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original article

Analysis of the trends of creatine kinase levels during the preseason of a professional soccer team

Análise do comportamento da creatina quinase ao longo da pré-temporada de um time de futebol profissional

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Abstract – Physical exercises can result in tissue damage on the muscular system, including during the preseason, which is a period of physical training aiming subsequent competitions. The aim of this study was to analyze the behavior of plasma CK as a marker of muscle damage during preseason of a professional soccer team; determine when preseason CK levels reach their peak value; and verify CK concentration on preceding moment to the first official match of the season. Professional soccer players (n = 31) attended this study (24.3 ± 3.9 years, 181.0 ± 7.0 cm, 9.1 ± 1.3%GC and 66.0 ± 4.5 mLO_2/kg/min). The plasma concentration of CK was determined at the beginning of the preseason (M1), 4 (M2), 10 (M3) and 15 (M4) days after. We identified CK values of 178.2 ± 12.0, 540.0 ± 59.1, 389.8 ± 49.5, 408.7 ± 45.0 U/L for M1, M2, M3 and M4 respectively. The peak concentration of CK occurred on M2 ($p<0.05$). The analysis of the behavior of plasma CK revealed increased levels throughout the preseason of a professional soccer team compared to the holiday period. The peak value of CK was reached on the 4th day of preseason. The concentration of CK on the day prior to the first official match of the season proved to be in the range of values recommended for professional players.

Key words: Creatine kinase; Musculoskeletal system; Physical exercise.

Resumo – *A realização de exercícios físicos pode resultar em danos teciduais sobre o sistema muscular, inclusive durante a pré-temporada, que é um período de preparação física visando competições subsequentes. O objetivo do estudo foi analisar o comportamento da CK plasmática como marcador de dano muscular ao longo da pré-temporada de uma equipe de futebol profissional; determinar em que momento da pré-temporada os níveis de CK atingem o valor pico; e verificar a concentração de CK no dia antecedente ao primeiro jogo oficial da temporada. Participaram deste estudo 31 jogadores de futebol profissional (24.3 ± 3.9 anos, 181.0 ± 7.0 cm de altura, 9.1 ± 1.3 %GC e 66.0 ± 4.5* mlO_2*/kg/min). A concentração plasmática de CK foi determinada ao início da pré-temporada (M1), 4 (M2), 10 (M3) e 15 (M4) dias após. Identificaram-se valores de CK de 178.2 ± 12.0, 540.0 ± 59.1, 389.8 ± 49.5, 408.7 ± 45.0 U/L para M1, M2, M3 e M4, respectivamente. A concentração pico de CK ocorreu no M2 (p<0,05). A análise do comportamento da CK plasmática revelou níveis aumentados ao longo de toda a pré-temporada de uma equipe de futebol profissional em comparação com o período de férias. O valor pico de CK foi atingido no 4º dia da pré-temporada. A concentração de CK no dia antecedente ao primeiro jogo oficial da temporada mostrou-se na faixa de valores recomendada para jogadores profissionais.*

Palavras-chave: *Creatina quinase; Exercício físico; Sistema musculoesquelético.*

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INTRODUCTION

Physical exercise can cause tissue damage in the muscular system[1]. Factors such as the type, intensity, duration, and frequency of activities performed affect the development and magnitude of micro-lesions on skeletal muscle fibers[2]. Previous studies have indicated that eccentric actions are the main cause of morphofunctional changes[1,3,4], as such actions involve extreme strain and significant muscle stretching. In contact sports such as soccer, these actions occur intermittently and at a high level of intensity, and are not only part of the game, but may also determine the outcome of a match.

Given that tissue damage can impair muscle function[5,6] and, consequently, the performance of athletes, various methods are required to analyze the extent of tissue damage. The direct methods of analyzing tissue damage are not only expensive, but also have considerable limitations. With regard to biopsy, only a fragment of the muscle is analyzed, which may underestimate or overestimate the magnitude of tissue damage. Therefore, indirect methods, such as the analysis of blood markers, has been recommended in several scientific studies, including those involving soccer players[7,8].

