Effects of an intense run of matches on blood biomarker and physical performance in professional soccer athletes

Efectos de una serie intensa de partidos sobre los biomarcadores sanguíneos y el rendimiento físico en futbolistas profesionales

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Abstract

Introduction: High-level soccer players frequently face congested match schedules, which limits recovery and increases muscle damage.
Objective: This study aimed to investigate the effects of a congested match period compared to a non-congested period on creatine kinase levels and physical performance metrics.
Methodology: Ten professional athletes were monitored over two thirty-day periods. Blood creatine kinase concentrations and global positioning system physical performance metrics were collected and compared.
Results: Blood creatine kinase concentrations were significantly higher during the congested period than in the non-congested period at twenty-four hours and forty-eight hours post-match. A significant positive correlation was found between total playing minutes and creatine kinase levels, whereas global positioning system physical performance metrics showed no significant differences.
Discussion: While previous literature reported performance declines during congested schedules, the results of this investigation aligned with studies showing maintained physical performance when tactical player rotation and adequate physical conditioning were implemented.
Conclusions: The congested period significantly increased internal load and muscle damage, which correlated directly with cumulative playing minutes rather than match count. However, external physical performance remains unaffected, indicating that strategic player rotation can successfully mitigate performance decrements.

Keywords

Creatine kinase, football, global positioning system, muscle damage, performance.

Resumen

Introducción: Los futbolistas de alto nivel se enfrentan frecuentemente a calendarios competitivos congestionados, lo que limita la recuperación e incrementa el daño muscular
Objetivo: Este estudio analizó los efectos de un periodo de partidos congestionado en comparación con un periodo no congestionado sobre los niveles de creatina quinasa y las métricas de rendimiento físico.
Metodología: Se evaluó a diez futbolistas profesionales durante dos periodos de treinta días. Se registraron y compararon las concentraciones de creatina quinasa en sangre y las métricas de rendimiento físico mediante el sistema de posicionamiento global.
Resultados: Las concentraciones de creatina quinasa en sangre fueron significativamente mayores en el periodo congestionado en comparación con el no congestionado a las veinticuatro y cuarenta y ocho horas postpartido. Se observó una correlación positiva significativa entre el tiempo de juego total y los niveles de creatina quinasa, mientras que las métricas de rendimiento físico no mostraron diferencias significativas.
Discusión: Aunque la literatura previa reportó caídas en el rendimiento durante calendarios congestionados, los resultados de esta investigación coincidieron con estudios que mostraron un rendimiento físico mantenido cuando se implementaron la rotación táctica de jugadores y un acondicionamiento físico adecuado.
Conclusiones: El periodo congestionado aumentó significativamente la carga interna y el daño muscular, correlacionándose directamente con los minutos de juego acumulados y no con la cantidad de partidos. Sin embargo, el rendimiento físico externo no se ve afectado, lo que indica que la rotación estratégica de los jugadores puede mitigar con éxito la disminución del rendimiento.

Palabras clave

Creatina quinasa, daño muscular, fútbol, rendimiento, sistema de posicionamiento global.

Introduction

The competitive season for top-level soccer players often involves congested games with back-to-back matches separated by only 2–3 recovery days (Mohr et al., 2016). It occurs because the club plays two or three competitions simultaneously, so it is common for athletes to have two matches a week, with some teams completing up to three matches in a weekly microcycle (Mohr et al., 2016; Póvoas et al., 2022). As a result, recovery time between games is limited, resulting in residual fatigue and increased risk of injury (Carling et al., 2016; Dellal et al., 2015).

The team's coaching staff uses the Global Positioning System (GPS) to monitor and control the athletes' fatigue (Djaoui et al., 2022). This device is routinely used during training sessions and games to monitor the external load (Rabita et al., 2015). Over the years, using physiological markers in soccer has become essential, allowing researchers and coaches to obtain information on the athletes' internal load (García-Romero-Pérez et al., 2021). One of the most used markers is creatine kinase (CK), which can indicate muscle damage and fatigue (Finsterer & Drory, 2016; Reichel et al., 2020). CK generally increases after 24–36h of strenuous exercise, making this biomarker a valuable tool for monitoring recovery efficiency (Nowakowska et al., 2019).

