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Exertional rhabdomyolysis in a 21-year-old, healthy female after performing three sets of the biceps curl exercise to failure with 30% 1RM: A case report

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Exertional rhabdomyolysis in a 21-year-old, healthy female after performing three sets of the biceps curl exercise to failure with 30% 1RM: A case report.

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Abstract

Background: The optimal resistance training program to elicit muscle hypertrophy has been consistently debated and researched. Although 3 sets of 10 repetitions at 70-80% of the 1-repetition maximum (1RM) is widely recommended, recent studies have shown that low-load (~30% 1RM), high-repetition (3 sets of 30-40 repetitions) resistance training can elicit similar muscular hypertrophy. Therefore, this type of resistance training has gained popularity, perhaps because less weight is lifted for a longer duration. In the process of testing this hypothesis in a research study in our laboratory, a subject was diagnosed with exertional rhabdomyolysis after completing a single resistance training session that involved 3 sets to failure at 30% 1RM. Exertional rhabdomyolysis is a condition characterized by the excessive breakdown of striated skeletal muscle that releases proteins from the muscle cell, particularly myoglobin, into the blood that can be toxic to the kidneys and is a significant health concern. Case Report: Reviewed were the events leading up to and throughout the diagnosis of exertional rhabdomyolysis in a healthy, recreationally-trained, 21-year-old female that was enrolled in a study that compared the acute effects of the traditional high-load, low-repetition versus low-load, high-repetition resistance training. The subject completed a total of 143 repetitions of the bilateral dumbbell bicep curl exercise. Three days post-exercise she reported excessive muscle soreness and swelling and sought medical attention. She was briefly hospitalized and then discharged with instructions to take acetaminophen for soreness, drink plenty of water, rest, and monitor her creatine kinase (CK) concentrations. Changes in the subject's CK concentrations, ultrasound-determined muscle thickness and echo intensity were monitored over a 14-day period are reported. Discussion: This case illustrates the potential risk of developing exertional rhabdomyolysis after a low-load, high-repetition resistance training session in healthy, young, recreationally-trained women. The fact that exertional rhabdomyolysis is a possible outcome is enough to warrant caution when prescribing this type of resistance exercise.

Background

A consistently debated topic in the area of resistance training is the appropriate load (amount of weight lifted), sets, and repetitions to best improve muscle strength and hypertrophy. Low-load (~30% 1RM), high repetition resistance training has been gaining popularity since recent experimental studies have shown that lifting a lower load to the point of failure (inability to achieve another repetition) may be equally effective at improving muscle hypertrophy as lifting heavier loads with lower repetitions (~80% 1RM) (1, 14). Consequently, the long-held belief that 3 sets of 10 repetitions with 70-80% 1RM as the optimal method of improving muscle strength and hypertrophy has been called into question, with the obvious benefit of reducing the amount of weight lifted to achieve the same goals (7, 16).

Our laboratory has published the results of three separate experiments in peer-reviewed, scientific journals on the comparison of low-load, high-repetition versus high-load, low repetition resistance training (9, 10, 11). In an ongoing effort to study this topic, we were conducting a new study on the acute effects of 3 sets of 30% 1RM versus 3 sets of 80% 1RM resistance training to failure during the biceps curl exercise in college-aged men and women. During the course of this study, one subject was diagnosed with exertional rhabdomyolysis 3 days after completing the low-load, high-repetition training visit (30% 1RM) and was briefly hospitalized. Subsequently, the study was voluntarily put on hold by the investigators pending a review of the existing information as well as the safety concerns that have arisen for this type of resistance training. As a means of informing the public about the potential risks of performing low-load, high-repetition resistance exercise to failure, the aim of this case report is to document the events leading up to and through this subject's diagnosis and treatment.

Rhabdomyolysis is a condition characterized by the excessive breakdown of striated muscle (20). This breakdown releases components of the muscle cell, particularly myoglobin, into the extracellular environment and the blood. Myoglobin is an oxygen-carrying protein inside the muscle cell that acts like hemoglobin in the blood. However, when excessive amounts of myoglobin are spilled into the blood, the binding capacity of plasma globulins to carry myoglobin is exceeded, and the excess myoglobin is filtered by the tubules of the kidney and can cause obstruction and renal dysfunction (20).

