

Rhabdomyolysis in Wildland Fire

An updated review of reported cases

Prepared By:

Molly West

Forest Service National Technology and Development Program

Reviewed By:

Joe Domitrovich, Ph.D.

Forest Service National Technology and Development Program

Jennifer Symonds, D.O.

Forest Service Fire and Aviation Management Medical Officer



From 2008 to 2016, 26 confirmed cases of rhabdomyolysis and 5 cases of compartment syndrome in wildland firefighting were reported.

A key goal of this report was to obtain information on each individual rhabdo case to investigate insightful information regarding signs, symptoms, and causes of rhabdomyolysis specific to the wildland firefighting occupation.

“Listen to your body. If something doesn’t feel normal—seek medical attention. The quick decision I made to go to the ER probably saved me a long recovery time. Don’t be afraid of potential ridicule that you may receive for going in.”

–Rapid Lesson Sharing, Onset of Rhabdo during physical training

This is the story/chronology of a 29-year-old engine captain who—during morning PT—thinks he is having severe heat cramps. Fortunately, he decides to go to the hospital—where he is diagnosed with rhabdomyolysis (“rhabdo”).

Contents

1. Introduction to Rhabdomyolysis and Cases.....	3
2. What Firefighters Need to Know.....	4
A. Risk Factors.....	4
B. Symptoms.....	4
3. Potential Effects.....	4
A. Compartment Syndrome.....	5
4. Summary of Cases.....	7
5. Methods.....	7
6. Rhabdomyolysis Case Findings.....	7
A. Risk Factors.....	8
B. Symptoms.....	8
C. Previous Physical Activity.....	9
D. Response Time.....	9
E. Diagnosis.....	11
F. Treatment and Recovery.....	12
7. Recommendations.....	12
8. Conclusions.....	15
9. References.....	16
10. Compartment Syndrome and Rhabdomyolysis Hand Out for Medical Providers.....	17

Rhabdomyolysis (often referred to as “rhabdo”) is the end result of any process that leads to the death of muscle tissue [References #11]. “Myo” refers to muscle, “rhabdo” means rod-shaped or striated (as in striated or skeletal muscle), and “lysis” is breakdown [References #4].

According to the National Institutes of Health, rhabdomyolysis is defined as “the breakdown of muscle fibers that leads to the release of muscle fiber contents (myoglobin) into the bloodstream”.

1. Introduction to Rhabdomyolysis

In the profession of wildland firefighting there has been a rise in the occurrence and awareness of exertional rhabdomyolysis, a serious medical condition.

Exercise, particularly when strenuous and unaccustomed, causes damage and subsequent muscle fiber breakdown, known as exertional rhabdomyolysis [References #2]. During training and fire suppression, firefighters engage in strenuous activities and prolonged exertion, often under harsh environmental conditions and difficult terrain. The nature of their work and duties puts them at an increased risk for rhabdo.

Each case of rhabdo is unique in its causes, signs and symptoms, health consequences, and recovery. Becoming educated on the condition is especially important. If left undiagnosed or untreated, rhabdomyolysis can become severe and lead to long-term health consequences and potentially death for firefighters.

Since 2008, 26 confirmed cases of rhabdomyolysis (some in conjunction with another reported injury) in wildland firefighters have been reported. According to the Wildland Fire Lessons Learned Center’s “Incident Review Summary” of 2013, 6 of 12 incidents in physical training were rhabdo [References #15]. In 2014, rhabdo accounted for 16% of medical incidents [References #14]. In 2015, 3 additional cases of rhabdo were reported.

Each reported case provides valuable lessons.

Becoming educated on the condition is especially important. If left undiagnosed or untreated, rhabdomyolysis can become severe and lead to long-term health consequences and potentially death for firefighters.

2. What Firefighters Need to Know

It is important to be aware of the general risk factors, signs and symptoms, and varying degrees of rhabdo. While these will vary from person to person, knowing what to watch out for can be crucial in quick recognition and subsequent treatment. **Timely recognition is key to a better recovery.**



A common sign of rhabdo is dark or little urine.

