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Muscle Recovery after a Session of Resistance Training Monitored through Serum Creatine Kinase

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ABSTRACT

De Castro APA, Vianna JM, Damasceno VO, Matos DG, Mazini Filho ML, Reis VMM. Muscle Recovery after a Session of Resistance Training Monitored through Serum Creatine Kinase. **JEPonline** 2011;14(5):38-45. The purpose of this study was to monitor the recovery period after a session of resistance training through the levels of serum creatine kinase (CK). Nine healthy subjects who were experienced in resistance training engaged in a training session that consisted of eight exercises with a load of 10 repetitions maximum (10 RM). For the monitoring of CK values, blood tests were performed prior to the training protocol (CKp) and 24 hrs (CK24), 48 hrs (CK48), and 72 hrs (CK72) after training. Significant differences were observed between the mean values of CKp and CK24 and CK48. Thus, the findings support the contention that the CK values at 48 hrs and 72 hrs after a training session with 10 RM are sufficient for the recovery of muscle fibers.

Key Words: Biological Markers, Physiological Stress Response, Pain Measurement, Muscle Strength

INTRODUCTION

Proper recovery is essential to any fitness program and can be described as a multifactorial process by which the body tries to overcome the effects of fatigue and restore homeostasis (1,2,30). Recovery periods include intervals between sets, those between exercises and periods between training sessions, and can be influenced by the type of exercise performed, age, training experience, gender, environmental factors, type of fiber used in training, energy source, psychological factors and diet (8,30). Neglect of the recovery time of biological systems can cause problems in a new training session, possibly leading to stagnation and reduction in motor performance as well as an increase in risk of serious injury (3,10).

According to Clarkson et al. (7), damage to muscle fibers after exercise is obvious, especially after exercise with a predominance of eccentric contractions. From a research perspective, the analysis of muscle damage and its recovery is determined by direct markers (e.g., tissue biopsies and magnetic resonance imaging techniques), and indirect markers (such as motor performance, delayed-onset muscle soreness and analysis of plasma enzymes, muscle proteins, and serum myoglobin) (6,7).

Among the indirect markers of muscle damage, measurement of serum creatine kinase (CK) has been highlighted because of its high percentage in skeletal muscle tissue and its release into the bloodstream after micro-damage to muscle fibers (4,10,11,19). Ehlers et al. (4) found that serum CK levels were significantly high after a 7-day training session. In agreement, Smith et al. (28) found significant changes 48 hrs after a protocol consisting of 3 sets of 12 eccentric contractions at 80% of concentric maximum voluntary contraction (MVC). Other studies that investigated the recovery period after exercises with eccentric contractions found divergent results. The recovery period ranged from 24 to 132 hrs (3,4,15,17,26)

Given the discrepancies observed in the literature between the periods required for adequate recovery after a session of resistance training, the purpose of this study was to monitor muscle recovery after a single session of resistance training with a load of 75% of MVC through the analysis of total CK.

METHODS

Subjects

The study consisted of nine healthy subjects experienced in resistance training who were engaged in training at least three times per week in the 12 weeks prior to the study. After being informed about the purposes of the research and its procedures, the subjects signed a consent form. This study was approved by the Ethics Committee of the Federal University of Juiz de Fora - Minas Gerais.

Procedures

The subjects were requested not to engage in physical activity other than that required for daily living, and to maintain their same nutrition and sleep status during the study. Subjects who used anabolic steroids or who were taking a prescribed medication were excluded from the study, as well as any subjects with known musculoskeletal disorders.

Body mass was determined with a platform scale Filizola (Brazil) with a 100 gm precision. Height was obtained by a Sanny stadiometer with precision of 0.1 cm, according to the procedures described by Lohman et al. (18). Body composition was determined from skinfold measurements, which were performed by the same examiner with a scientific caliper (Lange R,USA), according to the techniques

described by Slaughter et al. (27). The relative body fat was determined by the Siri`s equation, as described by Jackson and colleagues (13).

All subjects underwent a test of 10 repetitions maximum (10 RM) for each exercise. The testing procedures met the criteria proposed by Kraemer et al. (16). After obtaining the load in an exercise, intervals of at least 5 min were given before proceeding to the next test.

For determination of serum CK, blood samples were collected from an antecubital vein at four time points: pre-test (CKp), 24 hrs (CK24), 48 hrs (CK48), and 72 hrs (CK72) after the protocol. In addition to the analysis of circulating CK, CK data were also presented relative to lean body mass in which the absolute CK value was divided by the lean body mass.

The experimental protocol consisted of a typical workout for muscular hypertrophy for the following muscle groups: latissimus dorsi, pertoralis major, deltoids, triceps brachii, biceps brachii, quadriceps, hamstrings, and gastrocnemius. The exercises were conducted first with the major muscle groups and, then, with the smaller muscle groups. Each exercise was performed in 3 sets with a load of 10 RM and intervals of 90 sec between sets.

