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Creatine Kinase Response of Physically Active Young Men to One- and Two-Legged Cycling

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ABSTRACT

Figueira, TG, Magosso, RF, Campanholi-Neto, J, Carli, JPC, Robert-Pires, CM. Creatine Kinase Response of Physically Active Young Men to One- and Two-Legged Cycling. **JEPonline** 2017;20 (3):168-176. The purpose of the study was to compare blood creatine kinase (CK) concentration of 15 physically active healthy male after one- and two-legged cycling. After the procedures were explained, the subjects went to the laboratory on four occasions. The first was a familiarization session. During sessions 2, 3, and 4, the subjects performed one- and two-legged maximal tests that were separated by 48 to 72 hrs. A blood sample was taken before and 24 hrs after each test to determine blood CK responses. After the two-legged exercise, blood CK responses (7.14 ± 201.87 U/l) were significantly lower ($P<0.05$) compared to the right (138.87 ± 155.57 U/l) and the left leg responses (126.17 ± 115.02 U/l). When ΔCK was related to work load, the two-legged protocol led to lower increases (0.07 ± 0.78 ΔCK/W) compared to the right and left legs (1.69 ± 1.53 ΔCK/W and 1.75 ± 1.64 ΔCK/W, respectively). The present study shows that one-legged cycling exercise leads to great increases in blood CK of physically active men after 24 hrs.

Key Words: Creatine Kinase, Exercise-Induced Muscle Damage, Incremental Test, One-Legged Cycling, Two-Legged Cycling

INTRODUCTION

It is well established that some types of exercise can induce damage to skeletal muscle cells; a phenomenon known as exercise-induced muscle damage (EIMD). The greatest incidence of EIMD occurs in untrained individuals, exercises with eccentric muscle actions, sports, and other activities that involve intense contractions, muscular fatigue, and unaccustomed exercise (7,11).

Usually, ruptures in the sarcolemma and sarcomeres, especially in Z-lines, characterize the muscular damage. But, there are other muscular structures that are compromised when muscles are damaged. For example, there can be damage to the sarcoplasmic reticulum, T-tubules, myofibrils, and the components of the cytoskeleton (i.e., titin filaments). The signs and symptoms include delayed onset muscle soreness, muscle inflammation, decrease in strength, as well as an increase in blood concentration of myoglobin and creatine kinase (CK) (10,19).

Creatine kinase is a cytoplasmic enzyme that catalyzes the breakdown of phosphocreatine (PCr) to creatine (Cr) with energy release to resynthesize ATP (2). After an intense training session, the peak in blood CK values occur generally between 24 and 48 hrs and may remain elevated for up to 72 hrs after EIMD (15). The increase in blood CK concentration ([CK]) depends on the amount of damage to the sarcomeres induced by strenuous exercise or a muscular pathology such as rhabdomyolysis (5). Normal CK levels in blood range between 35-170 units per liter of blood (U/l), however, studies with ultra-distance triathletes and marathon racers report values of approximately 1500 U/l immediately after competition (2,3,13). Thus, CK analysis is capable of indicating the magnitude of EIMD by competitions or training sessions and, therefore, helping in the planning of the training program.

Cyclists use one-legged exercise as an alternative to overload peripheral metabolic capacity. The reduction in exercising muscle mass allows for a greater blood flow and oxygen supply to active muscles and most of the oxygen delivery becomes available to the exercising leg. The increased oxygen delivery yields greater work rate in each leg, which overloads the mitochondria and improves respiratory capacity (17). Therefore, one-legged cycling may induce greater mitochondrial adaptations compared to two-legged cycling (12).

Although one-legged cycling is suppose to allow for an increase in oxygen supply to the exercising limb, the mechanics of the exercise may impose limitations to intensity and volume (17). Specifically, during two-legged cycling, the gravitational and inertial forces are essentially balanced by the contralateral limb. Yet, one-legged cycling is typically performed with the removal of one leg from the pedal thus leaving the other leg to pedal alone. With one leg at rest, the contralateral limb no longer balances the forces and movement is unbalanced. This approach requires a hip flexion in the active limb to raise the pedal in a pattern and intensity at which the individual is not accustomed and possibly leads to EIMD, where the hip flexors that pull the lower limb up must increase their work (4).