A. Risk Factors

- Overexertion.
- Poor conditioning.
- Heat stress/stroke (working in extreme heat).
- Dehydration.
- Prescription medications such as cholesterol-lowering statins and antidepressants.
- Over-the-counter medications such as antihistamines.
- Nonsteroidal anti-inflammatory medications.
- Excessive caffeine intake.
- Use of dietary supplements such as creatine and Hydroxycut. (Creatine is mentioned often in the literature as a major risk factor.)
- Use of toxins such as alcohol or amphetamine.
- Underlying medical conditions such as sickle cell trait or lupus.
- Concurrent acute viral illnesses such as influenza.

B. Signs and Symptoms

- Muscle pain.
- Cramping.
- Swelling.
- Weakness.
- Stiffness and decreased range-of-motion of joints.
- Pain generally develops in the hours after exercise and peaks between 24 and 48 hours post exercise.
- Nausea or vomiting.
- Fever, rapid heart rate.
- Confusion or lack of consciousness.
- ❖ A common sign is dark urine (tea or Coca-Cola colored) and little urine.

3. Potential Effects

The prognosis depends on the extent and severity of rhabdomyolysis, as well as on the early and prompt medical intervention.

A mild case may or may not display symptoms and can be treated by drinking a lot of fluids [References #11]. Severe cases require hospitalization and treatment with intravenous fluids to dilute the proteins to minimize their damage to the kidney, and also to monitor surges in electrolytes that can cause dangerous heart rhythms [References #11].

Upon hospital release, most patients stay under a physician's care until protein levels return to normal. They may experience muscle pain and general weakness. Some patients develop acute

Some patients develop acute renal failure and recover quickly, whereas others require dialysis for more than 3 weeks. In some cases, the kidneys do not recover and the patient requires a kidney transplant or is put on permanent dialysis. Up to 8% of cases of rhabdomyolysis are fatal.

renal failure and recover quickly, whereas others require dialysis for more than 3 weeks [References #5]. In some cases, the kidneys do not recover and the patient requires a kidney transplant or is put on permanent dialysis. Up to 8% of cases of rhabdomyolysis are fatal [References #2].

Heat stress and heat stroke are possible contributing factors of rhabdomyolysis. Every 1°C increase in body temperature increases metabolic demand by approximately 10%. When oxygen delivery can no longer keep up with increasing requirements, cellular hypoxia ensues [References #4]. This is why exertional hyperthermia in particular is associated with the development of rhabdomyolysis.

A. Potential Complication: Compartment Syndrome

Another potential complication is compartment syndrome. This syndrome occurs when the release of muscle fiber contents causes swelling and pressure inside of injured muscle compartments that are unable to expand. This pressure can decrease blood flow, which prevents nourishment and oxygen from reaching nerve and muscle cells [References #6]. Without a steady supply of oxygen and nutrients, nerve and muscle cells can be damaged or die.

Since 2008, 5 confirmed cases of compartment syndrome in wildland firefighting have been reported. 3 were reported through the Wildland Fire Lessons Learned Center and 2 were logged via Safety Gram data collection and release. In all 5 cases the firefighters required 1 or more surgeries and in 2 cases the firefighters had dark colored urine. All 3 of the cases reported by the Wildland Fire Lessons Learned Center occurred during the Pack Test, the other 2 cases occurred on large fires.

In one case where the patient suffered compartment syndrome, he had 4 surgeries and was not released to full duty until 69 days after the accident. Furthermore, he also experienced rhabdomyolysis. As his muscle tissues died, the blood carried the byproducts to his kidneys, decreasing their ability to function normally.

In another case, upon arrival at the hospital, a serum creatine phosphokinase (CK) test was initially performed to look for rhabdomyolysis and the firefighter was put on an IV. But it was not until the next evening—after talks with his fiancé, coworkers, and another Forest Service employee who had previously suffered from rhabdo and compartment syndrome—that doctors agree to transport the patient to another hospital.

Within an hour of his admittance at this new hospital, the patient was positively diagnosed with compartment syndrome. Surgery preparation began. The doctors stated that the delay in

treatment of the compartment syndrome could have caused serious complications, even the necessity for amputation. Fortunately, these more serious outcomes did not occur.

