

**Preliminary Report:**  
**Cluster of Compartment Syndrome and Rhabdomyolysis**  
**Among McMinnville High School Football Team**

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## Summary

On 23 Aug 2010, the Oregon Public Health Division (OPHD), in coordination with Yamhill County Health Department, began investigating a cluster of triceps compartment syndrome and rhabdomyolysis among McMinnville High School football team members with onset of illness during the previous week. (Compartment syndrome, typically resulting from muscle injury, is characterized by abnormally high pressures in an enclosed muscle compartment that impedes adequate blood circulation; it is a surgical emergency. Rhabdomyolysis is muscle injury that can lead to kidney failure and death.) OPHD investigated this cluster in order to: 1) confirm the diagnoses and spectrum of illnesses; 2) identify contributing factors leading to illnesses; 3) derive information to help ensure the safety of participants in organized sports and prevent similar illnesses from recurring. Oregon Administrative Rule 333-018-0015 authorizes OPHD to conduct public health investigations of any “uncommon illness of potential public health significance”. This *preliminary* report summarizes the OPHD investigation as of 2 Sep 2010.

OPHD conducted interviews with team members, coaches, school administrators, hospital administrators, and physicians; and reviewed the hospital medical records for all team members cared for at Willamette Valley Medical Center (WVMC). OPHD also systematically assessed symptoms, exposures, and activities among team members. Following several hospitalizations of team members from 17-19 Aug 2010, WVMC offered creatine kinase (CK) testing (a blood test marker of muscle injury) of all team members on 19-20 Aug 2010 at McMinnville High School.

Among 43 team members participating in the varsity “immersion” football camp held the week 15 Aug 2010, 3 had triceps compartment syndrome, defined as a team member clinically diagnosed with this condition and treated with surgery, an additional 5 had rhabdomyolysis with muscle pain and CK > 23,200 U/L (100 times the upper limit of normal for WVMC laboratory), and 14 others had rhabdomyolysis with muscle pain and CK between 2,320 U/L (10 times the upper limit of normal) and 23,200 U/L. Of the 22 team members with triceps compartment syndrome and/or rhabdomyolysis, all

had muscle-related symptoms referable to the upper arm, 12 were hospitalized, and none had kidney failure. CK testing at McMinnville High School identified 16 of the 22 cases.

OPHD reviewed an upper arm exercise held on 15 Aug 2010 at approximately 1600 PDT in the high school wrestling room. The “team building” exercise involved repetitive, intensive, alternating chair dips and push ups for an estimated 4-5 minutes. It had been used by the head coach with previous teams dating back to 2003 without incident. Team members characterized this exercise as challenging but within the boundaries of pre-season conditioning. The temperature in the non-air conditioned wrestling room was not measured at the time of the exercise drill; however, the temperature recorded at McMinnville Municipal Airport at 1553 PDT was 92°F. While water was available and coaches encouraged consumption during the camp, most team members did not consume water during the exercises in the wrestling room.

Team members did not report use of illicit or performance enhancing drugs. Serum creatine levels, which do not distinguish creatine supplementation from dietary or endogenous creatine, were inconclusive. On preliminary review, OPHD did not find patterns suggesting an association with illness from specific prescription medications or nutritional supplements. Facilities assessment did not find any evidence that other environmental factors, including water quality, carbon monoxide, or volatile organic compounds, contributed to the illnesses. There was no evidence that infections or contaminated food or drinks were associated with illness.

OPHD concluded that multiple factors likely contributed to the cluster of triceps compartment syndrome and rhabdomyolysis, foremost among them an intense, short-duration, repetitive burst of resistance exercise on Sun 15 Aug 2010 that focused on a single muscle compartment. Additional contributing factors included environmental stress from heat and unrecognized dehydration.

Based on this preliminary report, OPHD recommends that:

1. Oregon coaches, trainers, school administrators, health professionals, parents, and recreational athletes recognize that intense, short-duration, repetitive resistance exercise involving a single muscle compartment can lead to serious health complications, particularly during exercise conditions with higher risk of heat stress and inadequate hydration.
2. Both during and outside of official sports seasons, Oregon coaches, trainers, and school administrators routinely and explicitly assess potential health and safety hazards to student-athletes, and implement appropriate countermeasures as warranted, such as activity modification, rest breaks, and hydration.