The congested period (CONGEST) is defined by sequences of games with only 2 to 3 days of recovery between them, whereas the non-congested period (NCONGEST) includes games separated by more than four days (Dellal et al., 2015; Julian et al., 2021). Under these conditions, maintenance or improvement of the player's performance is determined by adequate conditioning and the body's ability to recover after multiple stress stimuli (Ekstrand et al., 2011). Although there is a relationship in the literature between increased physical stress and low sports performance of athletes, the impact of CONGEST on performance is inconclusive (Dellal et al., 2015; Djaoui et al., 2022; Julian et al., 2021; Póvoas et al., 2022).

A recent study concluded that acceleration (ACC) and deceleration (DCC) performance in the game was affected during CONGEST compared to NCONGEST, highlighting a possible accumulation of fatigue (Djaoui et al., 2022). On the other hand, other studies have identified that physical performance is maintained when two or three games are completed in a weekly microcycle (Andrzejewski et al., 2014; Carling et al., 2016). Furthermore, the methodological approach of the studies differs, contributing to inconclusive results (Carling et al., 2016; Dellal et al., 2015; Ekstrand et al., 2011; Folgado et al., 2015; Jones et al., 2019; Julian et al., 2021; Mohr et al., 2016).

So far, the available literature has not investigated the impact of CONGEST on physical performance and fatigue biomarkers compared with NCONGEST. Some studies seek to analyze the physical performance of athletes only during the period with many games. Other studies make the comparison but with a short period of analysis (Folgado et al., 2015).

Therefore, this study aimed to investigate the effects of a congested match period (CONGEST) on biochemical markers of muscle damage (creatine kinase) and on-field physical performance metrics in professional soccer players, comparing them to a non-congested period (NCONGEST). We hypothesized that the congested period would lead to significantly higher creatine kinase concentrations, reflecting greater cumulative muscle damage and incomplete recovery, which in turn would result in a decline in the athletes' physical performance metrics compared to the non-congested period.

Method

Participants

The sample comprised ten elite male professional soccer players from a Brazilian first-division club. Participant selection was based on their match-play exposure during both congested and non-congested periods. The first selection criterion was individual match exposure; only athletes who played at least one half of a match (approximately 45 minutes) in a given game were considered, which initially yielded 16 athletes. The second criterion was the frequency of participation; athletes had to participate in at least 50% minus one of the total possible matches in each analyzed period. This equated to a minimum

of four matches during the congested period and two matches during the non-congested period. Applying these combined criteria resulted in a final sample of ten athletes (comprising two central defenders, three full-backs, two midfielders, and three forwards).

Congested and Non-Congested Periods

Two distinct 30-day periods within the team's competitive season calendar were selected for comparison: Congested Period (June): The team played nine matches (eight national championship matches and one continental tournament match). All matches during this month were separated by a brief recovery interval of only 3 to 4 days. Non-Congested Period (September): The team played four matches, all belonging to the national championship. These matches were scheduled once a week, allowing the players a recovery window of 5 to 6 days between fixtures.

Creatine Kinase (CK) Concentration

Throughout the competitive season, the club's medical staff collected capillary blood samples to quantify the athletes' CK concentrations. Collections were systematically performed at 24 and 48 hours post-match. Athletes with more than 45 minutes of match play were instructed to report to the Department of Exercise Physiology for sampling. To maintain methodological standardization and minimize analytical variance, the same investigator performed all blood collections and subsequent analyses throughout the study. Upon arriving at the laboratory, athletes remained in a standing position while the investigator prepared the materials. The puncture site (finger pulp) was sanitized with cotton soaked in 70% isopropyl alcohol. Light pressure was applied to the finger, and a sterile 1.5 mm Accu-Chek Safe-T-Pro Uno disposable lancet (Roche, Mannheim, Germany) was used to perform the puncture. The lancet was immediately discarded into a designated biohazard sharps container.

A 30-µL capillary blood sample was collected using a Reflotron Capilette (Roche, Mannheim, Germany). The sample was immediately transferred to a CK ECO POC reagent strip and analyzed using the Simplex ECO POC Analyzer (ECO Diagnóstica, Corinto, Brazil) for the quantitative determination of CK, strictly following the manufacturer's instructions. This analyzer has demonstrated excellent analytical reliability for CK measurement compared to standard automated central laboratory analyzers ($r \geq 0.98$; ICC > 0.95). Furthermore, it accommodates up to four reagent cartridges simultaneously, features a measurement range of 10 to 1200 U/L, and completes each analysis within 13 minutes. All blood chemistry results were subsequently tabulated in Microsoft Excel®.