In the “Lessons Learned” case described in the sidebar box below, the patient is initially treated with IVs and given a resting EKG before being released. He returns to the hospital the following day because none of the pain and swelling in his left leg has subsided. It is not until he returns that a different physician recognizes the need for emergency surgery to release the pressure in his leg. In addition, for multiple days this patient’s kidneys were functioning at 1/3 their normal capacity.

It is important to be aware of the possibility of compartment syndrome and rhabdomyolysis occurring. Quick recognition and treatment are key to recovering.

Lessons Learned

“You are the only one who knows your body. You therefore need to listen when it may be trying to tell you something. Take action and take the necessary steps to ensure the well-being of your own health.

After the Pack Test when my legs hurt, I shouldn’t have ‘cowboyed-up’—I should have been more of a realist about my pain.”

Injured Employee

At 0925 the Pack Test begins. On lap 10¼ (out of 12 total laps), he collapses and complains of leg pain.

He is transported to a local “critical access” hospital and is released that afternoon. The next day, he still has considerable left leg pain and seeks further medical attention. At this time, he is diagnosed with compartment syndrome/rhabdomyolysis. Over the next few weeks, the condition requires five surgeries to the patient’s lower left leg (see photo on right).

Forty-five days after the Pack Test, the employee is still on bed rest, as ordered by a physician.

[Compartment Syndrome Rhabdo FLA](#)



The Injured Employee’s left leg after his fifth surgery. Muscle has been removed and skin grafts have been performed after damage occurred due to both rhabdomyolysis and compartment syndrome that was triggered during the Pack Test—but not diagnosed or treated until later. The metal “halo” is mounted onto leg to help prevent muscle atrophy during the healing process.

4. Updated Summary of Cases

The 2016 fire season ended with 7 confirmed cases of Rhabdomyolysis and 4 reports. Since 2008, 26 confirmed cases of rhabdomyolysis in wildland firefighting have been reported. 17 were reported through the Wildland Fire Lessons Learned Center and 9 cases were logged via Safety Gram data collection and release.

In addition, more cases of rhabdomyolysis have likely occurred in the wildland firefighting profession that remain unreported. Some of these were reviewed by the Centers for Disease Control in 2010-2011 as part of an Epi-Aid investigation on rhabdomyolysis. It is not possible to conclude the extent of this condition among wildland firefighters unless more case reports are provided. The more information we have on Rhabdomyolysis the more we can understand how to prevent it in the field.

Given that each report contained unique information it was not possible to detect specific trends in cases of rhabdomyolysis. From the information provided it seems each patient varied in age, location, type of symptoms, length of symptoms, physical fitness level, recovery, and contributing factors to rhabdomyolysis. Each case is unique. There is no simple explanation for causes, prevention, or recognition. However, there are specific steps firefighters can take that will result in the prevention of rhabdomyolysis and will assure better outcomes when it arises.

5. Methods

In order to better understand incidents of rhabdomyolysis specific to the occupation of wildland firefighting, this report sought to review cases reported to the Wildland Fire Lessons Learned Center as well as cases listed on the NWCG Safety Gram archive.

The goal was to obtain information on each individual case to investigate any insightful information regarding signs, symptoms, and causes of rhabdomyolysis specific to the wildland firefighting occupation.

The Wildland Fire Lessons Learned Center was the primary source of case reports. In addition, incidents listed on the NWCG Safety Gram archive for which the Lessons Learned Center does not have any reports are included in the count of cases. The Safety Gram archive includes a one-sentence summary with the date, location, and activity of the firefighter during the incident.

The Lessons Learned Center reports varied from 2 sentences to 10 pages. All case reports varied in length, type of information given, and reporting source.

6. Rhabdomyolysis Case Findings

Rhabdomyolysis occurred in many climates and conditions and ranged in dates from March to December, indicating rhabdo can occur regardless of environmental conditions. In addition, firefighters were engaged in a variety of activities when rhabdo was presented. In 2016, 4 cases

of rhabdo presented within 4 days (May 2-May 5), 3 of these cases were on the first day of work. Rhabdo is likely to be seen during early season physical training.

