Original Article

Correlation between creatine kinase and match load in soccer: a case report

LUCAS DE ALBUQUERQUE FREIRE¹, MÁRCIO TANNURE², DANIEL GONÇALVES³, ESTEBAN AEDO-MUÑOZ⁴, DIEGO IGNACIO VANENZUELA PEREZ⁵, CIRO JOSÉ BRITO⁶, BIANCA MIARKA⁷

^{1,7} - Postgraduate Program in Physical Education, School of Physical Education and Sports. Federal University of Rio de Janeiro, BRAZIL.

^{2,3} - Flamengo Regattas Club, BRAZIL.

⁴ - Biomechanics Laboratory. Chilean High Performance Center. Physical Activity, Sport and Health Sciences Laboratory. Universidad de Santiago de Chile, CHILE.

^{3,4} - Physical Education Department. Universidad Metropolitana de Ciencias de la Educación, Santiago, CHILE.

⁵ - Escuela de Kinesiología. Universidad Santo Tomas, Santiago, CHILE.

^{4,6,7} - Postgraduate Program in Physical Education. Physical Education Department. Federal University of Juiz de Fora, BRAZIL.

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Abstract:

Our study evaluated the correlation of data measured by GPS (in the strength, endurance, and speed stimulus divisions) and creatine kinase (CK) levels in professional soccer players after a match. For this purpose, the sample was composed by 123 measures of the same 24 players who stayed at least 75-min on the field, during five professional matches. The measures were taken in two periods: a) 24 hours (CK-T1) and b) 48 hours (CK-T2). The main results indicated that there was a positive correlation between CK-T1 and displacement% above 14 km/h ($19\% \pm 5\%$; $p=0.029$) and% above 18 km/h ($8\% \pm 2.9\%$; $p=0.048$), efforts above 18 km/h ($58.6\% \pm 20.3\%$; $p=0.04$), decelerations (35.6 ± 10.4 frequencies; $p=0.004$), explosive efforts (126.9 ± 37.4 frequency; $p=0.004$) and inverse correlation with minutes of effort (91.9 ± 9.8 frequency/min; $p=0.016$). For the CK-T2 there was a positive correlation with accelerations (31.3 ± 9.2 frequency; $p=0.009$), decelerations (35.6 ± 10.4 frequency; $p=0.008$), explosive efforts (126.9 ± 37.4 frequency; $p=0.004$), inverse correlation with the total load (895.1 ± 143.3 index; $p=0.008$) and minutes of effort (91.9 ± 9.8 frequency/min; $p=0.014$). Our data indicate that the use of GPS can directly infer the degree of muscle damage, suppressing invasive measures that can lower the cost of the sport.

Key Words: Task Performance and Analysis, Sports, External Loads, Muscle Strength, Fatigue, GPS, Muscle Damage

Introduction

Load control in soccer is essential to avoid injuries in athletes (Ehrmann, Duncan, Sindhusake, Franzsen, & Greene, 2016). Among the monitoring methods, the Global Positioning System (GPS) and creatine kinase (CK) are widely used (Russell et al., 2016). GPS is one of the current models of external load control, monitoring the physical actions performed in training and matches (Aughey, 2011). Serum CK is applied to estimate muscle damage, but never with a diagnostic character, as other external factors may imply a higher CK concentration (Coelho, Morandi, de Melo, & Garcia, 2011). The primary function of CK in muscle is to deliver the phosphorus in a reversible way to the ADP for ATP resynthesis at high-intensity effort (Ascensão, Leite, Rebelo, Magalhães, & Magalhães, 2011). CK is widely used in soccer matches in power movements (such as jumps or sudden changes in direction), as well as in sprints (Ascensão et al., 2008). Thus, it is possible to find high serum CK up to 4 days after a match (Lazarim et al., 2009; Thorpe & Sunderland, 2012).

There is an increase in the CK curve after exercise, and the peak occurs between 24-48 hours post-match (Thorpe & Sunderland, 2012; ; Miarka et al., 2020). In this context, the CK is measured between 24 and 48 hours after a match when there is no decrease (48 hours after) in serum concentration, while the third exam is performed between 48-72 hours to decide if the athlete is recovered for the next match (Ispirlidis et al., 2008; Krstrup et al., 2011). The cost of these measures is often impractical since CK has to be measured invasively, which can be inconvenient for the athlete, and performing these tests on the whole team (about 30 athletes) can significantly increase the cost of the sport. On the other hand, the GPS is measured non-invasively and has a lower cost since there is no need for analysis costs. However, few studies have associated these measures.

