening and evacuating the injured employee and treated the situation as a worst case scenario.

Using a website to connect, communicate, and share news with concerned friends, family and co-workers, as well as receive support, reduced pressure on the injured employee's family by enabling them receive well wishes and provide updates to many people through a central contact point versus innumerable phone calls, emails and text messages.

Improve

When checking the readiness of first aid equipment, check both the presence of required elements as well as the function of those elements. If you know of missing or inoperable elements, replace them without delay.

Employee emergency contact information should be updated on the first day of work, prior to engaging in other activities.

When employee is not feeling well they need to tell their supervisor. Conversely, supervisors need to be very direct when inquiring about an employee's health status.

When an employee is injured, a person in a formal supervisory role should remain in command at the scene, if possible, and use the most expedient method of notifying EMS and obtaining EMS response.

Do not count on observing classic heat stroke symptoms; an injured employee may not present the symptoms you have been trained to look for.

No useful template exists for preparing required 24 hour and 72 hour notification reports.

The reporting relationships for injured employee notification within the NPS fire organization are not sufficiently clear.

Personnel filling the role of agency point of contact and liaison to an injured employee's family need a guide or standard operating procedure.

6. Additional Recommendations from the LLR Team

Develop a national protocol for responding to heat related injuries similar to the Standards for Burn Injuries developed by the National Wildland Fire Coordinating Group (NWCG). This protocol should specify that employees with suspected heat injuries should be transported to the nearest Level I Trauma Center.

Employees must be given opportunity to acclimatize and transition into arduous physical activity; particularly when they are joining a module in which other employees have already acclimatized. In addition, returning employees and supervisors should engage in purposeful and open communication about the employee's current physical conditioning and activity level, recent health history and lifestyle changes, and overall readiness on the employees' first day of work.

Employees should not participate in both the WCT and additional PT in the same day.

All WCTs must be conducted in strict adherence to all aspects of the NWCG Work Capacity Test Field Administrator's Guide.

Expand heat injury awareness and personal wellness training, both locally and nationally, to include recognition of Rhabdomyolysis symptoms and heat injury prevention. Develop a national training module addressing Rhabdomyolysis recognition and heat injury prevention.

The LLR Team does not recommend a "one size fits all" PT program. However, the Team does recommend careful design of exercise programs, particularly since recent research suggests that high intensity exercise, beyond what an individual may be used to performing, represents a risk factor for Rhabdomyolysis; as does performing activities that participants have not performed before. All PT programs should follow guidance provided by the most recent edition of the NWCG Fitness and Work Capacity Guide (NFES 1596) and/or NPS Reference Manual 57.

The family of an injured employee is best served when agency personnel filling the role of agency point of contact and liaison to an injured employee's family have a working knowledge of the injured employee, their job responsibilities, their co-workers, supervisory relationships, and OWCP requirements. As was done in this case, assign people who possess these qualities. In addition, NPS units should make effort to train fire program personnel as family liaisons.

NPS needs to clarify protocol for reporting employee injuries and accidents through the fire and aviation organization beyond the Park chain of command.

7. Commendations

The LLR Team would like to commend the EMS responders, both from the NPS and the CHP, for their quick- thinking and actions. The LLR Team is certain that if these employees had not done so, William's injury would have proved fatal.

Similarly, the LLR Team commends the NPS personnel who interacted with William's family, who appreciated the support of these NPS personnel and felt they did a fine job. The individuals assigned in this case had excellent familiarity with William, his crew, his activities, and the program in which he worked.

8. Lessons Learned Review Team

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9. Appendix: Injured Personnel Protocol

Objective

1. Provide medical care to injured staff member
2. Notify park management of injury in an accurate and timely matter
3. Ensure quality and timeliness of OWCP paperwork

Primary Point-of-Contact

- xxxxx xxxxx @ xxx-xxx-xxxx, Park OWCP contact, call first for questions
- xxxx xxxxxxx @ xxx-xxx-xxxx, back up
- Duty Officer and Program Manager for notification

Step O – Preplanning

- Carry paper CA-1 and CA-16 in crew boss kit

Step 1 – Injury and Medical Response

- Get immediate medical assistance, if needed. In serious cases, no need for prior paperwork
- Time depending, complete CA-1 in SMIS before going to medical facility
- If employee is unavailable, you can enter SMIS using last four SS#
- Give CA-16 to employee before first medical visit; make sure to sign the form.
- Supervisor or crew representative should accompany injured employee to medical clinic

Step 2 – At clinic

- Don't use home address to register. Use park address: 47050 Generals Hwy, Three Rivers, CA 93271
- Leave the clinic with note from Doctor describing results of exam or completed CA-16. Need to know about any work restrictions or limitations. Copy of work restrictions go to program manager.
- Referrals for further treatment: Doctor should be specific: ex. referring you to specific Doctor by name.
- For serious injuries consider requesting a family liaison..

Step 3 – Notifications

- Supervisor will make notifications within 2 hours of injury.
- Follow up after Doctor Appt. FMO and Chief Ranger need specific information on DARTS
- In-park notify Duty Officer
- Off-park notify Program Manager
- Duty Officer/Program Manager needs to notify CH-1, Dispatch, and Fire Program Assistant
- Duty Officer/Program Manager needs to summarize incident by email to CH-1

Step 4 – Paperwork

- CA-1 for Traumatic Injuries
- CA-2 for Occupational diseases. Do not give a CA-16 for occupational disease. Initial Doctor visit must be paid by employee.
- Take time to complete paperwork thoroughly will help employee with claim
- Give a detailed description of incident including narrative and witness statement