Engaged Activity During 26 Cases of Rhabdomyolysis

Physical Training	Number of Cases	Fire Suppression	Number of Cases
PT Run	6	Initial Attack	2
PT Hike	2	Extended Attack	5
Other PT	6	Prescribed Burn	1
Work Capacity Test	3	Unknown	1
Total PT	17	Total Fire Suppression	9

Of the 17 Lessons Learned Center cases, 14 included more information on the details of the subjects. Of the 14 subjects, 14 were male. Both permanent and seasonal employees were diagnosed with rhabdomyolysis, ranging from a first-year firefighter to those in supervisory positions. Ages were not included in most reports.

A. Risk Factors

One or more risk factor was present in each case:

- ❖ **5 cases:** Possible nutrition deficiency and insufficient caloric intake.
- ❖ **4 cases:** Dehydration.
- ❖ **5 cases:** New or unusually difficult workout and training.
- ❖ **5 cases:** Off-season and pre-season workouts not adequate.
- ❖ **2 cases:** High temperatures during strenuous activity.
- ❖ **3 cases:** Difficult acclimation to elevation change.
- ❖ **2 cases:** Subjects took performance supplements.
- ❖ **4 cases:** Prolonged physical activity across multiple days that led to fatigue.
- ❖ **4 cases:** Use of pain relievers and anti-inflammatories to treat muscle soreness.

B. Symptoms

One or more symptoms was present in each case, however not all were reliable to lead to the suspicion of rhabdomyolysis. This was due to lack of knowledge of the condition or mildness of symptom.

- ❖ **14 Cases:** Varying degrees of muscle pain, soreness, and weakness.
- ❖ **10 Cases:** Pain levels above what is expected for the level of activity

- ❖ **4 Cases:** Disorientation and in and out of responsiveness.
- ❖ **6 Cases:** The subjects experienced dark-colored urine and little urine output.

- ❖ **2 Cases:** Vomiting and nausea.
- ❖ **3 Cases:** Rapid heart rate.

C. Previous Physical Activity

If one's physical conditioning is not adequate to meet the demands of training and firefighting, they can be at risk for rhabdo. In addition, repetitive and/or exhaustive exercises with little rest can also predispose someone to rhabdo. Rhabdo is often experienced during critical training PT.

In multiple cases, individuals who were seen as physically fit experienced rhabdo after a new type of workout or increase in activity level occurred.

- ❖ **4 Cases:** Experienced a variety of what they considered normal physical training and fire suppression activities in the days leading up to the event.
- ❖ **5 Cases:** Experienced a new or unusually difficult workout.
- ❖ **2 Cases:** The firefighters had multiple days off with no physical activity leading up to the day of the incident.
- ❖ **5 Cases:** Experienced a buildup of workouts and training that could have contributed to muscle exhaustion.

D. Response Time

Minimizing the time between onset of symptoms and medical treatment is crucial to ensure the best physical outcome. In the 14 Wildland Fire Lessons Learned Center cases with reports, 9 firefighters were treated the same day as the onset of symptoms. The others ranged from 1 to 3 days later.

Of the firefighters treated the same day, 2 experienced such extreme cramping they felt they could not walk, and 3 others had extreme cramping accompanied with disorientation. 3 of these 5 subjects had severe symptoms that indicated medical transport was needed immediately.

The 4 other subjects experienced short delays in seeking treatment at a medical facility. In 4 cases, there was no mention of rhabdo by firefighters or medical personnel on scene. In 1 case the EMT's briefly mentions a suspicion of rhabdo while transporting patient to next level of care.

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

[–Lessons Learned Review, Rhabdomyolysis leading to heat stroke](#)

3 subjects experienced muscle cramping but waited to see if pain levels would improve. 1 drove himself to a medical facility after work. 1 subject was driven back to the station. They first attempted to treat him for a heat-related illness by submerging him in ice water. Upon realizing his temperature was not elevated, they called for ambulance transport.

In terms of initial medical response, once each case was recognized as possibly severe, all firefighters and first responders took appropriate first aid measures and transported patients as quickly as possible.

Muscle Fatigue and Dark Colored Urine

In 1 case, an individual experienced muscle fatigue and weakness after a firing methods class but waited hours to report the symptoms to his supervisor until he noticed dark colored urine. He was driven to a treatment center the next morning.

