ORIGINAL ARTICLE DOI: 10.5007/1980-0037.2011v13n3p189

Creatine kinase kinetics in professional soccer players during a competitive season

Cinética da creatina quinase em jogadores de futebol profissional em uma temporada competitiva

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Abstract – Serum creatine kinase (CK) concentration has been widely used as an indicator of skeletal muscle damage in sports. However, there are no longitudinal studies on post-game CK kinetics in Soccer during a competitive season. The aim of this study was to evaluate serum CK kinetics in professional Soccer players at different post-game times during a competitive season without training interruption. Seventeen professional Soccer players (age: 22.2±3.1 years, height: 179±6.0 cm, body fat percentage: 9.5±1.1, and 67.0±3.5 mL O_2/kg/min) were evaluated over a period of 3 months of the national championship. Serum CK concentration was measured before the beginning of the season (baseline) and at four different times after a Soccer game (post-1: 12-20 h, post-2: 36-48 h, post-3: 60-65 h, and post-4: 90-110 h). Plasma CK concentrations were higher at all times when compared to baseline ($p<0.05$). Post-2 CK concentration was lower than post-1 and higher than post-3 and -4 ($p<0.05$), with no significant differences between post-3 and post-4. In conclusion, serum CK kinetics was influenced by the training routine of the Soccer players, with a peak between 12 and 20 h after the game, returning to normal within 60-65 h. This procedure can be used to monitor the recovery state of athletes and game and training intensities.
Key words: Physical exercise; Training; Performance.

Resumo – *Concentrações plasmáticas de creatina quinase (CK) têm sido utilizadas como um indicador do estresse imposto à musculatura esquelética decorrente da atividade em várias modalidades esportivas. Porém, ainda não há estudos longitudinais sobre a cinética pós jogo dessa enzima de forma seriada no Futebol durante uma temporada competitiva. O objetivo foi analisar a cinética da concentração plasmática de CK em coletas seriadas em diferentes momentos pós jogo durante uma temporada competitiva de Futebol sem interrupção do cronograma de treinamentos. Participaram do estudo 17 atletas profissionais de Futebol (22,2±3,1 anos, 179± 6,0 cm de altura, 9,5±1,1% de gordura corporal e 67,0±3,5 mLO2/kg/min) foram monitorados durante três meses do campeonato nacional.A concentração plasmática da CK foi mensurada antes do início da pré-temporada (PRE) e em quatro ocasiões após dos jogos (PÓS-1 (12-20h), PÓS-2 (36-48h), PÓS-3 (60-65h) e PÓS-4 (90-110h). Os valores da concentração plasmática de CK foram maiores em todas as em comparação com a fase PRE (p<0,05). PÓS-2 foi menor que PÓS-1 e maior que PÓS-3 e 4 (p<0,05). PÓS-3 e PÓS=4 foram semelhantes. O estudo permitiu concluir que a rotina de treinamentos dos jogadores influenciou a cinética de remoção da CK, apresentando sua concentração pico entre 12-20h pós jogo, retornando aos valores normais de treinamento em 60-65h. Tal procedimento pode ser utilizado com o objetivo de se monitorar o estado de recuperação dos atletas e a intensidade dos jogos e treinamentos.*
Palavras-chave: *Esforço físico; Treinamento; Desempenho.*

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Received:
21 September 2010
Accepted:
21 February 2011

INTRODUCTION

Soccer is characterized by a large number of jumps, ball fights, sprints, accelerations and decelerations[1], and direction changes that occur every 2-4 s for a total of 1200-1400 times during a game[2]. This sport involves activities that require strength and, in particular, numerous eccentric actions[3]. This type of muscle action causes microtraumas[4], especially during intermittent activities[5,6]. Therefore, in addition to the different approaches to determine the effort of players in a soccer game, markers of physical stress have been investigated [7-13].

Plasma creatine kinase (CK) concentration has been used as a marker of the stress imposed on skeletal muscles during exercise[12,14,15] and also for the monitoring of training load[16-18]. The more intense and longer the exercise, the larger the number of muscle microtraumas that lead to the secretion of this enzyme into the extracellular medium[16]. Thus, CK monitoring has been used to determine the magnitude of physical stress on the skeletal muscle system, for example, as a result of eccentric contractions[19-21], in different sports modalities[22,23], in soccer[12,13,24,25], and also to chronically monitor the training status of athletes[11].

The post-exercise concentration of CK in athletes ranges from 300 to 500 U/L[3]. The serum concentration of the enzyme which depends on individual characteristics[26], is markedly elevated 1-4 days after exercise[21,27-29], and is an indicator of the training status and recovery of the athlete[12,24]. In the case of soccer, studies have shown that markers of muscle microtrauma such as CK increase within 72 h after a game[24]. However, there are no longitudinal studies on the post-game kinetics of this enzyme in Soccer during a competitive season. Most studies on this topic determined CK at only one time point after the game[11,13], investigated friendly games[24], or analyzed one or two games separately[12,24,25].

Therefore, the objective of the present study was to analyze the kinetics of plasma CK concentration in a series of samples obtained from soccer players at 12-20, 36-48, 60-65 and 90-110 h post-game during a competitive season without training interruption.