Rhabdomyolysis is diagnosed by measuring the concentrations of the enzyme creatine kinase (CK) in the blood. In addition to myoglobin, CK is also released into the blood following excessive muscle breakdown and damage. Normal CK levels range between 45-260 U/L (8). A CK level greater than 5,000 U/L usually indicates severe muscle damage, and rhabdomyolysis can be diagnosed (21). For example, one study reported CK levels as high as 40,000 U/L following a one-arm strenuous exercise protocol intended to induce muscle damage (18). Another study found that patients who experienced renal failure had an average peak CK of 55,366 U/L (5). Rhabdomyolysis can also be characterized by a red-brown discoloration of the urine, which is caused by the presence of myoglobin. Symptoms of rhabdomyolysis may include excessive soreness, muscle cramps, weakness, and swelling. Rhabdomyolysis can be caused by crush injuries, seizures, ischemia, and excessive drug or alcohol use (21). However, rhabdomyolysis after prolonged or repetitive physical exertion is widely recognized as exertional rhabdomyolysis (12). Untrained individuals or those who exercise in hot or humid conditions are placed at a greater risk for exertional rhabdomyolysis (20).

In this particular case, a 21-year old female who was accustomed to exercise was diagnosed with rhabdomyolysis after 3 sets of low-load, high repetition bicep curl exercises while participating in a resistance training study. The subject agreed to provide the details of her experience and release her medical records, understanding that the information would be used for publication in this case report without disclosing her identity.

Case Report

A 21-year-old Caucasian female volunteered to participate in a research study that aimed at comparing the acute effects of low-load (30% 1RM), high-repetition versus high-load (80% 1RM), low-repetition resistance training during the biceps curl exercise on muscle activation measured by electromyography (EMG) and muscle swelling measured by B-mode ultrasound imaging. All resistance exercise and testing in this study was performed in a university laboratory where the room temperature is controlled between 21 and 24° C (70 and 75° F). During her first visit to the laboratory, the subject signed an informed consent document that explained the purpose of the study and the potential risks associated with her participation. She then filled out a health and exercise history questionnaire. She reported taking regular yoga and barre classes as well as jogging, walking, and/or using a lateral elliptical almost daily. Her weight and height were measured on a stadium scale. The subject's height was 172 cm and weight was 61 kg (135 lbs), which was used to calculate her BMI of 21.8 kg/m2, which is classified as "normal" according to the National Institute of Health's BMI classifications (2). The subject was then familiarized to the protocol by completing a standard, trial-and-error 1-repetition maximum (1RM) strength test with the bilateral dumbbell bicep curl exercise. The result of her 1RM test was an 11.3-kg (25-lb) load for each dumbbell. During all exercise testing, the subject was instructed to stand upright with feet a comfortable width apart and back against the wall. The subject used an elbow stabilizing plate (Bicep Bomber, Body Solid, Inc., Forest Park, IL, USA), which ensured that the full range of motion of the elbow joint was achieved during each repetition and that the subject did not swing their elbows during the exercise. A metronome was set to 60 beats per minute and each participant was instructed to perform the concentric and eccentric phases of the exercise corresponding with each tick of the metronome. Therefore, the concentric and eccentric phase of each repetition were approximately 1 s in duration. The subject was instructed to begin the set when they felt ready and were told to stop when they couldn't complete the next consecutive repetition. The subjects were given two minutes of rest between each set. Since the order of exercise intervention (30% or 80% 1RM) was randomized, she was assigned the low-load (30% 1RM), high-repetition intervention for her next laboratory visit. Four days later, during her second visit to the laboratory, the subject was instructed to complete 3 sets of the same bilateral dumbbell biceps curl exercise to failure at 30% 1RM. Before the exercise, ultrasound images of the anterior arm (including the biceps brachii muscle) showed a muscle thickness of 1.943 cm (Figure 2b). Using a 3.4-kg (7.5-lb) load on each dumbbell, the subject completed 87 repetitions, 28 repetitions, and 28 repetitions during sets 1, 2, and 3, respectively, for a total of 143 repetitions. Ultrasound images were also taken immediately after she completed the exercises, which indicated that acute swelling increased her muscle thickness to 2.285 cm (Figure 2b). The magnitude of increase was 0.342 cm or 17.6%.