In another case, an individual delayed reporting symptoms for 2 days because muscle soreness was extremely mild. It was not until he experienced dark colored urine that he reported it to his squad boss. The next morning, he reported this symptom again to the crew EMT. The foreman and superintendent suspected rhabdo and arranged for treatment.

In 2 cases in 2016, subjects experienced discolored urine, fatigue, and soreness and decided to wait overnight to see if symptoms improved before seeking treatment.

Symptoms Buildup Over 4-Day Period

The longest delayed treatment included a buildup of symptoms over a 4-day period that the individual did not recognize or report. His condition was not noticed until after a PT run where he was wobbly, pale, had trouble speaking, and was hot to the touch.

In terms of initial medical response, once each case was recognized as possibly severe, all firefighters and first responders took appropriate first aid measures and transported patients as quickly as possible.

Individuals need to listen to their body and report any abnormalities to their supervisors. Supervisors should inquire on the health status of their crew and also create an open line of communication where firefighters feel comfortable reporting issues.

It is Imperative that All Firefighters Learn the Basics of Rhabdo
If pain and symptoms are not extreme, it may be difficult to recognize a possible rhabdo case.
This is why education and communication are very important to recognize the condition as

soon as possible. It is imperative that all firefighters learn the basics of rhabdo.

Need to Ensure Early Diagnosis

“Clinicians should have a high index of suspicion for rhabdomyolysis in wildland firefighters who present for treatment for heat stress and dehydration, muscle pain, or exercise intolerance. A serum creatine phosphokinase (CK or CPK) should be performed in wildland firefighters to ensure early diagnosis so that aggressive treatment can start as soon as possible.”

–Greensheet, FAE suffered from Rhabdomyolysis

E. Diagnosis

According to the Centers for Disease Control, the recognition of rhabdomyolysis and the speed of treatment can make a huge difference in each patient’s recovery.

This is why it is not only important for firefighters to recognize possible symptoms and seek treatment but for healthcare providers to also be informed of the increased risk of rhabdo in firefighters.

The most accurate way to diagnose rhabdo is with a serum creatine phosphokinase (CK or CPK) test. This test should be requested if there is any suspicion of rhabdomyolysis. Under normal conditions, CK levels are 45- 260 IU/L [References #5].

- ❖ In the 14 case reports, 5 CPK levels were given. Their peak levels were
 - 5,580 units per liter of blood (IU/L)
 - 40,000 IU/L
 - 67,000 IU/L
 - 92,000 IU/L.
 - 99,000 IU/L
- ❖ There is not a recommendation level for a diagnosis. One study states CPK levels are classified as mild, moderate, or severe. These classifications roughly correspond to less than 10 times the upper limit of normal (or 2,000 IU/L), 10 to 50 times the upper limit of normal (or 2,000 IU/L to 10,000 IU/L), and greater than 50 times the upper limit of normal (or greater than 10,000 IU/L) [References #4].
- ❖ **The risk of renal failure increases above 5,000 to 6,000 IU/L [References #4].**
- ❖ In 2 cases, the patients were not initially tested or treated for rhabdomyolysis. One was treated for heat cramps and abnormally low blood sodium. The other was treated for dehydration and heat stroke. **Firefighters accompanying the patient urged their medical care providers to consider looking into rhabdomyolysis.**

It is not only important for firefighters to recognize possible symptoms and seek treatment but for healthcare providers to also be informed of the increased risk of rhabdo in firefighters.

“The main concern is that levels of certain proteins in my blood will cause my kidneys to shut down or fail—resulting in either a kidney transplant or dialysis.”

–Rapid Lesson Sharing, Onset of Rhabdo during physical training

F. Treatment and Recovery

Depending on the severity of the condition, patients were treated in a hospital from 1 day to 2 weeks. Many had follow-up outpatient testing and monitoring. In the hospital, most were treated with IV fluids and pain medications.

2 of the 14 subjects had to undergo kidney dialysis treatment. Only a few of the cases mentioned recovery time, which greatly varied. One subject who was released from the hospital the same day, had 2 follow up tests and was released to full duty 4 days later. Another subject had protein levels return to an acceptable level three weeks after the incident and returned to full duty. The longest reported recovery time was 6 weeks until returning to full duty.