Creatine kinase (CK) analysis is considered as the best available indirect method[2]. CK is used both as a marker of the physical condition of the individual[9] as well as for monitoring the training load[7,10]. The concentrations of CK are known to remain high for hours and even several days after an intense and/or prolonged training session[3,11-13].

Previous studies have analyzed the CK levels as a marker of tissue damage in a single game[9] or during a competitive season[8] of soccer. However, no specific information is available on the trends of the CK level in the physical preparation phase, even though the training during this period is believed to be vital for ensuring a good season.

Therefore, in the present study, we aimed to analyze the trends of the CK levels as a marker of muscle damage during the preseason of a professional soccer team; to determine when preseason CK levels reach their peak value; and to measure the CK levels on the day prior to the first official match of the season.

METHODOLOGICAL PROCEDURES

This study was approved by the Research Ethics Committee (COEP) of the Universidade Federal de Minas Gerais (ETIC-291/09) and complied with all the standards set by the National Health Council (Res. 196/96) involving human research. A written consent form was signed by each volunteer prior to participation in the study, following the clarification of all questions arising from their respective reading of the form's contents.

Sample

The study included 31 professional players (age, 24.3 ± 3.9 years; height, 181 ± 7.0 cm; body fat percentage, 9.1 ± 1.3%; and, 66.0 ± 4.5 mLO_2/kg/min) who belonged to a first division Brazilian soccer club that participates in national and international competitions organized by the Brazilian Football Confederation (*Confederação Brasileira de Futebol;* CBF) and by the South American Football Confederation (*Confederação Sul-Americana de Futebol;* CSF). Players who attended all training sessions during the preseason, did not have any kind of injury, and did not use any medication were included in our study.

Procedures

The duration of the pre-season was 2 weeks. The plasma CK concentration was determined at 4 distinct time-points: the end of the off-season (first time-point, M1) as well as 4 days (second time-point, M2), 10 days (third time-point, M3), and 15 days (fourth time-point, M4) after the start of training (Figure 1). The last day of sample collection (day 15) corresponded with the day prior to the first official game of the season. All samples were collected in the morning (8:00 a.m. to 09:00 a.m.), prior to the training session.

For CK analysis, 32 μL of capillary blood was collected from the fingertip of the volunteers, after the site was cleaned with 70% ethyl alcohol. For puncturing, a lancet device with an automatic trigger was used and the blood was drained into a heparinized capillary tube (Cat No. 955053202 Reflotron®). The blood was immediately pipetted into a CK test strip (Cat No. 1126695 Reflotron®) and examined by reflectance photometry at 37° using the Reflotron Analyser Plus ® (Boehringer Mannheim).

The monitoring of the distance covered was performed by using portable GPS devices (Garmin Forerunner® 405). The heart rate (HR) represented as an absolute value, as percentage of the maximum heart rate (% HR_{max}) and the distance covered during training were recorded for all the players. Heart rate monitors (Polar® Electro Oy) were used to measure and record the heart rate; the sampling rate was set at 5 s. The HR_{max} was identified during a specific field test to determine the maximal aerobic capacity of the players *(YoYo Endurance Test)*[14]. This test consists of 2 × 20m sprints "there and back," with a period of 10 s of active recovery between each stage. The running speed during the test is progressive and controlled by audio signals. Because it is a maximal test, the *YoYo Endurance Test* is interrupted when the individual being evaluated cannot complete the prescribed route twice, thus characterizing the state of fatigue[15].

Based on the proposal of Frisseli and Mantovani[16], the activities performed during training were classified into 5 categories: general exercise recovery, general exercise development, simple specific exercise, complex specific exercise, and competitive exercise.

Throughout the preseason, the players were housed at the club's facilities, trained 7 days a week, and followed a diet that was controlled and standardized by the club's nutrition department. The climatic conditions observed during this period were 24.65 ± 3°C and 61% ± 7% relative humidity.