## **Background**

On Monday, 23 Aug 2010, in coordination with Yamhill County Health Department, OPHD began investigation of a cluster of triceps compartment syndrome and rhabdomyolysis among McMinnville High School football team members with onset of illness the previous week.

OPHD investigated this cluster in order to:

- 1) confirm the diagnoses and spectrum of illnesses,
- 2) identify contributing factors leading to illnesses,
- 3) derive information to help ensure the safety of participants in organized sports and prevent similar illnesses from recurring.

Oregon Administrative Rule 333-018-0015 authorizes OPHD to conduct public health investigations of any “uncommon illness of potential public health significance”.

This *preliminary* report summarizes the OPHD investigation as of 2 Sep 2010.

## **OPHD Investigational Methods**

The OPHD field investigative team visited WVMC and/or McMinnville High School on 23, 24, 27, and 29 Aug 2010. An OPHD industrial hygienist augmented the team on a site visit of the school facilities on 27 Aug 2010, and recorded real-time measurements of carbon monoxide, carbon dioxide, and volatile organic compounds (VOCs).

OPHD reviewed the hospital medical records for all football team members who were hospitalized and/or seen in the emergency department, focusing on physician notes, laboratory results, and clinical outcomes. In addition, OPHD reviewed the CK results for all team members who underwent testing on 19-20 Aug 2010. OPHD held phone or in-person interviews with selected physicians involved in care of the team members, including the two orthopedists who performed the operations and the hospitalist/football team physician involved in the inpatient management of many of the hospitalized

team members. At least 7 WVMC medical staff contributed to admission or emergency department examinations.

Meetings and interviews were held with WVMC administrators, McMinnville School District superintendent, high school principal, athletic director, facilities director, football coaching staff, and team members. OSAA provided information on heat index rules. OPHD was also invited to a football parents meeting on 24 Aug 2010 that involved a question-and-answer session with three Oregon physicians from outside Yamhill County with expertise in sports medicine and nutrition. During and after this meeting, OPHD addressed team member parents' questions and concerns.

OPHD developed a standardized questionnaire that systematically assessed symptoms, exposures, and activities; attempts were made to interview all team members by phone or in person. Phone interviews with student-athletes commenced 26 Aug 2010. To increase the number of respondents, with the permission of the head coach, two OPHD epidemiologists conducted in-person interviews concurrent with team film study on 29 Aug 2010. All interviews were conducted privately. Student-athletes and parents were instructed that individual responses were confidential, non-attributable, and not reportable to school, parental, and legal authorities. As of 2 Sep 2010, questionnaires were completed by 40 of 43 team members.

### **Summary of Events at McMinnville High School Football Camp – Sun 15 Aug 2010 – Fri 20 Aug 2010**

Source: Interviews with coaching staff and team members; temperature data at McMinnville from National Weather Service (McMinnville Municipal Airport, elev. 157 ft.)

**Sun 15 Aug 2010** – Beginning of football “immersion” camp at McMinnville High School. The overnight camp was restricted to 10<sup>th</sup>, 11<sup>th</sup>, and 12<sup>th</sup> grade football team members. After the team dropped off personal items in White Gymnasium (sleeping quarters for the camp), team members warmed up on the football field and completed several timed sprints. At approximately 1600 PDT, the team moved to the