The purpose of this study was to compare blood [CK] of healthy young men in one- vs. two-legged cycling. Our hypothesis was that despite the smaller muscle mass involved, one-legged cycling would lead to greater EIMD and, consequently, a higher blood [CK].

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METHODS

Subjects

Fifteen physically active and healthy young males volunteered to participate in this study. We excluded individuals with injuries, pathologies, and/or metabolic disorders that influences exercising and/or [CK]. The characteristics of the subjects are presented in Table 1. First, the subjects went through an interview with the leading researcher during which they were fully informed of the purposes, proceedings, risks, and benefits of the study. After this briefing, all subjects signed an informed consent. The study was approved by the local ethics committee that oversees human research (protocol n. 1.218.462).

Table 1. Descriptive Data of the Subjects.

Parameter	Value (mean ± SD)
Age (yrs)	24.1 ± 5.0
Body Mass (kg)	79.97 ± 12.76
Height (cm)	176.0 ± 5.2
BMI ($kg \cdot m^{-2}$)	25.74 ± 3.30
Body Fat (%)	16.17 ± 4.07
VO_2 max ($mL \cdot kg^{-1} \cdot min^{-1}$)	46.2 ± 11.2

Experimental Design

After the initial visit with the volunteers, those who were physically able to participate went the Exercise Physiology Laboratory of the Federal University of São Carlos. During the first of the four session, the subjects were familiarized with the cycle ergometer (Ergo-fit 167®) by performing one- and two-legged cycling. In the following three sessions, the subjects performed the maximal incremental tests in two-legged cycling and with the right and left leg in one-legged cycling. The tests were performed randomly and at the same time of day. The interval of rest between the tests was 72 to 96 hrs.

Maximal Incremental Tests

The tests were performed on an electromagnetically braked cycle ergometer. Load increases were made every 2 min until voluntary exhaustion. The initial load was 10 W with a 10 W increase in one-legged cycling and a 20 W increase with two-legged cycling.

During one-legged cycling, the non-exercising limb was placed on a wood platform and the pedal was removed from the cycle. The foot of the exercising limb was attached to the pedal in order to better perform the push and pull movements during the exercise and also to avoid the foot from escaping the pedal.

Blood CK Concentration

To measure blood [CK], a sample of 30 µl was taken from the fingertip and immediately transferred to a specific test strip to be analyzed with a Reflotron® (Roche, Germany). All subjects were instructed not to engage in any physical straining type activity 72 hrs before the tests so the [CK] would not be affected. Analyses were made 3 min before and 24 hrs after each test to compare the [CK] responses to each protocol. The results are presented as the change in blood CK (∆CK) concentration (U/l) from pre- to post-test and the ratio between ∆CK and maximal load in the incremental test (∆CK/W).

Statistical Analyses

Results are presented as means ± standard deviation. After the data passed the Kolmogorov-Smirnov test, a one-way ANOVA was used to compare the changes in blood [CK] with the Tukey *post-hoc* when applicable. Statistical significance was set at P≤0.05. All data were analyzed using the software SigmaPlot version 11.0.

RESULTS

Peak power on the two-legged cycling was 255.3 ± 36.6 W, which was statistically higher (P≤0.05) than the one-legged cycling with the right leg (93.3 ± 37.7 W; 36.5% of two-legged) and left leg (84.6 ± 39.4 W; 33.1% of two-legged) and also higher (p ≤ 0.05) compared to the sum of the peak power achieved with each leg (177.9 ± 75,6W) as shown in Figure 1. There were no significant differences between the one-legged tests.