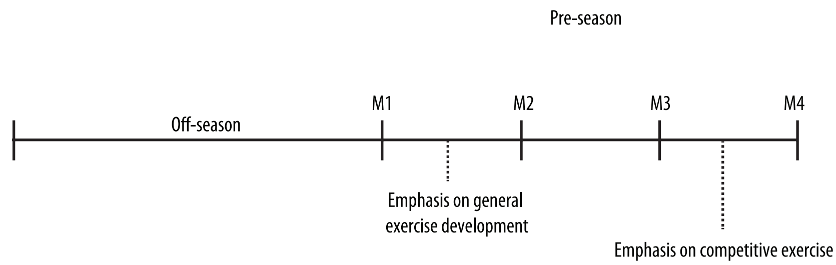

Figure 1. Experimental design. The duration of the off-season was 1 month and that of the preseason was 2 weeks.

Statistical analysis

After investigating the data for normality by applying the Shapiro-Wilk test, analysis of variance was applied for repeated measures, followed by the Tukey test for the analysis of values throughout the time-points evaluated. The significance level adopted was $p < 0.05$.

For the estimation of the sample size, a CI of 95% was considered, with a statistical power of 80% for the test and co-efficient of variation for the variable in question (CK) for analysis between time-points. The minimum "n" was determined to be 11 individuals.

RESULTS

Table 1 shows the amount and type of training exercise performed each week during the pre-season.

Table 1. Details of training performed during the 2-week pre-season period.

	1st		2nd		Total	
General development Exercise (min)	240	27.1%	60	8.8%	300	19.1%
General recovery Exercise (min)	190	21.5%	110	16.1%	300	19.1%
Simple specific exercise (min)	270	30.5%	195	28.5%	465	29.6%
Complex specific exercise (min)	105	11.9%	110	16.1%	215	13.7%
Competitive exercise (min)	80	9.0%	210	30.7%	290	18.5%
Sum of the exercises in the week (min)	885	100.0%	685	100.0%	1570	100.0%
HR_{aver} (bpm/min)	154.8±12.4	-	152.9±11.7	-	-	-
% HR_{max}	76.8±3.5	-	76.7±3.2	-	-	-

HR - Heart rate; HR_{aver} - Average Heart Rate; % HR_{max} - percentage of the maximum heart rate. The exercises were classified according to Frisseli and Mantovani[16].

Figure 2 shows the plasma levels of CK at each of the time-points analyzed. Among the samples collected during the pre-season, the values were found to be higher at the end of the off-season, and the concentration reached a peak during the first days of training ($p < 0.05$).

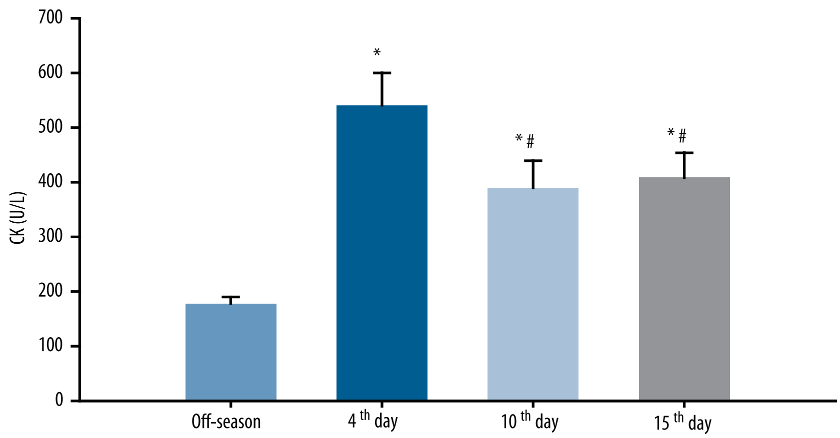

Figure 2. Plasma creatine kinase (CK) levels during the pre-season *Indicates the difference in relation to the off-season (last day of the off-season). #Indicates the difference in relation to the fourth day of the pre-season ($p < 0.05$).