Three days after her second laboratory visit, the subject reported that she was unable to fully extend her forearms due to excessive swelling at and just proximal to both elbows, with the left elbow appearing more swollen than the right. She also reported excessive muscle soreness in both her arms that had started two days after her laboratory visit and was persistent on the third day. After being informed of these signs and symptoms, the investigators encouraged the participant to visit the University Health Center for medical attention. Subsequently, approximately 72 hours post-exercise, the subject received medical attention, which included a physician consult and a routine antecubital venipuncture blood draw. After receiving initial medical attention, she was sent home with instructions to take acetaminophen (rather than aspirin, ibuprofen, or naproxen) and drink plenty of water and await her blood test results. Several hours later, she was called and informed that her blood test results indicated a CK concentration 11,683 U/L (Figure 4), and she was instructed to go to the emergency room for further testing and monitoring. Therefore, later on the 3rd day post-exercise (approximately 78 hours post-exercise), the subject checked into an emergency room, where she received two saline bags intravenously. Her CK concentration was tested again and reported at approximately 12,200 U/L. However, her kidney function, as indicated by blood urea nitrogen (BUN), creatinine, sodium, and potassium concentrations (still awaiting report from the hospital), was normal. Furthermore, her urine sample was not discolored or darkened. Therefore, after about 6 hours, the participant was discharged and sent home from the emergency room. The attending physician encouraged her to take acetaminophen for soreness, drink plenty of water, rest, and monitor her CK concentrations at the University Health Center in the following days.

Figure 4. Creatine kinase (CK) concentrations reported at various time points after the resistance training exercise.

Subsequently, at 4 days (96 hours) post-exercise CK levels were tested and recorded at 8,346 U/L. At 6 days (144 hours) post-exercise, CK had dropped to 2,498 U/L. Finally, at 13 days (312 hours) post-exercise, CK levels had dropped to 440 U/L (Figure 4).

Our laboratory also performed ultrasound imaging of the anterior arm at four, six, and fourteen days after the resistance exercise bout as a noninvasive monitoring of the swelling (Figure 3). Figures 2a and 2b show the echo intensity (EI) and muscle thickness measurements recorded from the ultrasound images. Four days post-exercise, the muscle thickness was still .084 cm (4.3%) greater than the baseline measurement, but was 11.3% (0.258 cm) lower than the peak thickness measured immediately post-exercise. Fourteen days after the exercise, muscle thickness measured 1.937 cm which was equivalent to the pre-exercise measurement of 1.943 cm (Figure 2b).

Echo intensity (EI) is a measure of the pixel density of the image and has been used as a surrogate, noninvasive measure of muscle damage and muscle quality in age comparisons (6, 19), and muscle glycogen content (17). Per protocol evaluation of EI indicated that this subject experienced a 10.8% increase from pre- to immediately post-exercise (Figure 2b). Since increases in EI are characterized by a whiter image, it is thought that the acute edema that occurs after a bout of resistance exercise can increase EI. Incidentally, the EI measured 4 days after the exercise was 34.9% greater than the baseline EI. After 6 days, the EI was still 16.7% greater than baseline EI. However, 14 days post-exercise, the EI was only 3.3% greater than baseline and effectively very similar to the EI measured before the resistance exercise. These data support the hypothesis that EI measurements from ultrasound images can provide a noninvasive, surrogate assessments of muscle damage, which may be useful clinically (19).