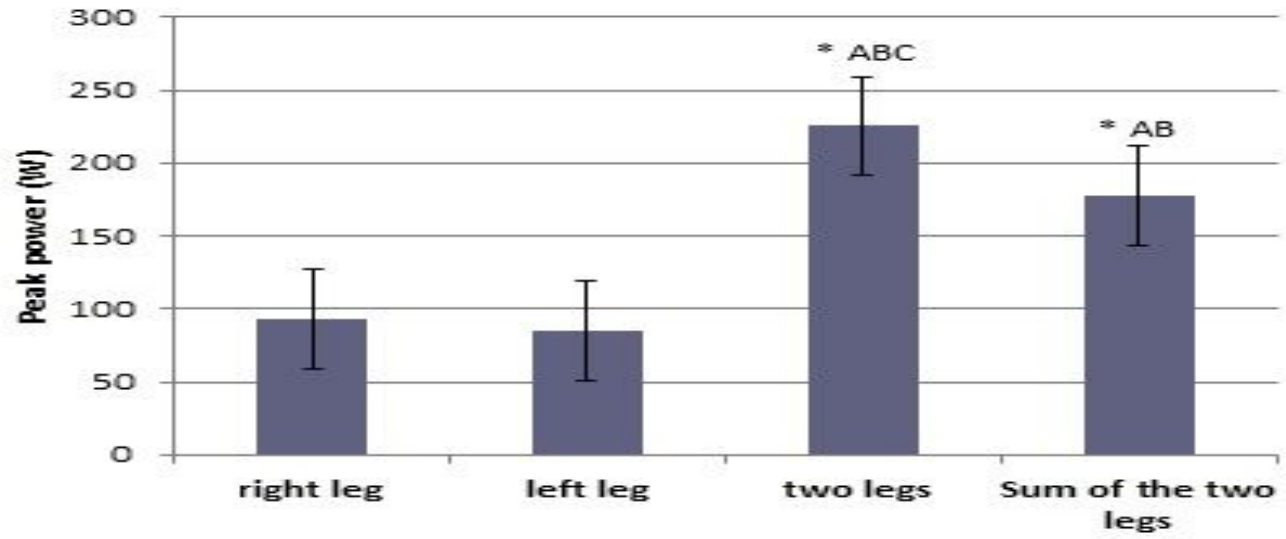

Figure 1. Peak Power in the Incremental Tests and the Sum of the Two Legs. [A]Significantly different from right leg; [B]Significantly different from left leg; [C]Significantly different from sum of the two legs.

When the subjects performed the two-legged cycling, the ∆CK (7.14 ± 201.87 U/l) was significantly lower (P≤0.05) than the right (138.87 ± 155.57 U/l) and left (126.17 ±115.02 U/l) legs. This represents an average of 1945% and 1767% superior increase in blood [CK] of the right and left leg compared to the two-legged protocol, respectively. There were no significant differences between blood [CK] after the two protocols of one-legged cycling (Figure 2).

