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***Case Report***

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# Elite athlete with rhabdomyolysis after a world extreme conditioning competition: A case report

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## Abstract

Stress rhabdomyolysis is especially common after extreme conditioning exercise programs, such as CrossFit®. This study aimed to better understand the conditions surrounding rhabdomyolysis in elite CrossFit® athlete to prevent new cases. Blood tests, abdominal ultrasound, and urine summary of a 36-year-old CrossFit® athlete were analyzed after an injury during the first match of the last day of a world competition (Reebok CrossFit Games® 2018). On the day of the injury, great abdominal distension was noted. The creatine kinase (CK) values were 42,040 U/L, and after 72 h, these values reached 82,443 U/L. After 6 days, abdominal ultrasound was performed to identify areas of hemorrhage and rupture in the rectus abdominis bilaterally and throughout. After 8 days, blood tests showed elevated levels of enzymes other than CK, such as aspartate transaminase (AST) and alanine transaminase (ALT). Elevated lactate dehydrogenase (LDH) and CK levels were also observed. The urine summary showed an increase in the red blood cell level and the presence of hemoglobin. After 15 days, the examinations were repeated, and the AST, ALT, LDH, and CK levels decreased by 92.6%, 72.7%, 71.7%, and 99.6%, respectively. Thus, suspected rhabdomyolysis was confirmed.

**Keywords:** Rhabdomyolysis, CrossFit, High-intensity interval training, Exercise-induced injury.

## INTRODUCTION

Effort rhabdomyolysis continues to be reported with some frequency, despite the efforts made by the medical and research communities to provide guidance for prevention. Rhabdomyolysis causes damage to the muscles. It was first identified during the Second World War in 1941, when people with limb injuries survived the initial injury and subsequently died of kidney failure [1]. There are numerous causes of rhabdomyolysis, including those that developed due to exertion. The condition generally becomes clinically relevant when there is severe pain, swelling, or muscle weakness. Large amounts of muscle proteins such as creatine kinase (CK), lactate dehydrogenase (LDH), and myoglobin are released into the blood. Myoglobin is also present in the urine, in addition to other manifestations considered part of rhabdomyolysis. These proteins, especially myoglobin, can precipitate in the kidneys, causing oxidative stress and nephrotoxicity, ultimately resulting in acute renal failure [1, 2].

Stress rhabdomyolysis has been reported in numerous cases after intense exercise [3]. The condition involves various scenarios, ranging from military training, extreme unsupervised training, and marathons, to other risk factors, such as nutritional status (dehydration), type of muscle contraction (eccentric), and environmental conditions (extreme heat or cold), among others [1]. In terms of physical exercise, extreme conditioning programs have become very popular. Characterized by functional movements performed at high intensities with constant variations, these programs may involve movements of Olympic weightlifting (snatch, clean, and jerk), gymnastics (pull-ups, ring muscle-ups, and handstands), and aerobic training (rowing, cycling, and running), alone or in combination [3]. It is necessary to better understand the conditions contributing to rhabdomyolysis in extreme conditioning programs, such as CrossFit®, and to prevent new cases. As reported by Tibana *et al.* [3], the best treatment is prevention.

## CASE PRESENTATION

A 35-year-old female athlete presented with rhabdomyolysis after a competition. She has been competing

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in martial arts for more than 15 years and in CrossFit® competitions for 5 years and was training six times a week for 2-3 h a day. The athlete provided written informed consent for the publication of this case study. Table 1 shows the anthropometric, physiological, and metabolic characteristics of the athlete assessed before the competition. She participated in a worldwide competition, with athletes from different countries. It is considered the most important worldwide competition in CrossFit® (Reebok CrossFit Games® 2018). The competition took place between the 1st and 5th of August 2018. The tests conducted in the competition are listed in Table 2.