indoor wrestling room to perform an exercise drill that the head coach had used numerous times with previous teams. The intent of the drill, as described by the head coach, was primarily to build team unity and accountability to other team members. None of the assistant coaches had prior experience with this drill. Team members voluntarily picked partners for the exercise drill. The first exercise was described as a chair dip/push up exercise. The first partner, with second partner spotting, performed chair dips using the folding chair as support for 30 seconds, immediately followed by pushups for 30 seconds. This sequence was repeated in consecutively shorter intervals: 20 seconds, 10 seconds, 7 seconds, 5 seconds, with no scheduled rest periods. For incorrect performance by any team member, the exercise was suspended and then re-started by all team members at the beginning of the exercise component and time interval that team members had been engaged in at the time of suspension. The spotting partner was responsible for providing support for muscle fatigue and assist in both the concentric and eccentric phases of muscle contraction. The targeted muscles during the drill were the triceps, pectoralis major, and deltoids. After the first group completed the exercise, the roles were switched. The exercise, without transition time, lasts 144 seconds. The actual estimated time for one partner to complete the exercise, including transition time and repeated interval times, was approximately 4-5 minutes. The second exercise focused on abdominal and leg muscles, and incorporated a similar timed format. The total amount of time in the wrestling room was estimated as 20-25 minutes. Team members characterized the arm exercise as challenging but within the boundaries of pre-season conditioning. Water was available and consumption encouraged by coaches throughout the camp, but most team members did not consume water while they were in the wrestling room. The temperature in the non-air conditioned wrestling room that day was not available; the temperature in McMinnville at 1553 PDT was 92°F. Team members slept at home. High/Low temperature: 94°F/53°F.

**Mon 16 Aug 2010** – 2<sup>nd</sup> day of football camp. Practices were held throughout the day, with conditioning work in the form of sprints held in the evening. Team members began to sleep at the high school gymnasium that night. High/Low temperature: 94°F/54°F.

**Tue 17 Aug 2010** – An assistant coach transported a team member with arm pain and swelling to a physician appointment. The first case of compartment syndrome was diagnosed. A light weightlifting session was held in the morning. Practices were again held throughout the day. No conditioning drills were reported. High/Low temperature: 88°F/57°F.

**Wed 18 Aug 2010** – Five more team members were hospitalized, including 2 additional cases of compartment syndrome. In the evening, the remainder of team was briefly screened for compartment syndrome at the high school by one of the treating WVMC orthopedists. No additional suspect compartment syndrome was identified. High/Low temperature: 76°F/50°F.

**Thu 19 Aug 2010** – No outdoor or indoor exercise drills were held. WVMC sponsored voluntary CK testing of all team members in the evening; 28 team members underwent testing.

**Fri 20 Aug 2010** – An additional 6 team members and 5 coaches underwent CK testing. Parents were notified of CK results. Team members with CK > 3000 U/L were advised to seek emergency care at WVMC. This led to 6 additional hospitalizations, and 10 other team members seen in the WVMC emergency department only. Football camp closed on 20 Aug 2010, one day prior to scheduled conclusion.

### **Findings of OPHD Investigation:**

#### Description of Cases:

Among 43 team members participating in the varsity “immersion” football camp held the week 15 Aug 2010, 3 had triceps compartment syndrome, 5 others had rhabdomyolysis with CK > 23,200 U/L (100 times the upper limit of normal for WVMC laboratory), and 14 others had rhabdomyolysis with CK

between 2,320 U/L (10 times the upper limit of normal) and 23,200 U/L. Of the 22 team members with triceps compartment syndrome and/or rhabdomyolysis, all had muscle-related symptoms referable to the upper arm, 12 were hospitalized, and none had kidney failure. CK testing at McMinnville High School identified 16 of the 22 cases.

Toxicology data:

Team members did not report use of illicit or performance enhancing drugs. Urine toxicology testing was not done during hospitalization and emergency department evaluation. Serum creatine levels, which do not distinguish creatine supplementation from dietary or endogenous creatine, were inconclusive. On preliminary review, OPHD did not find patterns suggesting an association with illness from specific prescription medications or nutritional supplements.

Potential environmental sources of illness:

OPHD investigated school facilities, including the gymnasium, wrestling room, football field, school locker room, cafeteria, and food court. Several persons questioned whether environmental factors may have contributed to illness, including water, sewer work, mold, and floor finishing products. An OPHD industrial hygienist accompanied the investigative team on 27 Aug 2010 (high temperature that day was 76°F) and toured the facilities. Real-time measurements were taken for carbon monoxide, carbon dioxide, and volatile organic compounds (VOCs). VOC samples addressed concerns that White gymnasium had an offensive chemical smell attributed to recent refinishing. All VOC samples were non-detectable. In addition, there was no source of VOCs identified. There was no carbon monoxide present in any area. Carbon dioxide (CO<sub>2</sub>) samples were taken as a surrogate indicator of adequate ventilation; excessive CO<sub>2</sub> levels can indicate a lack of fresh air. All CO<sub>2</sub> levels were below 400 ppm, including background levels that were taken outside. The OPHD investigators noted that the wrestling room seemed less ventilated than other indoor areas visited.