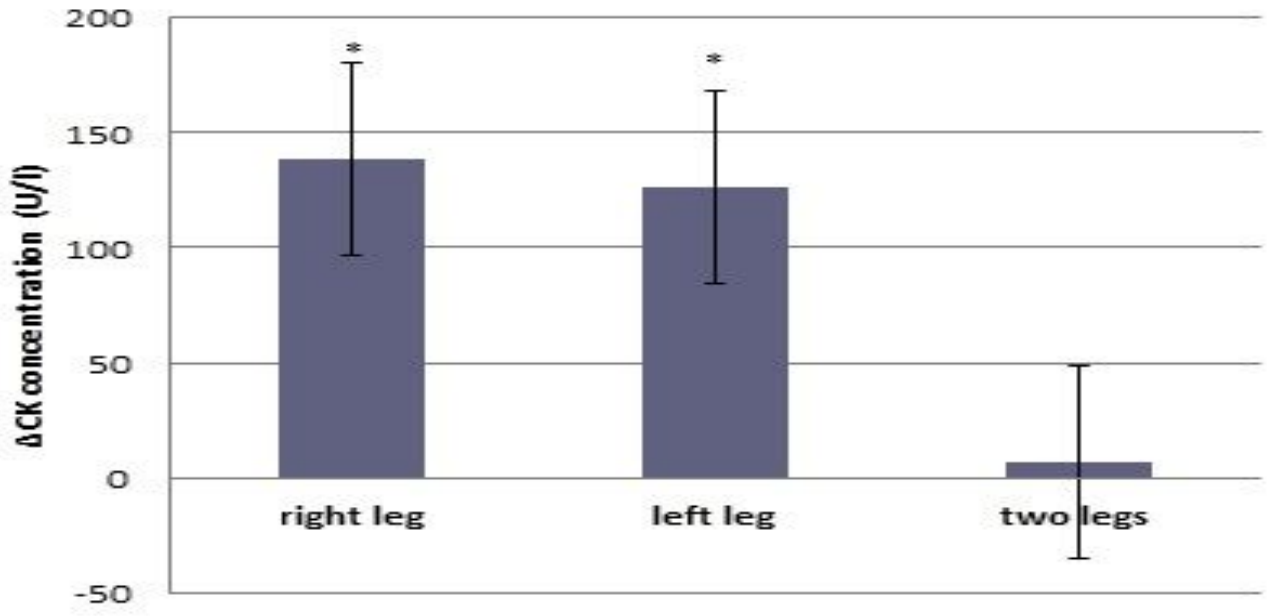

Figure 2. Changes in Blood [CK] After One-Legged Protocols (Right and Left) and Two-Legged Protocol. *Significantly different from two legs.

When ΔCK was related to peak power (ΔCK/W), the increase after the two-legged protocol (0.07 ± 0.78) was significantly lower compared to the right (1.69 ± 1.53) and left (1.75 ± 1.64) legs, with no significant difference between one-legged protocols, as shown in Figure 3.

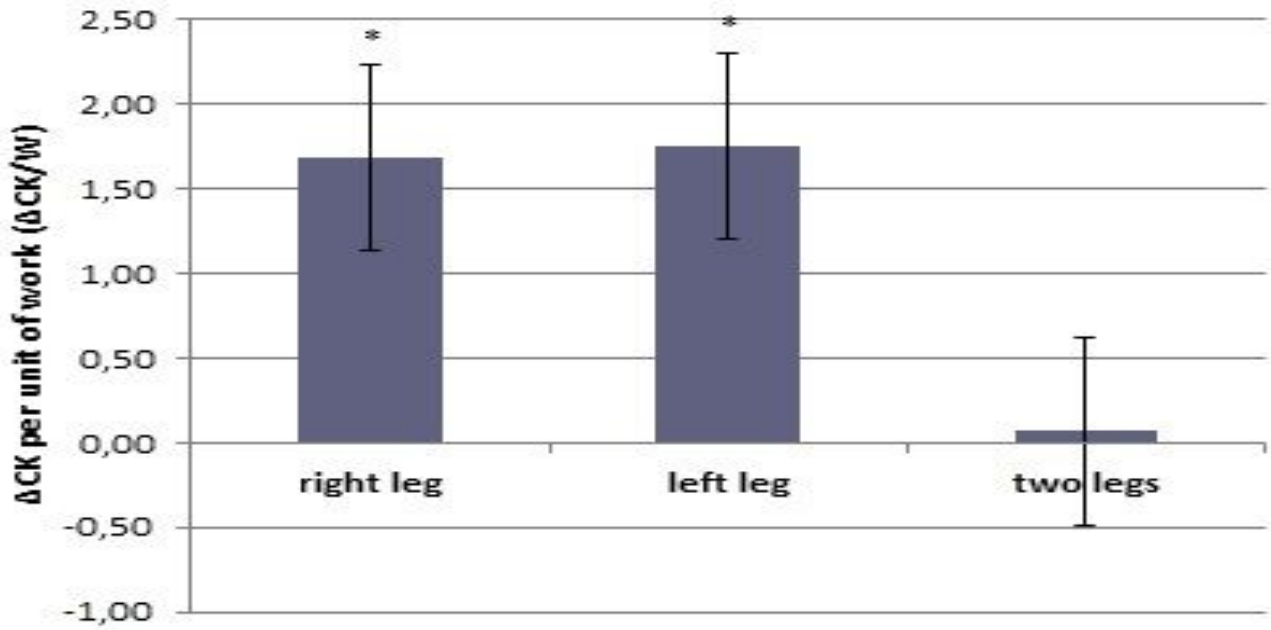

Figure 3. ΔCK Per Unit of Work (ΔCK/W) After One-Legged Protocols (Right and Left Legs) and Two-Legged Protocol. *Significantly different from two legs.