Some authors found a positive correlation between total distance at high intensity ($r=0.386$), speed ($r=0.363$), total sprints ($r=0.433$), high-intensity deceleration ($r=0.404$) and serum CK 24 hours in English Premier League (Football) athletes, but no correlations were observed with CK 48 hours. Russell et al. (2016).

Similar results were observed by da Silva et al. (2018) with College athletes in a simulated match protocol (SAFT-90). Therefore, to the best of our knowledge, only one study has measured the possible association between GPS and serum CK in professional players before and after a match. In this sense, new studies can corroborate or refute the previously evidenced results. Based on the above, this study aims to correlate the effort measures by GPS (in the strength, resistance and speed divisions) with serum CK. We hypothesize that serum CK will be correlated with the high intense actions measured by GPS.

Material & methods

Experimental approach

The research is descriptive and documentary, since it uses the database provided by a Club in the first division of Brazilian Soccer as a primary source. The present design aims to verify the strength association between Serum CK and effort measured by GPS. We used the CK measured from 10 soccer athletes (except the goalkeeper), who started the match played for ≥ 65 minutes in the one match, across all matches in the Brazilian soccer season (February-October 2018). The CK measurements were performed in 2 periods: 24 hours (CK-T1) and 48 hours (CK-T2), and were collected from blood (index finger) by specific reactive tapes (Reflotron test strips®, Roche, Switzerland) and measured in a biochemical analyzer (Reflotron plus®, Roche, Switzerland).

Participants

Data from 123 measurements of the same 24 professional soccer athletes (age: 25.75 ± 4.1 years-old; weight: 76.1 ± 4.4 kg; height: 179.4 ± 5.9 cm, and; Body Fat: $13.6 \pm 1.2\%$) were used. The following inclusion criteria were adopted: a) ≥ 18 yrs.; b) played ≥ 65 min of the match. The following players were excluded: a) removed from the game due to injury; b) those who had errors in the GPS signal capture; or CK) those who wished to withdraw from the study. All subjects had undergone pre-season training and had appropriate conditioning levels without injuries.

These athletes competed five-six times in national and international representative championships once per week and were regularly training (technical and tactical) 4-7 times a week during the evaluation period, except for the 2 days after the game when CK was collected (Ghoul et al., 2019). All measures occurred between February and September 2018. All participants attended a briefing meeting prior to data collection and signed an informed consent document to ensure the understanding of the testing parameters and the risks and benefits associated with the study. In addition, a letter of consent was sent and duly signed by the respective soccer club. This study was submitted to and approved by the Local Committee of Ethics in Research, following the resolution rules of the WMA Declaration of Helsinki.

Global Positioning System (GPS) measurements

The following measurements were collected by the GPS Vector (Catapult Innovations®, Australia) and analyzed by Sprint software (version 5.0, Catapult Innovations®, Australia): a) total distance performed at any intensity; b) distance in meters/minutes; c) Max speed; d) minutes in the match; e) $\% > 14$ km/h (percentage of time the athlete performed > 14 km/h); f) $\% > 18$ km/h (percentage of time the athlete performed ≥ 18 km/h); g) sprint frequency ≥ 18 km/h; h) distance performed (m) ≥ 18 km/h; i) sprint frequency ≥ 24 km/h; j) distance performed (m) ≥ 24 km/h; k) maximum speed; l) accelerations (efforts, on the horizontal axis, > 2.5 ms²; m) and decelerations (efforts, on the horizontal axis, < 2.5 ms²; m); jumps (displacements to the vertical axis, > 30 cm); n) explosive efforts (sum of all accelerations > 2 mss², decelerations < 2 mss², jumps > 30 cm and the sum of inertial movements).

Statistical analysis

The descriptive data and the correlations between the groups were performed using the Statistical Package for Social Sciences 20.0 (SPSS) program. Means and standard deviations, all parametric, were calculated according to the Kolmogorov-Smirnov normality test. Pearson's correlation was used for all tests, using the classification: > 0.7 positive or negative indicates a strong correlation, between 0.7 and 0.4 moderate, and below 0.4 weak correlation. The level of significance was set at 5% in all analyzes.