Other causes of rhabdomyolysis:

Through medical record review and interviews, OPHD did not find trauma, genetic defects, infections, and metabolic or electrolyte derangements contributed to this cluster of rhabdomyolysis.

Other findings of significance:

Compliance with OSAA rules pertaining to heat index calculation, recordkeeping, and practice restrictions was not mandatory during the football immersion camp. These rules were enforceable to OSAA member schools beginning on 23 Aug 2010, the first official day of high school football practice. Prior to 23 Aug 2010, McMinnville High School athletics did not record the heat index, which is typically done by a school athletic trainer during the official season. The heat index on 15 Aug 2010, based on conditions at 1553 PDT (temperature of 92°F, dew point of 59°F, relative humidity of 33%) was 91°F. For heat index < 95°F, OSAA recommendations include: “maximum of 5 hours of practice today, provide ample amounts of water, water should always be available and athletes should be able take in as much water as they desire, watch/monitor athletes for necessary action.” The short duration of team exercises that day, comprising two timed sprints on the football field followed by the resistance exercises in the wrestling room, were not considered high operational risk for heat-related illness. No specific safety briefings on Sun 15 Aug 2010 addressing heat were reported by the coaching staff.

**Discussion**

Compartment syndrome and rhabdomyolysis both result from muscle injury. Trauma and exertion are known precipitants of these conditions. Upper arm acute compartment syndrome is extremely rare, however, and its occurrence following exertion is novel. In contrast, rhabdomyolysis secondary to exertion and/or heat-related illness has been well described in the medical literature, especially in athletes and military recruits. Eccentrically based activities, performed while the muscle elongates while under tension (“negatives”), pose a particular risk for rhabdomyolysis.

Although the CK threshold for diagnosing rhabdomyolysis has been proposed as 5-10 times the upper limit of normal, conditioned athletes who have had CK measured post-exertion in a non-clinical setting can have very high CK values. In one study of college football players in preseason practice, the average CK was 5,125 U/L, 30 times the norm for men. The CK testing on 19-20 Aug 2010 conducted at the high school likely contributed to case finding. OPHD was unable to determine how many of the 16 rhabdomyolysis cases who were first identified through this CK testing would have sought medical care in the absence of the testing.

OPHD was unable to find any evidence that the cluster of compartment syndrome and rhabdomyolysis resulted from a primary cause that was not exertion-related.

OPHD concluded that multiple factors likely contributed to the cluster of triceps compartment syndrome and rhabdomyolysis, foremost among them an intense, short-duration, repetitive burst of resistance exercise on Sun 15 Aug 2010 that primarily involved a single muscle compartment. Additional contributing factors likely included environmental stress from heat and unrecognized dehydration. Although compartment syndrome is distinct from rhabdomyolysis, OPHD concluded that similar factors contributed to both conditions; all three cases of compartment syndrome also had rhabdomyolysis. Although uncommon, prior case reports have also found rhabdomyolysis among conditioned athletes can result from similar intense, short-duration, repetitive resistance exercises focused on a single muscle compartment.

OPHD reiterates that this report is *preliminary*; additional analyses are planned to better characterize this cluster of illness.

Based on this preliminary report, OPHD recommends that:

1. Oregon coaches, trainers, school administrators, health professionals, parents, and recreational athletes recognize that intense, short-duration, repetitive resistance exercise involving a single

muscle compartment can lead to serious health complications, particularly during exercise conditions with higher risk of heat stress and inadequate hydration.

2. Both during and outside of official sports seasons, Oregon coaches, trainers, and school administrators routinely and explicitly assess potential health and safety hazards to student-athletes, and implement appropriate countermeasures as warranted, such as activity modification, rest breaks, and hydration.