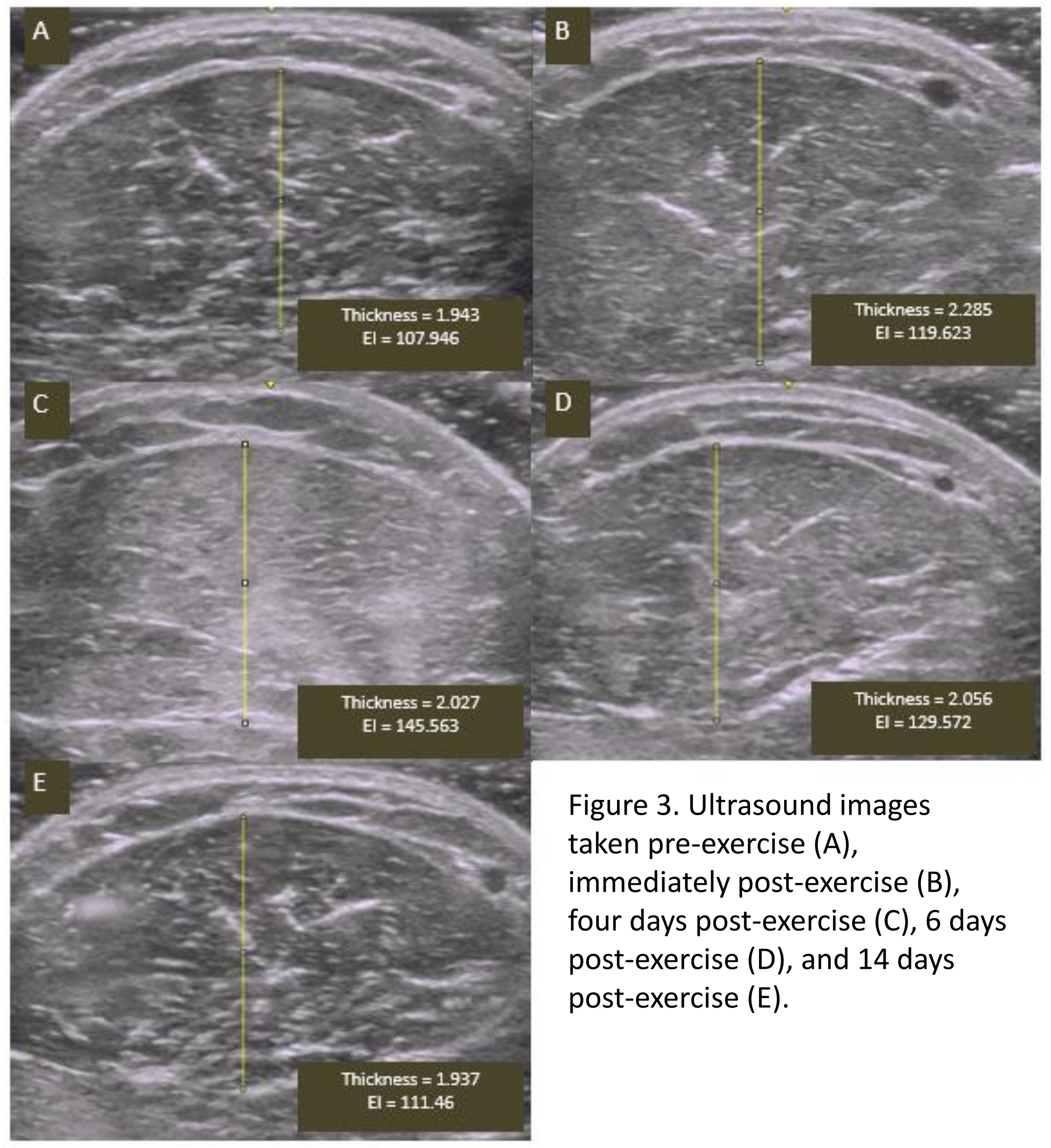


Figure 3. Ultrasound images taken pre-exercise (A), immediately post-exercise (B), four days post-exercise (C), 6 days post-exercise (D), and 14 days post-exercise (E).

Figure 1. Case report timeline.