Results

The mean serum CK at baseline was 200.8 ± 29.2 U/L -1, then CK-T1 it was 846.8 ± 560.9 U/L -1 and CK-T2 648.9 ± 459.6 U/L -1. The Pearson's correlation demonstrated $r=0.813$ ($p \geq 0.001$) for the correlation between CK-T1 and CK-T2 after the match. No significant correlation was observed between CK baseline and the other moments ($p < 0.05$ for the both correlations). Table 1 shows the descriptive data and correlations between the external load and the CK.

Table1. Match load measures in mean $\pm$ standard deviation and correlations with CK 24h (CK-T1) and 48h (CK-T2) after match.

Measure	Results	CK-T1	CK-T2
Total distance (m)	9261.6 $\pm$ 1260.3	-0.043; p=0.533	-0.109; p=0.087
Speed (m/min)	101.1 $\pm$ 10.0	0.131; p=0.06	-0.003; p=0.963
% >14km/h	19% $\pm$ 5%	0.152 [*] ; p=0.029	0.114; p=0.074
% >18km/h	8% $\pm$ 2.9%	0.137 [*] ; p=0.048	0.102; p=0.11
Effort >18km/h (frequency)	58.6% $\pm$ 20.3%	0.143 [*] ; p=0.04	0.082; p=0.199
Distance >18km/h (meters)	781.1 $\pm$ 304.0	0.099; p=0.153	0.048; p=0.451
Effort >24km/h (frequency)	10.0 $\pm$ 5.9	0.09; p=0.196	0.007; p=0.909
Distance >24km/h (meters)	149.0 $\pm$ 96.4	0.047; p=0.5	-0.002; p=0.973
Speed max (km/h)	29.7 $\pm$ 2.1	-0.034; p=0.627	-0.002; p=0.974
Total load (index)	895.1 $\pm$ 143.3	-0.1; p=0.149	-0.169 ^{**} ; p=0.008
Load/min (index/min)	9.8 $\pm$ 1.3	0.019; p=0.784	-0.091; p=0.151
Acceleration (frequency)	31.3 $\pm$ 9.2	0.131; p=0.059	0.166 ^{**} ; p=0.009
Deceleration (frequency)	35.6 $\pm$ 10.4	0.197 ^{**} ; p=0.004	0.169 ^{**} ; p=0.008
Jumps (frequency)	12.6 $\pm$ 5.4	-0.019; p=0.786	-0.02; p=0.75
Explosive effort (frequency)	126.9 $\pm$ 37.4	0.197 ^{**} ; p=0.004	0.142 [*] ; p=0.025
Relative Effort (freq./min)	91.9 $\pm$ 9.8	-0.167 [*] ; p=0.016	-0.156 [*] ; p=0.014

Note: CK-T1 = 24h post-match, CK-T2 = 48h post-match.

There was a negative correlation between total distance and CK-T1 and CK-T2. However, CK-T1 strongly and positively correlated with the levels at CK-T2. Displacement per minute, explosive efforts, accelerations and decelerations also showed a weak positive correlation.

Discussion

The use of indirect non-invasive techniques can increase the efficiency in taking measurements in more athletes at a lower cost (Gastin, Hunkin, Fahrner, & Robertson, 2019) and without causing the discomfort arising from blood collection (Brito et al., 2018). Thus, this study correlated the data from GPS (in the strength, resistance and speed stimulus divisions) with the serum CK. The results show a negative correlation between total distance and CK after 24h and 48h after the match. Distance per minute, explosive efforts, accelerations, and decelerations have a positive correlation, with a weak classification. Our results are in line with previously published results (da Silva et al., 2018; Russell et al., 2016) which suggest the ability of the GPS to monitor the external match load applied to athletes. These findings are relevant because they make it possible to perform an indirect estimative of the muscle damage, thus establishing a better understanding of the risk of injury in high-performance athletes (Ehrmann et al., 2016). Anticipating the risk of injury is crucial as many matches are played throughout the season (Aughey, 2011; Ehrmann et al., 2016).