GPS Metrics

During every official match, player movement patterns were monitored using a wearable 10-Hz GPS tracking system (Catapult® Vector S7, Melbourne, Australia). The device was housed in a specialized tight-fitting vest positioned between the player's scapulae. The GPS unit captured spatial and temporal data at a sampling frequency of 10 Hz, providing data points every 0.1 seconds. The following physical performance metrics were analyzed: Total Distance (TD): The overall distance covered during the match, expressed in meters (m). Distance at High Intensity (DHI): The cumulative distance covered at speeds greater than 19 km/h. Sprint Distance (SD): The cumulative distance covered at speeds greater than 25 km/h. Number of Sprints: The total frequency of running actions exceeding a speed threshold of 25 km/h. Distance in Acceleration (Dist. ACC): Cumulative distance covered during accelerations greater than 3 m/s^2. Distance in Deceleration (Dist. DCC): Cumulative distance covered during decelerations greater than 3 m/s^2 (expressed as a negative value, less than -3 m/s^2). Accelerations and Decelerations per Minute (ACCDCC/min): The relative rate of accelerations (greater than 3 m/s^2) and decelerations (less than -3 m/s^2) normalized to match play duration. Number of Accelerations (Number ACC): Total count of accelerating efforts greater than 3 m/s^2. Number of Decelerations (Number DCC): Total count of decelerating efforts less than -3 m/s^2. To minimize inter-device variability, each player wore the same microtechnology unit across all matches. Furthermore, the same sports science staff managed the distribution, retrieval, and data extraction protocols throughout the entire 2022 season.

Data analysis

Data distribution normality was assessed using the Shapiro-Wilk test. To compare physical performance (GPS) and physiological (CK) variables between the congested (CONGEST) and non-congested (NCONGEST) periods, a paired-samples t-test was used for parametric data, while the Wilcoxon signed-rank

test was applied to non-parametric data. Pearson's correlation coefficient was calculated to examine the relationships between internal (CK) and external (GPS) load metrics. All descriptive statistics are presented as mean and standard deviation (SD). Statistical significance was set at $p < 0.05$. Statistical analyses and graphical representations were performed using GraphPad Prism software (version 8.0, San Diego, CA, USA).

Results

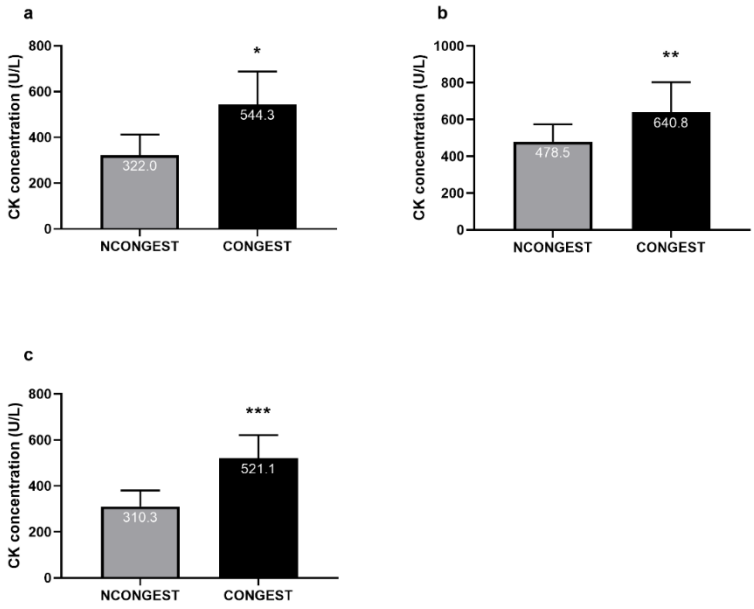
CK data

Total CK represents the mean of the samples taken 24 and 48 hours after the match. Fig. 1a compares total CK in CONGEST and NCONGEST, with concentrations of 544.3 ±143.5 and 322.0 ±90.43 U/L, respectively. CONGEST was significantly higher (p=0.0003), indicating more significant muscle damage in the period with less recovery time between games. Fig. 1b and 1c compare 24 and 48 hour CK in CONGEST and NCONGEST, respectively.