While recovery time depends on a case-by-case basis, it can be significantly shortened if rhabdomyolysis is treated quickly.

Undergoing Kidney Dialysis

Another patient underwent kidney dialysis three times a week for seven weeks, reduced to once a week at the time this report was written.

He was projected to make a full recovery.

This patient also lost 35 pounds, mostly comprised from loss of muscle tissue broken down by rhabdomyolysis.

These lessons suggest there are specific actions that agencies, supervisors, and firefighters can take to prevent and respond to rhabdo effectively.

7. Recommendations

Throughout the 14 Wildland Fire Lessons Learned Center rhabdomyolysis reports, some common lessons arose. These lessons suggest there are specific actions that agencies, supervisors, and firefighters can take to prevent and respond to rhabdo effectively.

A. Awareness and Education

Each firefighter should receive education on rhabdomyolysis, its risk factors, signs and symptoms.

- ❖ Here is a link to quick, helpful information for firefighters: [Rhabdomyolysis fact sheet for firefighters](#) .

“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.”

–Lessons Learned Review, Rhabdomyolysis leading to heat stroke

- ❖ Prevention strategies are key. It is important to maintain proper hydration, caloric intake, and meet nutritional needs. Supervisors should be supported with materials that they can use to educate crews on strategies to accomplish this.
- ❖ Supervisors should give clear direction on each firefighter’s responsibility in taking care of their own health and monitoring the health of fellow firefighters.

B. Listen to Your Body!

A firefighter should seek medical attention if any of the following arise:

- ❖ Muscle pain is unusual or extreme.
 - ❖ Signs and symptoms (listed on page 4) are occurring.
 - ❖ Soreness is elevated in comparison to level of activity.
 - ❖ The firefighter has one or more risk factors and is showing signs and symptoms.
-

“Know your limits and listen to your body. It’s OK to push yourself. But realize when something is wrong—and stop. Remember that it’s OK to be ‘that guy’ who stops—if you do it for the right reasons. Also, prepare for the season with the same level of intensity as your PT sessions will be. I didn’t do that as well as I should have.”

–Rapid Lesson Sharing, Rhabdo incident during PT

C. Open Communication and Monitoring

- ❖ Employees and supervisors should work to keep open communication from the beginning to the end of fire season about employee’s health, fitness level, and any possible physical ailments.
- ❖ Crewmembers can consider keeping accountability and monitoring one another to ensure each member stays in the best health status possible. In addition, by paying attention to the normal physical status of their coworkers, crewmembers will become more keenly aware if an unusual symptom arises.
- ❖ Wildland firefighting is a tough job and firefighters will become uncomfortable, experience pain, soreness, and other ailments on the job. However, each module

***Units should consider conducting a refresher or
medical scenario on rhabdomyolysis, or even creating a specific
medical plan for rhabdomyolysis.***

should work to create a culture in which it is acceptable to report physical ailments that seem out of the ordinary for the job.

D. Readiness of Medical Supplies and Medical Plans

- ❖ During the Work Capacity Test (Pack Test), all physical training, and firefighting, all firefighters and medical responders should be prepared to recognize a potential rhabdomyolysis case and respond appropriately.
- ❖ Units should consider conducting a refresher or medical scenario on rhabdomyolysis, or even creating a specific medical plan for rhabdomyolysis.

E. Ensure Medical Providers Test for Rhabdomyolysis

- ❖ Instruct those patients admitted to a treatment center or someone accompanying the patient to inform medical providers they are at an increased risk for rhabdomyolysis due to their occupation, and request a CPK test.
- ❖ Print and carry the “Hand Out” for physicians provided on Page 18! (This link takes you directly to Page 18: “Physicians Handout”.)

F. Reporting Procedures

- ❖ **Reports are vital to educate firefighters, and can directly influence positive factors in responding to future cases**
- ❖ To study cases of rhabdomyolysis effectively and gain more insight into similarities and trends in cases, a surveillance system should be put in place to gather detailed and standardized information from each case.
- ❖ If each case report includes the same type of information it can be studied and compared. This will allow research on specific risk factors, symptoms, and the overall incidence of rhabdomyolysis.