DISCUSSION

The analysis of blood [CK] showed that the increases were significantly higher after both one-legged protocols compared to the two-legged protocol, thus confirming our initial hypothesis. This is justified by the motor pattern of the one-legged protocols, to which the subjects were not accustomed. Cycling with one leg and no counterweight is not common among cyclists and that leads to EIMD and the increase in blood [CK].

One-legged cycling has different biomechanical characteristics compared to two-legged cycling, especially with no counterweight that leads to greater stress in hip flexor muscles for both concentric and eccentric contractions (and with the use of counterweights peak power would be higher) (4). According to Abbiss et al. (1), when one-legged cycling is performed with a counterweight, the intensity reached with each leg is more than half the intensity reached with the two-legged test. Their data agree with our study where the sum of the two legs was significantly lower compared to the peak power with both legs, given that our study did not employ counterweight. The absence of a counterweight in the present study was done to verify how the act of pulling the pedal would influence the action of the hip flexors, given that these muscles are not accustomed to such work rate.

In this sense, the greater increase in blood [CK] after the one-legged cycling can be explained by the motor pattern of the exercise. EIMD is initially caused by the mechanical strain placed on the muscles (8) during one-legged cycling, especially without counterweight, which leads to greater torque in the hip flexors. This increased torque seems to be the main factor in blood [CK] changes, given the significant differences when ΔCK was related to peak power. Our results show that for both legs, the increase in ΔCK/W was significantly greater than in the two-legged protocol, thus more damage is caused by a lower intensity of work in one-legged cycling.

The CK enzyme is predominantly present in sarcoplasm from which it is released into the blood stream during the process of muscular damage that is caused by the trauma of intense exercise. Therefore, the increase in blood [CK] is an important marker in exercise physiology and sports medicine that allows for detecting muscular damage and/or excess of muscle work (4,15). A limitation in the present study is in making only a single analysis of [CK] after each protocol. Yet, Mendham et al. (14) demonstrated peak blood [CK] 24 hrs after high-intensity aerobic exercise. Camargo et al. (6) also reported peaks in blood [CK] 24 hrs after exercising in the water compared to rest. Thus, we believe that the period of analysis was adequate to determine blood [CK] responses after one- and two-legged cycling.

The values of blood [CK] found in the present study where highly variable between subjects as observed in other studies. According to Baird et al. (2), some subjects present much higher serum levels of CK after exercise compared to other subjects matched by aged, gender and training status. This variability may be due to genetic factors or even changes in the subjects' body composition. While these factors are unclear and more studies are necessary to determine the ranges in blood [CK] in different populations and during different exercise modes (9), the data in the present study are rather clear in defining the differences between the one-legged cycling and the two-legged cycling.

Schneider et al. (16) analyzed the variation in blood [CK] of 12 cyclists in non-competitive 300 km cycling with average duration of 1021 min and reported a main change of 480.5% from pre- to post-exercise. In our study, the change in blood [CK] after the one-legged protocol was over 1500%. This indicates that the one-legged cycling exercise may help prepare the muscles against damage caused by long exercise courses.

The data of the present study show that one-legged cycling leads to great increases in blood [CK] when performed without counterweight. In this sense, despite the reported benefits of this type of training, trainers and cyclists must be cautious in designing training programs to ensure adequate recovery is reached. Also, considering the high variability in absolute blood [CK] values, it is recommended that results are interpreted by changes in [CK] rather than the absolute values.

CONCLUSIONS

The present study shows that one-legged cycling with no counterweight leads to great 24-hr increase in blood [CK] of physically active men in absolute values and also when ΔCK is related to work rate (ΔCK/W). More studies are necessary to determine the chronic effects of this type of training and to compare blood [CK] responses after one-legged cycling with and without counterweight.

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