METHODOLOGICAL PROCEDURES

The study was approved by the Ethics Committee of Universidade Federal de Minas Gerais (ETIC-291/09) and was conducted in accordance with the guidelines on human research of the National Health Council (Resolution 196/96). Written informed consent to participate in the study was obtained from each volunteer after clarification of all doubts.

The study included professional players from a club of the Brazilian first division soccer league that participates in national and international competitions organized by the Brazilian Soccer Confederation (CBF) and South American Soccer Confederation (CSF). All athletes of the club were monitored over the last 3 months of the national championship, corresponding to a total of 14 games. Seventeen players who met the following inclusion criteria participated in the study: participation in the pre-season and in the national championship and measurement of baseline values of CK before the pre-season (BAS) and at all times analyzed after the game, in at least three games, with a minimum participation of 75 min per game. The mean number of games played per athlete was 5 ± 2, corresponding to approximately 425 CK measurements in the present study.

Plasma CK concentration was measured at five time points. For the determination of BAS CK concentration, blood was collected on the day the athletes reported for the pre-season training, after a 30-day vacation. The other four samples for analysis of CK kinetics were collected 12-20 h (POS-1), 36-48 h (POST-2), 60-65 h (POST-3), and 90-110 h (post-4) after the games. The mean value of the CK measurements obtained for the athletes was then calculated for each sampling time (BAS, POST-1, POST-2, POST-3, and POST-4) and used for analysis. All collections were performed within the facilities of the club before the training sessions.

For enzymatic measurement of plasma CK concentration, 32 µL capillary blood was collected from the fingertip of the subjects. The fingertip was cleaned with 95% ethanol and dried with cotton, and blood was collected with an automatic lancet device into a heparinized capillary tube (Reflotron®, catalog No. 955053202). The blood was immediately pipetted on a CK test strip (Reflotron®, catalog No. 1126695) and analyzed in a Boehringer Mannheim Reflotron Analyzer®.

Statistical analysis

The Kolmogorov-Smirnov test was first applied to determine whether the data showed a normal distribution. BAS and post-game CK concentrations were analyzed by repeated-measures ANOVA and the *post hoc* Tukey test, if necessary, adopting a level

of significance of 0.05. The results are reported as the mean and standard error.

RESULTS

Table 1 shows the anthropometric characteristics of the volunteers studied.

Table 1. Anthropometric characteristics of the sample studied.

N	Age (years)	Height (cm)	Body fat (%)	VO_{2max} (mL/kg/min)
17	22.2 ± 3.1	179 ± 6.0	9.5 ± 1.1	67.0 ± 3.5

Values are reported as the mean and standard error.

As can be seen in Table 2 and Figure 1, plasma CK concentrations were higher at all time points studied when compared to BAS ($p<0.05$). Post-2 CK concentration was lower than post-1 concentration and higher than post-3 and post-4 concentrations ($p<0.05$). No difference was observed between post-3 and post-4.

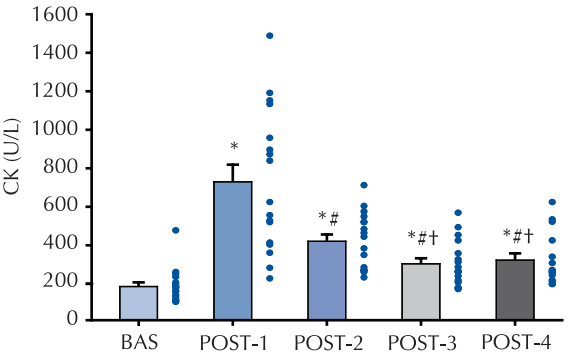

Figure 1. Plasma creatine kinase (CK) concentration at different times after soccer games. POST-1: 12-20 h; POST-2: 36-48 h; POST-3: 60-65 h; POST-4: 90-110 h. * Significant difference compared to BAS; # significant difference compared to post-1; † significant difference compared to post-2 ($p<0.05$).

DISCUSSION

In the present study, peak CK concentrations were observed in professional Soccer players between 12-20 h, returning to normal training levels within 60-65 h. Certain types of training are known to favor the recovery of athletes[30]. Since the training program was maintained throughout the blood collections, the 12-20 h interval was the only post-game period during which the athletes had not undergone any training session. This fact suggests that the training routine influenced the kinetics of CK removal in the present study. Our results are more likely to represent the actual behavior of CK during a Soccer season than the results reported in studies in which only a single measurement was performed [12,24].

Some studies have monitored CK and other parameters after soccer games to determine the physiological stress imposed on the players. In this respect, Ascensão et al.[24] evaluated 16 soccer players at BAS and 30 min and 24, 48 and 72 h after a game. In contrast, to the present study, the authors evaluated biochemical and physical performance parameters of second-division players after a single friendly game. CK concentrations were higher at all post-game times when compared to BAS, with the highest concentrations being observed between 24 and 48 h (mean of 800 U/L). Markers of incomplete recovery were also identified up to 72 h after the game, with a reduction of lower limb strength and significant late muscle pain. With the same objective, Ispirlidiset et al.[12] evaluated markers of physical demands during a soccer game in 24 players. Ten of these players were allocated to the control group and did not participate in the activity. The volunteers were monitored by physical and biochemical tests up to 6 days after the game. CK concentrations increased gradually, reaching a peak between 48 and 72 h after the game, in contrast to the present study in which the highest CK concentrations were observed between 12-20 h. Performance of the players in sprint and vertical jump tests declined up to 3 days after the game. The same study also showed a reduction in the post-game testosterone/cortisol ratio, indicating a

Table 2. Creatine kinase concentration (U/L) at different times after soccer games.