G. PT Program Considerations

While rhabdomyolysis can happen in individuals regardless of their fitness level, there are ways in which physical training can be adjusted to reduce the rhabdomyolysis risk.

- ❖ Supervisors should consider that at the beginning of the season employees may need to acclimatize and transition into arduous physical activity slowly.

- ❖ Firefighters should also continue to train in the off-season and take responsibility to be at the proper fitness level for their job. Supervisors and crewmembers should communicate about what is expected when reporting to work.
- ❖ Incorporate total health and wellness into physical training which includes proper nutrition, hydration, and sleep habits. In addition, a proper rest/work cycle should be incorporated into PT plans.
- ❖ When the heat stress index is high or environmental conditions are adverse, PT and training should be adjusted to lower the risk of heat injuries.
- ❖ Supervisors should consider designing a PT program that not only conditions for the job duties but that also avoids repetitive exercise routines. Because new types of workouts can put firefighters at risk for rhabdomyolysis, it is important to introduce novel training slowly and understand it may not work for all crewmembers. In addition, crewmembers can train in the off-season with a similar program to ensure readiness.

8. Conclusions

Rhabdomyolysis will continue to arise in wildland firefighters.

It is therefore necessary that they are best equipped to deal with this medical emergency.

In the 14 Wildland Fire Lessons Learned Center's reported rhabdomyolysis cases, the most significant issues are related to:

- ❖ The buildup of risk factors,
- ❖ Recognition of symptoms, and
- ❖ Delays in reporting and treatment.

Firefighter education and awareness has helped the response to Rhabdo become more effective, decreases the chances of complications and recovery time. Please educate yourself and your fellow firefighters.

If all cases were reported and the same type of information was given, it would become easier to target similarities among cases, and further prevent cases from arising.

All of these 14 rhabdomyolysis cases occurred during or after strenuous physical activity—which is unavoidable in the wildland firefighting job. However, firefighters can follow the recommendations outlined in this report—in addition to other precautions—to best prevent and respond to rhabdomyolysis.

Webinar Discussion

This insightful discussion on rhabdomyolysis, compartment syndrome, and exertional heat illness—that includes myth busting—features a firefighter rhabdo victim/survivor as well as helpful insights from medical and physiology experts Dr. Joe Domitrovich and Dr. Jennifer Symonds:

<http://bit.ly/ExertionRhabdoWebinar>

9. References

1. Bhalla, Mary Colleen, and Ryan Dick-Perez. "Exercise Induced Rhabdomyolysis with Compartment Syndrome and Renal Failure." *Case Reports in Emergency Medicine* 2014 (2014): 735820. *PMC*. Web.
2. Clarkson, Priscilla M., and E. Randy Eichner. "Exertional Rhabdomyolysis." *Current Sports Medicine Reports* 5.2 (2006): 57-60. Web.
3. Clarkson PM, Hubal MJ: Exercise-induced muscle damage in humans. *Am J Phys Med Rehabil* 2002, 81(11 Suppl): S52–S69.
4. Criddle, L. M. "Rhabdomyolysis. Pathophysiology, Recognition, and Management." *US National Library of Medicine. National Institutes of Health* 6 (2003). Web.
5. Efstratiadis, G. et al. "Rhabdomyolysis Updated." *Hippokratia* 11.3 (2007): 129–137. Print.
6. "Health Information Library: Compartment Syndrome." *Orthopedics Center - Penn State Hershey Medical Center*. Web.
7. Khan FY [2009]. Rhabdomyolysis: a review of the literature. *Netherlands J Med* 67(9): 272-283.
8. Latham and Nichols. How Much can Exercise Raise the CK level – and does it matter? *The Journal of Family Practice*. Vol: 57 (8) 545-546.
9. Line RL, Rust GS [1995]. Acute exertional rhabdomyolysis. *Am Fam Phys* 52(2): 502-506.
10. Melli, Giorgia, Vinay Chaudhry, and David R. Cornblath. "Rhabdomyolysis: An Evaluation of 475 Hospital Patients." *Medicine* 84.6 (2005): 377-85. Web.
11. NWCG [2011]. Rhabdomyolysis Epidemiological Study Results and Recommendations. National Wildfire Coordinating Group. Risk Management Subcommittee. Boise ID.
12. NWCG [2011]. Rhabdomyolysis in Wildland Firefighters. National Wildfire Coordinating Group. Boise ID
13. NWCG [2011]. Rhabdomyolysis: What Firefighters Need to Know. National Wildfire Coordinating Group. Boise ID