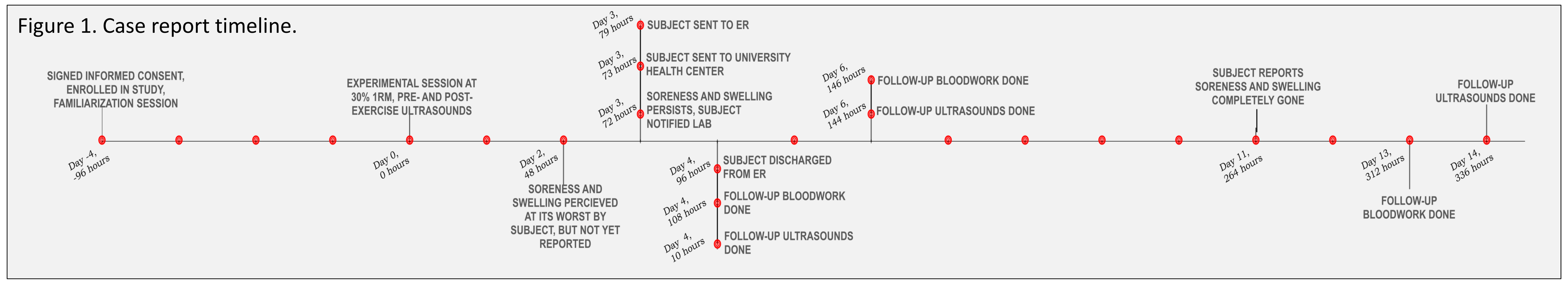
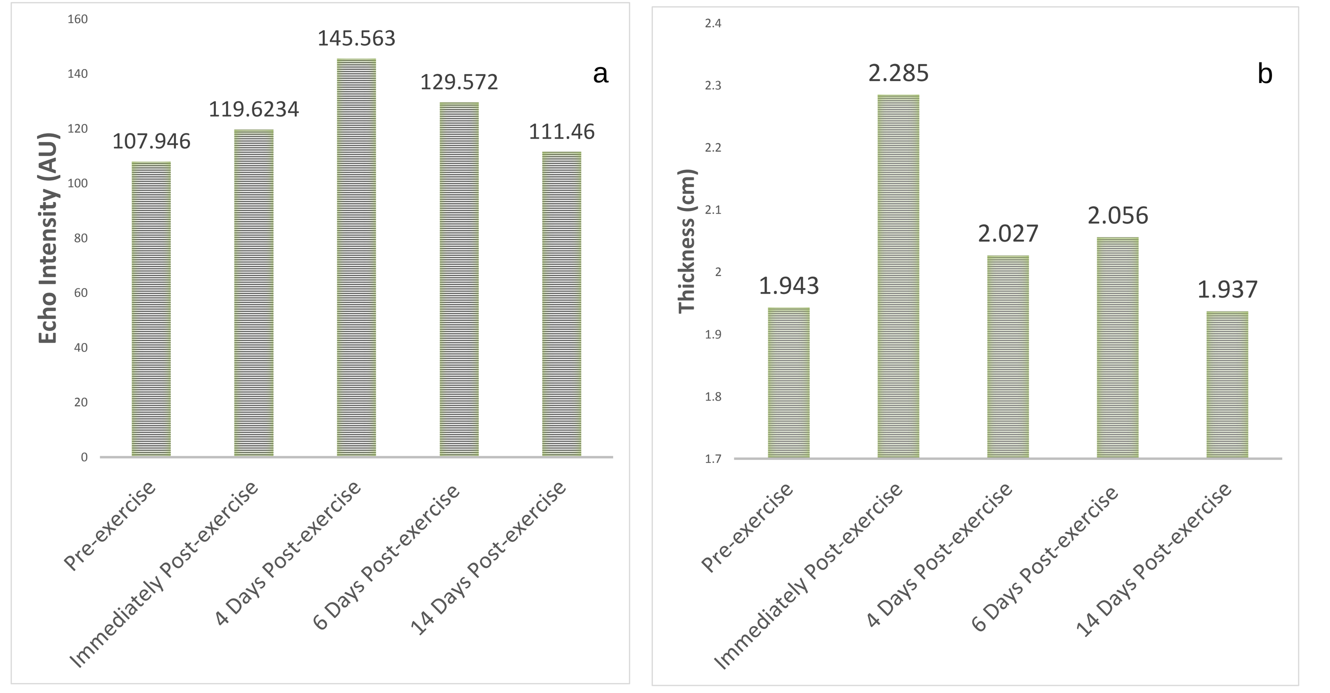


Figure 2. Bar graphs of the echo intensity (a) and muscle thickness (b) measurements recorded from the ultrasound images at various time points before and after the resistance training exercise.



Discussion

The subject of this case report is a 21 year old, healthy female. She was accustomed to regular resistance and cardiovascular exercise, and she exhibited no unusual, predisposing risk factors for rhabdomyolysis. She had not been taking any nutritional supplements or regular medications. Yet, she was diagnosed with rhabdomyolysis after completing 3 sets of low-load, high repetition bilateral dumbbell biceps curl exercises with 30% 1RM (3.4 kg) for 143 total repetitions. As a result, her CK concentrations peaked at about 12,000 U/L. Other cases of rhabdomyolysis have reported CK concentrations of approximately 60,000 U/L to over 200,000 U/L (12, 21). However, even if the present case appears mild, a clinical diagnosis of rhabdomyolysis was still made, and this subject's health was compromised. Our hope is that this information can be used to promote safe resistance exercise, even when the risk of exertional rhabdomyolysis in a healthy, young woman may seem relatively low. Low-load, high-repetition resistance exercise is performed with light weight, but when performed to failure, the time that the muscle is under tension and the total work performed by the muscle is much higher than traditional, high-load, low-repetition resistance exercise (i.e., 3 sets of 10 repetitions) (10). It should also be noted that muscles exercised at a longer length produce more muscle damage (15). This could have affected our subject as the elbow stabilizer ensured she completed the full range of motion of the elbow joint. In conjunction with our previous studies on this topic (9,10,11), this is the first of approximately 48 subjects to be diagnosed with exertional rhabdomyolysis, but the fact that rhabdomyolysis is a possible outcome for an otherwise healthy, young woman is enough to warrant caution in prescribing this type of resistance exercise. Even if low-load, high-repetition resistance training can elicit similar increases in muscle hypertrophy as traditional, high-load, low-repetition training the additional work performed by the muscle may cause significant muscle damage, which may result in rhabdomyolysis (1, 14). Exercise professionals should be aware of this risk to hopefully avoid the outcome of exertional rhabdomyolysis.

Conflict of Interests:

The authors declare to have no conflicts of interest.

Acknowledgments:

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