DISCUSSION

The findings indicate that the plasma CK levels were higher throughout the pre-season compared to that at the final time-point of the off-season, and that the concentration reached a peak value on day 4 after initiation of training ($p < 0.05$). Although the plasma CK level has been adopted as an indicator of tissue damage by soccer teams nationally, no studies have analyzed the trends of this blood marker throughout the pre-season in a professional team.

Ehlers et al.[17], with a similar methodological design, monitored the concentrations of CK in 12 football players throughout a pre-season. The athletes were evaluated before the pre-season, and on the fourth, seventh, and tenth day of training, and the last time-point was the day prior to the first game of the season; the CK concentrations at these time-points were found to be 203.8 ± 67 U/L, 5124.7 ± 5518 U/L, 3369.8 ± 3658 U/L, and 1263.7 ± 990 U/L, respectively. The values recorded in that study were higher than those found in the present study, although the peak value was recorded on the fourth day of pre-season and a significant decline was observed for the subsequent time-points in both the studies.

Increased CK levels reflect tissue injury due to physical exertion, since structural damage can occur at the level of the sarcolemma and the Z discs[17]. Microtrauma occurs in the muscle fibers primarily due to irregular exercise[18], with a significant eccentric component[3]. Thus, general development exercises, such as strength training, conducted at the start of pre-season, may have influenced the findings of the present study.

The first phase of the physical preparation period in professional soccer is usually composed of an increased volume of activities that aim to develop overall strength and endurance, and not via specific exercises. Players participating in this study underwent weight lifting training sessions from the first day of pre-season onwards, which in fact may explain the peak plasma CK concentrations on the fourth day of training. Besides the tissue damage that may develop when practicing strength training exercises, it should also be noted that the players also returned to the club after a period of rest, during which regular and systematic training were not part of their routines.

A significant reduction in the plasma CK levels at M3 appear to be related to the "effect of repeated loads[19]." As proposed by Clarkson et al[19], neurological and cellular factors are involved in a process of adaptation, wherein a single session of eccentric exercise makes muscle tissue more resistant to damage when subjected to subsequent exercise sessions.

Furthermore, Eston et al.[20] have shown that the "effect of repeated loads" can be transferred between different types of exercises that involve the same muscle group, and thus does not require the same type of protocol for developing this resistance. This muscular adaptation, which increases the protection of tissue against injury, explains the lower plasma CK concentration in samples collected after M2. Although training still causes microtrauma in such cases, the degree of damage is reduced[21].

Another interesting finding of this study is associated with the values recorded at M4. As mentioned above, the last collection was performed on the day before the first official match of the season, and therefore, represents the muscle condition of the players at both the end of the preseason and the start of the competition. The plasma CK value at M4 (408.7 ± 45.0 U/L) indicates a normal standard for the population investigated, since values of approximately 975 U/L were determined as the upper limit point among players of the first division of Brazilian soccer[7].

With regard to the limitations of the study, even though the players have been staying under standard conditions on the premises of the club, factors such as individual differences in the release of CK after exercise[10] were not assessed. Because of the difficulties in pairing a group of athletes from the same competitive level and because these groups could not be subjected to specific training sessions as a treatment factor, a control group was not used.

CONCLUSION

The CK plasma levels were increased throughout the pre-season of a professional soccer team, compared to those during the off-season. The peak CK value was attained on the fourth day of the pre-season. Moreover, the CK concentration on the day prior to the first official match of the season and the last day of preparation was reportedly within the range recommended for professional players. The results indicate that "the effect of repeated loads" for eccentric exercise influences the kinetics of plasma CK and manifests itself during the first week of training, thus enabling adaptation and an increase in the strength of the muscular system during subsequent exercise sessions.

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