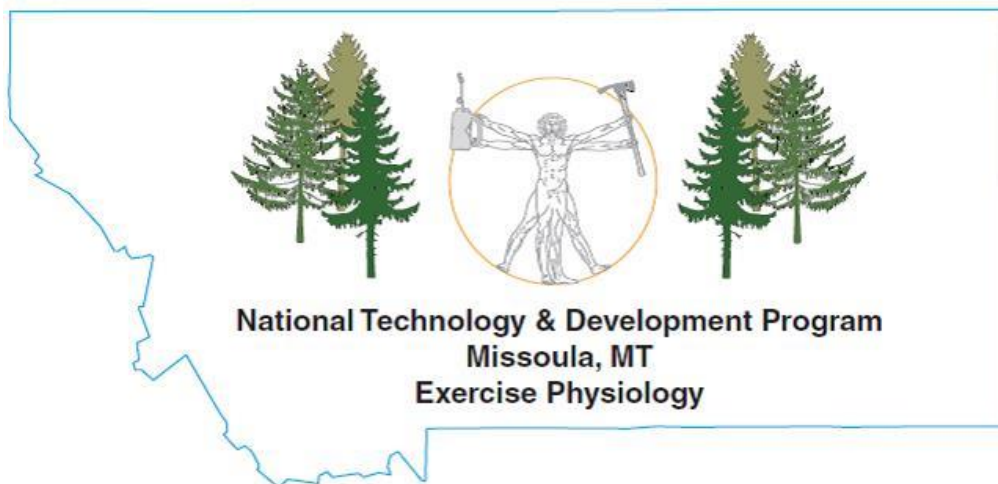
14. *2014 Incident Review Summary*. Rep. Tucson, AZ: Wildland Fire Lessons Learned Center, 2014. Print.

15. *2013 Incident Review Summary*. Rep. Tucson, AZ: Wildland Fire Lessons Learned Center, 2013. Print.

10. Compartment Syndrome and Rhabdomyolysis Hand Out for Medical Providers

**The hand out on the following page
is designed for you to print out and carry
with you in the field.**

**Send this hand out with your firefighter
to the medical provider
if you suspect exertional non-traumatic compartment syndrome or
rhabdomyolysis.**



Note: Crew leaders should print this page and carry it with them. In the event of a potential case of rhabdomyolysis, bring this sheet with you to the hospital, clinic, etc.

Exertional Non-traumatic Compartment Syndrome and Rhabdomyolysis in Wildland Firefighters

This wildland firefighter is presenting to your Emergency Department for evaluation of muscle pain along with possibly heat illness. Our wildland firefighters in the last several years have had an increased incidence of exertional non-traumatic compartment syndrome as well as rhabdomyolysis because of the prolonged exertion during fire response duties and training, carrying heavy loads (up to 110 lbs.) and arduous exertion for long periods of time across steep terrain. Several cases have become permanently disabling.

These firefighters tend to be stoic in regards to their injuries and pain, and don't normally complain of much until they can't deal with it. As a result, the pain tends to be an acute onset complaint. These two diagnoses are rare, often initially misdiagnosed, and difficult to identify, but please consider them high in your differential, so that we can keep these firefighters doing a job they love.

Classic signs/symptoms:

- Muscle pain/cramping
- Swelling of affected area of limb
- Weakness/decreased ROM of affected limb
- Dark, tea colored urine in rhabdomyolysis

Consider:

- Check serum CPK
- Value is considered positive if 5X's greater than the upper limit of that assay's reference range or above 1000 IU/L²
- If normal but high suspicion, admit for observance and serial CPK's q6hr x 12- 24 hr¹

1. Criddle LM [2003], Rhabdomyolysis: Pathophysiology, Recognition, and Management. Crit Care Nurse 23(6):14-30.
2. Khan FY [2009], Rhabdomyolysis: A Review of the Literature. Netherlands J Med 67(9):272-283.