**Table 1:** Characteristics of the athlete

| | |
|---|---|
| **Anthropometry** | |
| Height (m) | 1.74 |
| Weight (kg) | 70.6 |
| Body mass index (kg/m$^2$) | 23.3 |
| Arm circumference (cm) | 30.8 |
| Waist circumference (cm) | 72.0 |
| Hip circumference (cm) | 95.0 |
| Thigh circumference (cm) | 54.5 |
| Calf circumference (cm) | 37.6 |
| **Skinfolds Measured By Adipometer** | |
| Tricipital (mm) | 8 |
| Medial thigh (mm) | 12.5 |
| Medial calf (mm) | 9.5 |
| **Anatomical Points Measured By Ultrasound** | |
| Thoracic (mm) | 1.9 |
| Scapula (mm) | 3.6 |
| Axillary (mm) | 1.8 |
| Triceps (mm) | 3.9 |
| Abdominal (mm) | 3.4 |
| Suprailiac (mm) | 4.8 |
| Medial thigh (mm) | 6.0 |
| Medial calf (mm) | 4.5 |
| **Body Composition** | |
| Body fat percentage (%) | 12.6 |
| Body fat (kg) | 8.9 |
| Fat-free mass (%) | 87.4 |
| Fat-free mass (kg) | 61.7 |
| Skeletal muscle mass (%) | 42.06 |
| Skeletal muscle mass (kg) | 29.7 |
| **Physiological Characteristics** | |
| Systolic blood pressure (mmHg) | 120 |
| Diastolic blood pressure (mmHg) | 80 |
| Mean blood pressure (mmHg) | 93.3 |
| Resting heart rate (bpm) | 55 |
| Maximum heart rate (bpm) | 183 |
| O2 saturation (%) | 99.0 |
| Body temperature (°C) | 37 |
| **Metabolic Characteristics** | |
| Resting energy expenditure (kcal) | 2203 |
| $VO_2$ at rest (mL/min) | 319 |
| $VCO_2$ at rest (mL/min) | 247 |
| Respiratory quotient | 0.77 |
| VO2 - 1 MET estimated (mL/kg/min) | 4.25 |
| Fraction of expired $VO_2$ (%) | 16.89 |
| Tidal volume (L) | 0.63 |
| Minute ventilation (L/min) | 10.6 |
| Respiratory rate (n) | 17.4 |

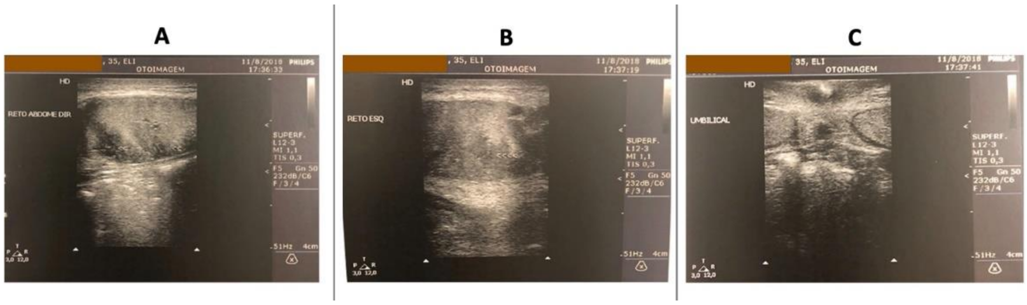
**Note**: $VO_2$: consumption of oxygen; $VCO_2$: carbon dioxide production; MET: metabolic equivalents

**Table 2:** Schedule of events in the CrossFit® Games 2018

| Wednesday | Thursday | Friday | Saturday | Sunday |
|---|---|---|---|---|
| 500-m run<br>Obstacle course run | Rest day | 3 attempts to establish 1 rep-max shoulder-to-overhead | 5 rounds:<br>6 ring muscle-ups<br>3 back squats (84 kg)<br>Then, 30 box jump-overs after 5 rounds | 3 rounds:<br>30 medicine-ball (6 kg) GHD sit-ups<br>10 sandbags clean (45 kg) |
| - 12-m handstand walk obstacle course<br>- 20 wall-ball shots (9 kg)<br>- 12-m handstand walk obstacle course | | 2 rounds:<br>1000-m row<br>750-m SkiErg<br>50 dumbbell squats | 500-m swim | 7/7/7 bar muscle-up, chest-to-bar pull-ups and chin-over-bar pull-ups<br>21 thrusters (29 kg)<br>5/5/5 bar muscle-up, chest-to-bar pull-ups and chin-over-bar pull-ups<br>15 thrusters<br>3/3/3 bar muscle-up, chest-to-bar pull-ups and chin-over-bar pull-ups |
| 4 rounds:<br>- 50 double-unders<br>- 5/4/3/2 snatch<br>[5 (52 kg)/ 4 (56 kg)/<br>3 (61 kg)/ 2 (65 kg) snatch] | | 4 rounds:<br>300-m run<br>4/3/2/1 rope climbs<br>13-m yoke carry (172 kg) | 30 deficit handstand push-ups<br>40 deadlifts (70 kg)<br>50-cal BikeErg<br>60 bar-facing burpees | |

**Note**: GHD: glutes-hamstring developer; m: meter

The defining moment for the athlete's injury occurred in the first race of the last day of competition. Great abdominal distension was obvious. The CK values were 42,040 U/L, and after 72 h, these values reached 82,443 U/L. After 6 days, an abdominal ultrasound was performed (Figure 1) and showed bilateral areas of hemorrhage and rupture in the rectus abdominis and all its extension, with signs of inflammation in the adjacent subcutaneous planes.