Statistical Analyses

For the characterization of the sample, descriptive statistics were used. For the comparison between the mean levels of CK and CK lean body mass for the pre-test, 24, 48, and 72 hrs after the protocol, ANOVA was used followed by *post hoc* Tukey HSD tests. Statistical significance was set at $P = 0.05$. All samples were analyzed with the statistical package Statistica 6.0 R for Windows R (Statsoft. Inc., Tulsa, USA, 2001).

RESULTS

Nine healthy males with experience in resistance training for 9.2 ± 4.5 months participated in this study (see Table 1).

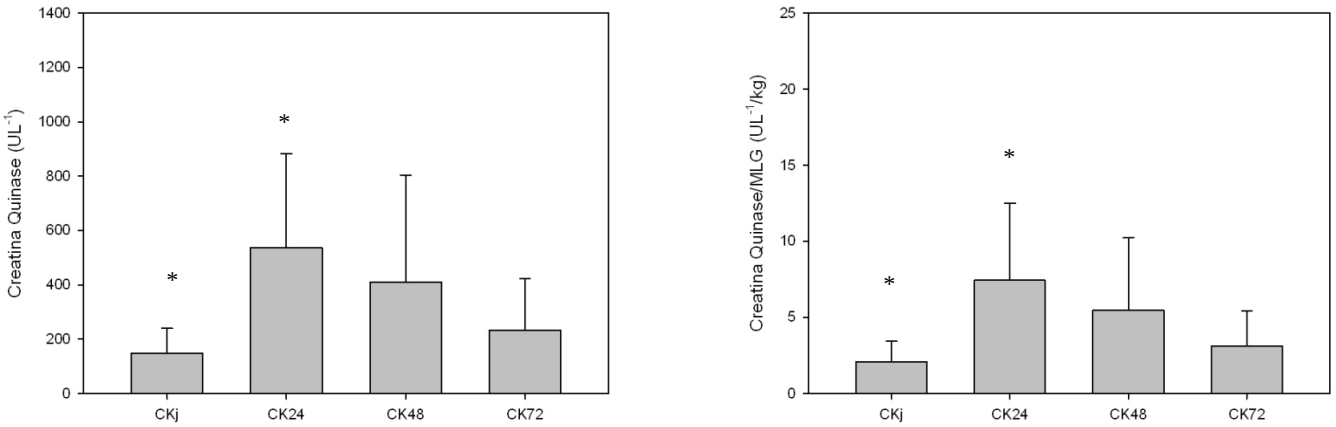
Table 1. Characterization of the sample.

	Mean ± SD
Age (yrs)	21.3 ± 1.6
Body Mass (kg)	84.2 ± 15.5
Height (cm)	179.5 ± 7.5
Fat free Mass (kg)	72.7 ± 9.4

The mean CK value at 24 hrs was significantly higher than the CKp mean value for both absolute CK and CK per kg of fat free mass (FFM) ($P = 0.03$ and $P = 0.04$, respectively; refer to Figures 1a and 1b). The CK values at 48 hrs ($P = 0.21$) and 72 hrs ($P = 0.97$) after training were not significantly different from the CKp mean value, which suggests that muscle damage may have been partially

repaired. Among the subjects studied, only one individual did not reach the peak concentration of CK in 24 hrs, with the peak occurring only at 48 hrs after the protocol. With respect to recovery time, two subjects required a period exceeding 72 hrs to return to the values found before training. This finding is different from the other subjects with elevated CK, who returned to baseline at 48 hrs and 72 hrs (Figure 2).

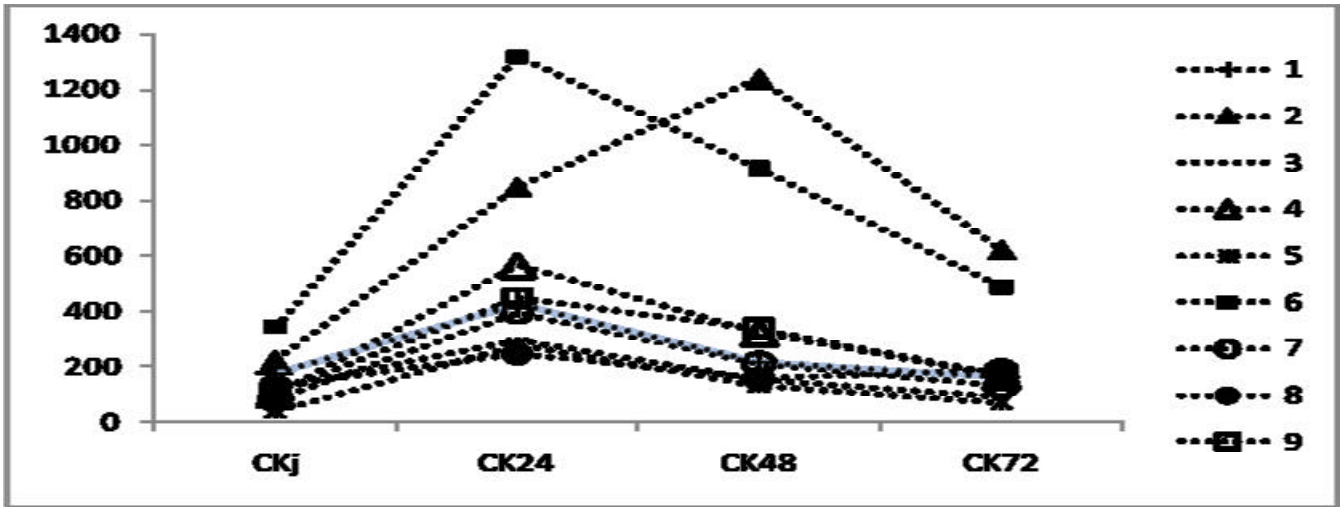
Figure 1. (a) Serum CK (UL^{-1}) values before and daily for the 3 days after the resistance training bout. (b) Serum CK/FFM (UL^{-1}/kg) values in relation to the 4 time points.