The athletes measured in our study maintained the average total distance during the match, which is expected for professional soccer athletes who performed between 9-14 km/match (Carling & Dupont, 2011). Furthermore, the high-intensity actions performed during the match increase the external load that the athlete is submitted to (da Silva et al., 2018). Soccer teams have been monitoring the post-match recovery course due to the accumulated external load of a match in order to decide which athletes should be selected for the next match (da Silva et al., 2018; Ehrmann et al., 2016). Thus, CK levels are one of the indicators of athlete recovery among the methods used (Coelho et al., 2011; da Silva et al., 2018; Ispirlidis et al., 2008). However, the CK measure is invasive and needs to be monitored for at least 3 days after a match (Ispirlidis et al., 2008), thus the use of external load measured by the GPS seems to be more advantageous (Russell et al., 2016). The correlations observed for high-intensity activities in our study and those observed by da Silva et al. (2018) were weak; however, our data were obtained from professional athletes in a match condition compared to those obtained from amateur athletes using a simulated protocol, but the correlations obtained are closer when compared to English professional players (Russell et al., 2016). A third factor may be related to the biological variation of CK concentrations (Chen, 2006; Gastin et al., 2019). However, we tried to minimize the interference of CK variability in our protocol by measuring the same group of players throughout a season, thus avoiding errors associated with a single measure.

Ispirlidis et al. (2008) observed that serum CK remains highly concentrated up to 48 hours post-match in elite athletes. Therefore, recovery measures must be carried out by the technical team so that all screening and prevention of possible injuries is carried out. It should be noted that part of our results is corroborated by previously published studies (da Silva et al., 2018; Ispirlidis et al., 2008; Russell et al., 2016). In this line, Gastin et al. (2019) observed that the acceleration and deceleration are those which most contribute to the increase in muscle damage in Australian football. Football movements performed at high intensity have repeated eccentric contraction actions (Petersen, Thorborg, Nielsen, Budtz-Jørgensen, & Hölmich, 2011), and in these conditions sarcomeres undergo repeated periods of overstretching, thus increasing the risk of Z-filament misalignment (Brancaccio, Lippi, & Maffulli, 2010) and in turn the disruption of sarcomeres, thereby resulting in a higher CK

release into the blood (Coelho et al., 2011). Despite the variability, CK levels have been used by technical teams for the recovery of athletes from matches to prevent muscle injuries (da Silva et al., 2018).

CKT2 in our study remained high compared to baseline. Dellal, Lago-Peñas, Rey, Chamari, and Orhant (2015) observed that the risk of injury increases when a new match is played less than 4 days after, therefore residual fatigue estimated by CK may actually indicate an increased risk for injury. In fact, when two matches are played, the risk of injury is doubled (33.7 vs. 15.6 injuries/1,000 hours) when compared to one per week (Howle, Waterson, & Duffield, 2020).

The use of GPS to monitor the external loads of soccer games has grown in recent years (da Silva et al., 2018; Ehrmann et al., 2016; Russell et al., 2016). We observed a positive correlation with CK when these distances are performed at >14 and 18 km/h and acceleration and deceleration movements, being in line with our results. Ehrmann et al. (2016) observed that the distance performed (m/min) increases the incidence of injuries by 9.6% and the acceleration and deceleration movements by 7.4%. The monitoring of these variables is essential to avoid the risk of injury during the season, since an increase in the distance covered by the athletes during the season is expected (Ehrmann et al., 2016; Rahnama, Reilly, & Lees, 2002). Among the limitations of the present study is the lack of control by the position of the athlete and the use of other direct measures of muscle strength and power. Future studies should focus on the use of measurements by position (i.e. fullback, center and forward) and establish cut-off points to estimate the risk of injury based on the GPS measurements. Based on our aims, methods and results, we can conclude that there is a correlation between some data obtained by GPS and serum CK presented 24 and 48 hours, mainly in high-intensity efforts, acceleration and deceleration.

Conclusions

This research provided a comprehensive account of the relationship between external (GPS parameters) and internal (muscle damage through CK responses) load from professional soccer demands. Results demonstrated a negative correlation between total distance and CK after 24h and 48h after the match. Distance per minute, explosive efforts, accelerations, and decelerations have a positive correlation. These findings are important for conditioning professionals and recovery strategies and could be used as a supplementary method for monitoring directions for profiling the fatigue and recovery process of soccer athletes for direct and peak CK response from 24 to 48 hours.

Conflicts of interest - None.

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