Note: 1A: Right abdominal rectus muscle; 1B: Left abdominal rectus muscle; 1C: Umbilical image

**Figure 1:** Abdominal ultrasound.

After 8 days, blood tests (Table 3) showed elevated enzymes other than CK, including aspartate transaminase (AST) and alanine transaminase (ALT). Elevated LDH and CK levels were also observed. After 15 days (Table 3), the tests were repeated. The AST and ALT levels decreased by 92.6 and 72.7%, respectively. The LDH level also decreased to 157 U/L and CK level to 284 U/L (99.6% reduction). The urine summary (Table 4) showed an increase in the levels of red blood cells and hemoglobin. Twelve days after the first abdominal ultrasound examination, a new examination was performed and compared to the previous examination. There was no characterization of superficial inflammatory processes, muscle injuries, or peripheral hematomas.

**Table 3:** Blood tests performed 8 and 15 days after the event

| **Blood Tests** | **Reference values** | **8 days after the event** | **15 days after the event** |
|---|---|---|---|
| Prothrombin time | 9.8 to 14.8 s | 11.1 s | - |
| Activated partial thromboplastin time | Until 40 s | 22.7 s | - |
| Sodium | 132 to 146 mEq/L | 142 mEq/L | - |
| Potassium | 3.5 to 5.5 mEq/L | 4.3 mEq/L | - |
| Magnesium | 1.3 to 2.7 mg/dL | 2.0 mg/dL | - |
| Phosphorus | 2.5 to 4.8 mg/dL | 3.8 mg/dL | - |
| Chlorine | 99 to 109 mEq/L | 106 mEq/L | - |
| Uric acid | 3.1 to 7.8 mg/dL | 4.2 mg/dL | - |
| Urea | 15 to 50 mg/dL | 39 mg/dL | - |
| Creatinine RFG: > 60 ml/min/1.7 $m^2$ | 0.6 to 1.1 mg/dL | 1.05 mg/dL | - |
| Aspartate transaminase (AST) | 5 to 40 U/L | 456 U/L | 29 U/L |
| Alanine transaminase (ALT) | 10 to 49 U/L | 513 U/L | 140 U/L |
| Lactate dehydrogenase (LDH) | 120 to 246 U/L | 555 U/L | 157 U/L |
| Creatine kinase (CK) | 33 to 211 U/L | 18,962 U/L | 284 U/L |

**Table 4:** Urine summary

| | ***Athlete results*** | ***Laboratory reference values*** |
|---|---|---|
| **GENERAL FEATURES** | | |
| Color | Yellow | Yellow, Citrus yellow, amber |
| Aspect | Slightly cloudy | Clear |
| Density at 15ºC | 1,023 | 1,016-1,025 |
| pH | 6.5 | 5-6 |
| **ABNORMAL ELEMENTS** | | |
| Proteins | Negative | Negative |
| Glucose | Negative | Negative |
| Bilirubin | Negative | Negative |
| Hemoglobin | Positive (++++) | Negative |
| Ketone | Negative | Negative |
| Leukocytes | Negative | Negative |
| Nitrite | Negative | Negative |
| Urobilinogen | Normal | < 1.0 mg/dL |

| MORPHOLOGICAL ANALYSIS OF THE FIGURED ELEMENTS OF URINE | | |
|---|---|---|
| Hyaline cylinders | 0.27 uL | ≤ 12.0/uL |
| Red cells | 1322.9 uL | ≤ 23.0/uL |
| Leukocytes | 14.4 uL | ≤ 23.0/uL |
| Epithelial cells | 12.9 uL | ≤ 27.0/uL |
| Bacteria | 122.4 uL | ≤ 100/uL |
| **Examination notes**:<br>Rare mucus filaments<br>Red blood cells are intact and undergoing lysis<br>Presence of small number of bacteria (heterogeneous microbiota)<br>Presence of calcium oxalate crystals | | |

## DISCUSSION

In this case report, a trained 35-year-old female athlete exhibited rhabdomyolysis after the CrossFit® world competition. Rhabdomyolysis causes damage to muscle tissue, and it becomes clinically relevant when the damage caused to muscle tissues is accompanied by severe pain, and a large amount of muscle proteins is released into the bloodstream [1]. In particular, myoglobin and other molecules are filtered by the renal glomeruli. Precipitation may occur and lead to secondary intratubular obstruction, renal vasoconstriction, inflammation, and tubular damage associated with oxidative stress. Myoglobin can be oxidized to reactive oxygen species (ROS), which promote lipid peroxidation of the membrane fatty acids. This whole cascade generates positive feedback, potentiating inflammation in the renal cells, which are responsible for the antioxidant action of neutralizing ROS [4].