Match Exposure

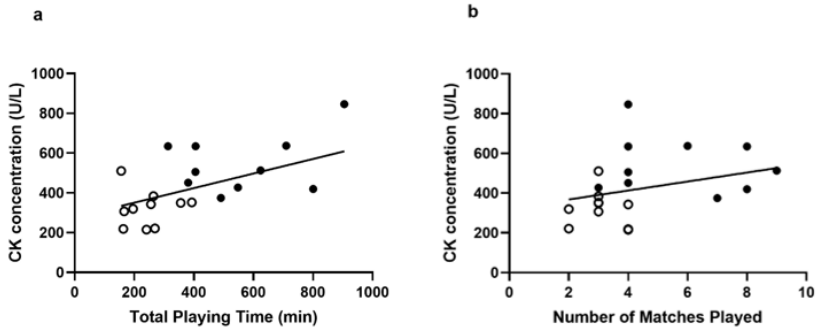
Regarding match exposure in the final sample (n = 10), total playing time was significantly higher during the CONGEST period compared to the NCONGEST period (530.00 ±200.81 min vs. 274.40 ±76.89 min, p = 0.005). Likewise, players completed a significantly greater number of match appearances during CONGEST than in NCONGEST (5.70 ±2.16 matches vs. 3.10 ± 0.74 matches, p = 0.006).

Figure 1. Comparison of blood creatine kinase (CK) concentrations between congested (CONGEST) and non-congested (NCONGEST) match periods: (A) total mean, (B) 24-hour post-match, and (C) 48-hour post-match.



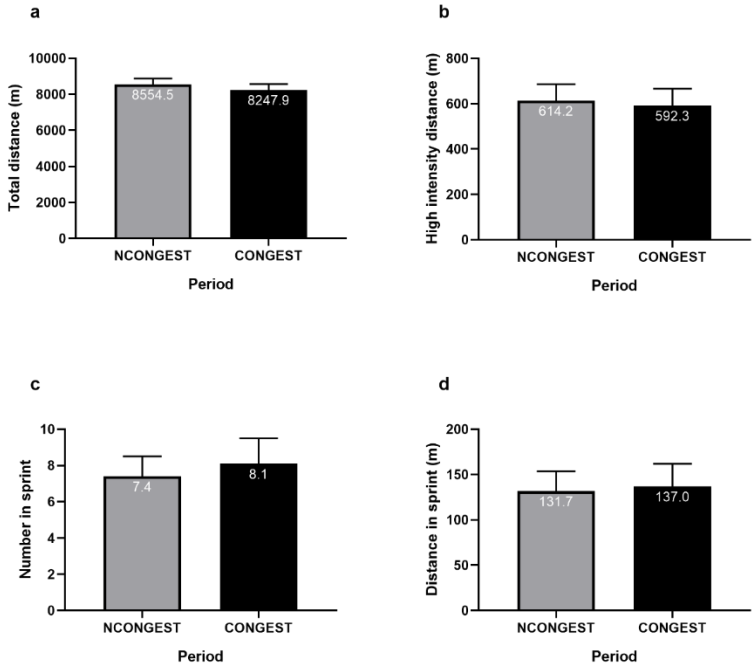
Regarding 24-hour post-match values, CK concentrations were significantly higher in CONGEST compared to NCONGEST (640.8 ±162.3 U/L vs. 478.5 ±95.4 U/L; p = 0.046; Figure 1B). Similarly, 48 hours post-match, athletes exhibited higher blood CK concentrations during CONGEST than NCONGEST (521.1 ±99.7 U/L vs. 310.3 ±70.1 U/L; p < 0.0001; Figure 1C). Furthermore, playing time was significantly and positively correlated with total CK concentration (r = 0.6428; p = 0.0022; Figure 2A). In contrast, the correlation between the number of games played and CK concentration was not statistically significant (r = 0.3600; p = 0.1100; Figure 2B).

Figure 2. Correlation of blood creatine kinase (CK) concentrations with total playing minutes (a) and number of matches played (b). Filled circles represent the CONGEST period and open circles represent the NCONGEST period.