Time	BAS	POST-1	POST -2	POST -3	POST -4
X ± SE	192.1 ± 23.0	785.8 ± 95.5*	388.2 ± 37.8* #	299.1± 30.5*# †	317.0 ± 37.7*# †
Minimum	23.0	95.5	37.8	30.5	197.0
Maximum	497.0	1.580.0	748.5	594.5	654.0

Values are reported as the mean and standard error (SE). POST-1: 12-20 h; POST-2: 36-48 h; POST-3: 60-65 h; POST-4: 90-110 h.
* Significant difference compared to Baseline (BAS); # significant difference compared to post-1; † significant difference compared to post-2 ($p<0.05$).

catabolic state of the athletes. This monitoring of markers of muscle microtrauma such as CK, the presence of late muscle pain and reduced jump and sprint performance are indicative of the high physical demands during a soccer game and the need for longer recovery periods.

Andersson et al.[25] monitored recovery-related neuromuscular and biochemical parameters after two consecutive games of women's soccer. The parameters were investigated at two different times after the first game and immediately after the second game. An increase in CK concentrations compared to BAS was observed immediately after the game (approximately 350 U/L), after 21 h (430 U/L), and after 45 h (250 U/L), with levels returning to BAS after 69 h. The CK kinetics identified in that study was similar to that observed in the present investigation, but with lower absolute values at the respective time points studied. In addition, the authors observed levels of approximately 400 U/L after the second game, which occurred 72 h after the first one. Among the neuromuscular parameters, sprint ability was recovered 5 h after the first game and peak torque after 21 h, whereas jump ability was still reduced after 72 h. However, the performance parameters of the second game, such as intensity, distance run and high-intensity activities, were not affected by this recovery interval. This identification by Andersson et al.[25] disagrees with the recommendation of studies involving soccer players[12,24] and runners submitted to intermittent protocols[5,6], which found biochemical and physical performance parameters to be altered up to 72 h after a game and recommend a longer recovery period.

Zoppi et al.[13] used CK as a parameter to monitor 21 under-20 soccer players over 5 months of the Brazilian championship. CK concentrations were determined every month after 36 h of rest during training. The first assessment was performed at the end of the preparatory period before the beginning of the competitions (pre-season) and the last assessment at the time when the team was disqualified from the championship. Mean concentrations of 350 to 400 U/L were found during the season. These CK levels are above those considered to be normal for non-athletes. However, according to Mougios[3] who studied 728 male and female athletes of different sports modalities in order to determine the expected range for athletes and non-athletes, these levels are expected for active subjects, athletes and particularly for soccer players. In the same study, the author found higher plasma CK concentrations in soccer players when compared to swimmers and attributed these differences to the different characteristics of the respective modalities.

In the present study, although similar, CK concentrations increased until post-4 (90-110 h) when compared to BAS. There was no difference in CK levels between post-3 (60-65 h) and post-4. The levels of approximately 300 U/L observed at these times are similar to those reported in the study of Zoppi et al.[13] and lower than those observed by Lazarim et al.[11], who found a mean resting value of 493 ± 315 U/L.

In general, these CK levels may indicate a training status of the players during a very long national competition. In the present study, in addition to the recovery periods between games, the athletes participated in technical, tactical and physical training sessions. The main objective of the last type was to maintain the physical capacity of the athletes or even to contribute to their recovery. Therefore, these values are expected during a season when the athletes are evaluated before games and during training. This procedure is therefore useful to individually monitor the recovery state of an athlete and the magnitude of game and training intensities. This approach, in turn, contributes to the planning of recovery periods and indicates when to apply new training loads, assisting in the prevention of overtraining and favoring the maintenance of physical capacity during a competition.

Finally, the mean CK levels reported should be interpreted with caution. As can be seen in Table 2, post-1 values varied widely, indicating large variability in game intensity between volunteers. The exercise intensity during the games was not evaluated and this could represent a limitation of the present study.

CONCLUSIONS

Soccer is a high-intensity activity in which CK concentrations, an indirect marker of muscle microtraumas, reach their peak between 12-20 h after a game during the competitive season. The present findings led us to conclude that systematic training during a soccer season influences the kinetics of CK removal which, in turn, affects the time of recovery of the athletes. This information is important for the development of training plans. High CK concentrations of approximately 300 U/L

above BAS are detected up to 4 days after a game, but these levels can be considered normal for soccer players along a competition. Therefore, CK can be used as a marker to monitor the training status and recovery of soccer players.

Thanks to

FAPEMIG, CNPq., CAPES and Cruzeiro Esporte Clube.

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