A very common sign of rhabdomyolysis is the color of the urine. The urine becomes brownish or reddish as the kidneys try to clear the blood, and myoglobins reach the urine [1]. Due to the difficulty in directly measuring (biopsy and magnetic resonance) the muscle tissue damage, many studies have used indirect measures. The most common indirect measures are the subjective analysis of muscle pain, analysis of blood tests, and the evaluation of loss of muscle strength [5]. Assessment of muscle proteins in plasma is the second most common way to identify potential damages to the muscle tissues, with possible development of rhabdomyolysis. Muscle damage promotes the deposition of intracellular calcium, which activates proteases and causes necrosis, leading to initial hypocalcemia [1, 4]. Hyperuricemia may also be present (although this was not found in our athlete's results). Other enzymes, such as LDH, AST, and ALT may also be detected (as observed in our athlete's results in this study) [4, 5].

The most common cause of exertional rhabdomyolysis is unusual exercise contractions. In trained individuals, this occurs when there is a drastic increase in training volume, or when they train a different muscle group or use a different type of contraction, often motivated/encouraged by coaches or during a competition. In this case report, two factors were combined. First, as already mentioned, the increase in the intensity and volume of exercise can generate a different stimulus than usual [1]. The second is the type of exercise performed before the onset of symptoms. The most common exercise in CrossFit® is the glutes-hamstring developer (GHD), which in competition, is performed with overload, and it ends up stretching the abdominal muscles through hyperextending the trunk and while a load of 6 kg is held. This type of contraction (stretching/eccentric phase/negative phase) is the most common cause of stress rhabdomyolysis [1, 6].

As a diagnostic measure for clinically relevant exertional rhabdomyolysis, O'Connor *et al*. [2] propose a CK level five times above the established upper limit, ranging from 1500 to 100,000 U/L, and/or a positive urine test for the presence of blood, but without the presence of red blood cells under microscopic analysis.

The treatment is dependent on the degree of injury. It may involve complete rest and rehydration. The aim is to increase the production of urine to dilute the myoglobin and other potentially nephrotoxic substances. Intravenous fluids with or without bicarbonate may be administered to alkalinize the urine for 3-7 days and dilute the myoglobin and prevent its precipitation, thus preventing its oxidation (one of the main causes of acute renal failure, a comorbidity to be avoided), along with compartment syndrome. The latter consists of restrictions to the muscles by the connective tissues, increasing pressure, and limiting the blood flow to the muscle, thus generating a "vicious cycle" of tissue necrosis [1, 2, 4, 5, 7].

Since oxidative damage results in deleterious effects in stress rhabdomyolysis, part of the treatment involves the administration of antioxidants. Vitamin C has the potential to inhibit the oxidation of myoglobin in urine due to its water-soluble characteristics. The administration of polyphenols, such as flavonoids, can potentiate this effect of ascorbic acid. Vitamin E, the main lipophilic antioxidants present in cell membranes, also protects against lipid peroxidation. However, due to its lipophilic characteristics, it has a low capacity to prevent oxidation of the myoglobin. N-acetylcysteine, which is a source of glutathione, also has a protective effect in models of nephrotoxicity, ischemia-reperfusion injury, and chronic kidney disease, and should also be considered in the case of antioxidant treatment. Considering the inflammatory activity in the injured muscle and renal parenchyma, the use of anti-inflammatory drugs has also been studied [4].

Although there is no standardized guide for the time needed to return to activities, O'Connor *et al*. [2] also suggested evaluation of three conditions: 1) the risk of recurrence and whether further evaluations are necessary; 2) in cases of athletes who do not need further investigation, the return to sport should be considered; and 3) whether there should be any restrictions on the athlete. They also classify a guide in the form of a table separating the athlete's risk phases and the period of safe return to activities into categories [2].

Hopkins *et al*. [8] presented a series of 11 patients who practiced CrossFit® and demonstrated that these athletes may be at increased risk of rhabdomyolysis. In this study, most of the participants were beginners in the sport, and 82% were men. Other studies [9, 10, 11] have also demonstrated rhabdomyolysis in CrossFit® athletes. These studies have highlighted the importance of observing and looking for strategies to prevent rhabdomyolysis in CrossFit® athletes.

Training strategies to improve athletic performance should be reassessed with caution, as effort rhabdomyolysis can occur in CrossFit® athletes. The periodization of the training program with a progressive increase in intensity and volume, especially when training in unusual exercises, can be a strategy for preventing unwanted injuries, such as rhabdomyolysis.

**Conflicts of Interest**

The authors declare no conflict of interest.

**Author's Contribution**

All authors contributed for conception and design of this study, analysis and interpretation of data, and manuscript preparation. All authors also approved the final version of the paper.

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