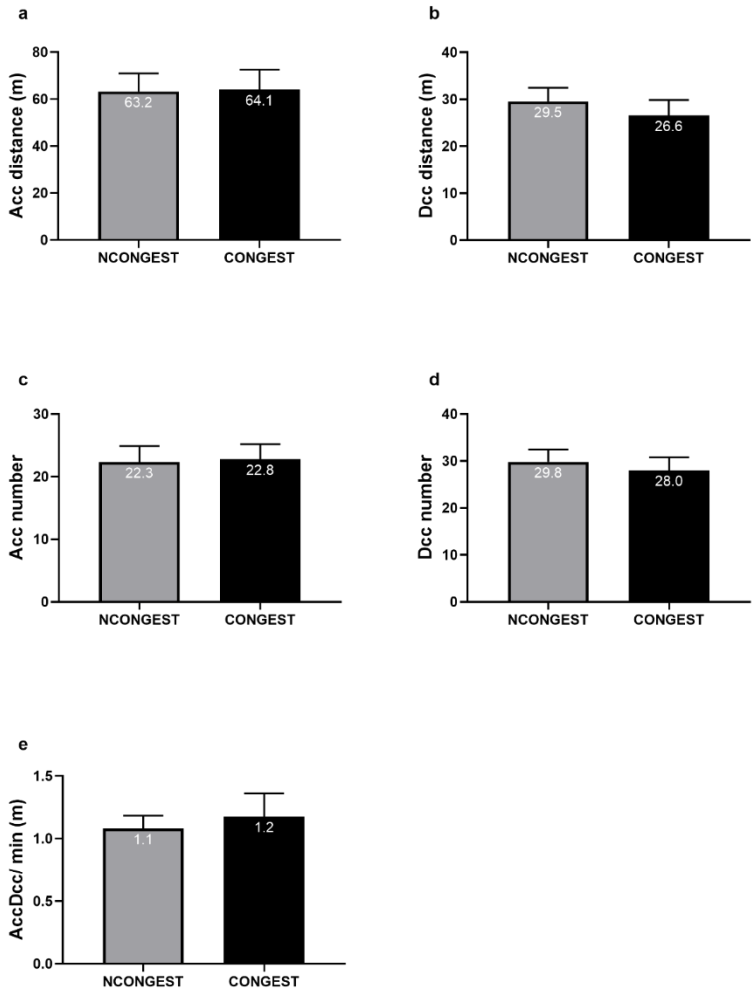
The mean TD covered in the two periods did not show a significant difference, as did the mean DHI, SD, and number of sprints (Fig. 3). The present study also compared the ACC and DCC occurring in congested and non-congested periods.

Figure 3. Comparison of Global Positioning System-derived physical performance metrics and sprint profiles between congested and non-congested match periods.



The results show that there was no significant difference when comparing CONGEST and NCONGEST for distance in acceleration (Dist. in Acc) and distance in deceleration (Dist. in Dcc) (64.0 ±26.8m vs. 63.2 ±24.4m; and 26.5 ±10.3m vs. 29.5 ±9.3m, respectively; Figures 4A and 4B). The number of accelerations (Acc Count) and decelerations (Dcc Count) represent speed changes during matches. Comparison between CONGEST and NCONGEST revealed no statistically significant differences for mean acceleration count (22.7 ±7.5 vs. 22.3 ±8.0; Figure 4C) or mean deceleration count (28.0 ±8.7 vs. 29.8 ±8.3; Figure 4D).

Figure 4. Comparison of acceleration (Acc) and deceleration (Dcc) distances and counts between congested (CONGEST) and non-congested (NCONGEST) match periods.



The ACCDCC/min is the sum of the acceleration and deceleration distance divided by the minute of each player on the field. Fig. 4e demonstrates the result of comparing this metric in the CONGEST and NCONGEST (1.17±0.58 m/min vs. 1.08±0.32 m/min, respectively), where it also showed no statistically significant difference (>0.05).

Discussion

The primary objective of this study was to investigate the effects of a congested match period (CONGEST) on biomarkers of muscle damage and on-field physical performance in professional soccer players compared to a non-congested period (NCONGEST). Our main findings revealed that the congested schedule imposed a substantially higher internal load on the athletes, characterized by significantly elevated total creatine kinase (CK) concentrations ($p=0.0003$), as well as higher CK levels at both 24 hours ($p=0.046$) and 48 hours ($p<0.0001$) post-match. Furthermore, a significant positive correlation was identified between total playing minutes and CK concentrations ($p=0.0022$, $r=0.6428$), whereas the total number of games played did not yield a significant relationship.

Taken together, these biochemical outcomes strongly indicate that the reduced recovery time between matches during the congested period led to heightened cumulative muscle damage, even though external physical performance metrics remained statistically unchanged. Several studies conducted on semi-professional and professional male soccer players have reported CK values as a reliable method to assess exercise-induced muscle damage (Botelho et al., 2022; Hacker et al., 2021; Selmi et al., 2022; Souglis et al., 2018).

In addition to periods of high-intensity training, substantial increases in circulating CK levels immediately after a match are typically considered a sign of muscle damage produced during the game (Andersson et al., 2008). A study by Chou et al. (2021) simulated congested and non-congested games in female soccer players. The authors utilized 90-minute match simulations reproduced over one, three, or six consecutive days. They concluded that three and six games on successive days induced a more significant increase in blood CK levels compared to a single game, suggesting an accumulation of muscle damage, which is highly consistent with the results of the present study.