(a) (b)

*Significant differences between CKp and CK24 (Figure 1a, P = 0.03; Figure 1b, P = 0.04).

Figure 2. Individual CK responses before and daily for the 3 days after the resistance training bout.



DISCUSSION

The purpose of this study was to determine muscle recovery based on serum CK concentration after a single resistance training session consisting of 3 sets of resistance exercises at 10 RM with 90-sec intervals between sets. In agreement with previous reports (22,25), serum CK was elevated after the

single training session. Significant elevations in both CK and CK/FFM ratio were found 24 hrs after the training session. Forty-eight hrs after exercise serum CK returned to values close to those found in the pre-test, which was also the case at 72 hrs after the exercise. In contrast, Rodrigues et al. (25), after subjecting volunteers to an experimental protocol of 3 sets of each exercise with 80% of 1RM and 1-min (SEQ1) or 3-min (SEQ3) rest between sets and exercises were found significant elevations in serum CK at 24 hrs, 48 hrs, and 72 hrs after the exercise protocol. This may be due to the difference in the percentage of load used in the protocol (i.e., 80% of MVC) since the induced damage to the muscle fibers is influenced, among other factors, by the exercise intensity (20).

Chen et al. (5) found no significant differences for the periods of 24 hrs and 48 hrs after 30 eccentric contractions at 80% and 90% of maximal isometric strength. However, after the 4th and 5th days, the values were significantly different and remained above baseline for 9 days. Given the studies cited it is possible to observe different behaviors of serum CK levels in the literature, thus indicating a high variability of the muscle recovery period.

Increases in CK levels may be related to muscle damage, especially when eccentric contractions are involved. According to Brancaccio et al. (4), the presence of CK in the blood stream is a result of damage to the sarcoplasmic membrane, such damage being dependent mainly on the volume and intensity of the exercise. Chen et al. (5) found a negative correlation between CK levels and muscle performance. This indicates that the capacity to generate force may be reduced because of micro damage present in muscle fibers. From the results of this study, it is possible to infer that the process of restoration of muscle fibers was completed within 48 hrs because no differences were found between CK48 and CKp (Figure 1a and 1b).

In the study by Vacz et. al. (31), the authors compared two training programs in which the knee extensor exercises were performed at different ranges of motion. Several variables were evaluated, including CK and lactate dehydrogenase (LDH). The variables were measured before the protocol, as well as 24 hrs, 48 hrs, and 6 days after the training program. It is noteworthy that muscle pain was also assessed daily during the experiment. The results indicated that in both groups CK levels were significantly higher 24 hrs after training. Six days after training, serum CK values remained higher than pre-training values, which goes against much of the literature and shows that values of serum CK can remain higher than pre-training values for up to 9 days after the protocol (5,28).

Muscle recovery time depends on a number of factors such as age, gender, diet, amount of sleep, training experience, and type of exercise (8,9,30,32). Inadequate recovery can result in reduction of motor performance, high susceptibility to injury in the locomotors system, and unfavorable mental conditions (3,10). All of these effects are associated with fatigue of the neural, endocrine, and metabolic systems (24). On the other hand, proper recovery is associated with gains in performance since it enhances the body`s ability to support a higher training volume and intensity (24,21,23,29).

The isolated use of CK as a marker of the recovery period can be regarded as a limitation of this study. Friden et al. (12) found no significant correlation between serum CK and muscle torque in rats after the performance of eccentric contractions of the ankle dorsiflexor muscles. The authors argue that the permeability of cell membranes may or may not be involved in the contractile process. Hence, it is more than reasonable to suggest that more studies should be carried out with the combination of other recovery markers (particularly, motor performance and electromyography).

CONCLUSIONS

According to the data in the present study, we conclude that the CK values at 48 hrs and 72 hrs after the training session with 10 RM are sufficient for the recovery of muscle fibers in trained males.

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