Monitoring external match load via GPS metrics (e.g., high-intensity running, accelerations, and decelerations) has become essential for managing physical strain and recovery kinetics in soccer (Diaz-García et al., 2024). Recent studies published in football contexts similarly emphasize that fixture congestion significantly alters physiological stress and neuromuscular fatigue markers, reinforcing the necessity of individualized load monitoring to optimize player performance and reduce injury risk (Castillo et al., 2023; Modric et al., 2023).

Similar to the present investigation, Carling et al. (2012) analyzed the effects of a prolonged period of congestion (8 games in 26 days). Their primary finding indicated that the distance covered at high intensity remained unchanged. Likewise, the research by Dellal et al. (2015) investigated variations in physical performance (including total distance, light running, low-intensity, moderate, and high-intensity running) during three different periods of congested games (six games in 18 days). This study found no significant differences between congested and non-congested periods across all analyzed physical performance metrics.

In contrast, Djaoui et al. (2022) investigated the influence of congested periods on acceleration (ACC) and deceleration (DCC) profiles during 32 matches. Their results showed that acceleration and deceleration frequencies were lower during congested periods, leading to the conclusion that these metrics were significantly affected compared to non-congested periods, highlighting a potential accumulation of fatigue. However, it is worth noting that in the research by Djaoui et al. (2022), other speed variations of ACC and DCC did not show statistical differences, which may explain the sustained performance observed in the present study.

A probable explanation for the sustained physical performance of the athletes during the games may be related to the coaching staff's strategies of relaying and replacing athletes during these critical periods of the match sequence, as observed in previous research (García-Romero-Pérez et al., 2021). Under this perspective, the current rule allowing five substitutions makes it easier for coaching staffs to sustain team performance and reduce the likelihood of injury (Mota et al., 2020). The strengths of the current study include the fact that it was conducted within a professional soccer club competing in the first division of the Brazilian national championship. In contrast to previous short-term prospective studies (Dellal et al., 2015; Zanetti et al., 2021), we evaluated a total of 60 days. Secondly, the present study verified the effects of CONGEST within the same group of athletes during NCONGEST, unlike other investigations in the literature (García-Romero-Pérez et al., 2021; Julian et al., 2021).

From a practical standpoint, these findings offer valuable insights for soccer coaching and sports science staffs when managing player rotation and recovery strategies. The clear discrepancy between increased internal load (elevated CK at 24h and 48h) and unaltered external load (maintained physical performance metrics) suggests that professional players can sustain high-intensity physical performance during congested schedules, but at the cost of heightened and cumulative muscle damage. Therefore, practitioners should not rely solely on GPS metrics to assess a player's readiness to play; instead, the integration of post-match biochemical monitoring is essential to detect residual fatigue. Furthermore, since muscle damage was strongly correlated with total playing minutes rather than the number of matches, technical staffs should strategically manage individual match exposure through early substitutions or rotation of high-minute players to mitigate injury risks during congested competitive microcycles.

This study has some limitations that should be acknowledged. First, the data were collected from a single professional soccer club, which restricts the generalizability of the findings to teams operating under different environmental conditions, tactical systems, or competitive levels. Second, although GPS and CK are highly robust measures, other markers of internal load—such as subjective ratings of perceived exertion (RPE) or countermovement jump (CMJ) performance—were not evaluated, which could have provided a more comprehensive understanding of the players' neuromuscular recovery. Finally, while

our sample size represents the realistic core of a professional starting lineup, future multicenter studies with larger cohorts are warranted to confirm these patterns across different playing positions and squad structures.

Conclusions

The congested match period significantly increased total, 24-hour, and 48-hour post-match creatine kinase concentrations compared to the non-congested period, indicating heightened cumulative muscle damage. Total playing time demonstrated a significant correlation with this biochemical marker, suggesting it is a critical metric for coaching staffs to monitor internal load, whereas the mere number of games played may not be the most effective strategy. Furthermore, despite the reduced recovery time, the congested period did not lead to a decrease in the athletes' physical performance, as all GPS metrics remained unaltered.

This suggests that tactical player rotation and adequate physical conditioning successfully maintained on-field performance. For future investigations, it is recommended to conduct multicenter studies with larger samples to analyze these responses across different playing positions. Additionally, future research should integrate complementary markers, such as subjective ratings of perceived exertion and neuromuscular power tests, to provide a more holistic understanding of soccer players' recovery kinetics during high-density competitive schedules.

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