Impact of COVID-19 lockdown on match activity and physical performance in professional football referees

AUTHORS: Victor Moreno-Pérez¹², María Luisa Martín-Sánchez³, Juan Del Coso⁴, Jose Luis Felipe⁵, Javier Courel-Ibáñez⁶, Javier Sánchez-Sánchez⁷

¹ Sports Research Center, Miguel Hernandez University of Elche, Alicante, Spain
² Center for Translational Research in Physiotherapy, Department of Pathology and Surgery, Miguel Hernandez University of Elche, San Joan, Spain
³ Grupo IGOD, University of Castilla La Mancha, Toledo, Spain
⁴ Centre for Sport Studies, Rey Juan Carlos University, Fuenlabrada, Spain
⁵ Faculty of Sport Sciences, Universidad Europea de Madrid, Madrid, Spain
⁶ Faculty of Sport Sciences, University of Murcia, Murcia, Spain
⁷ Comité Técnico de Árbitros (CTA) de la Real Federación Española de Fútbol (RFEF), Spain

ABSTRACT: To investigate the effect of COVID-19 lockdown on match-play metrics in professional football referees during official matches of the Spanish professional leagues. Forty-two professional football referees from the First (n = 20) and Second Division (n = 22) were monitored during 564 official games using Global Positioning System (GPS) technology. Data of matches before lockdown were compared to matches after resumption of the competition. Compared to pre-lockdown, in the referees of the First Division there was a decrease in the total running distance and the distance covered at all speed thresholds > 6 km h⁻¹ after lockdown (P < .05). In the Second Division referees, the post-lockdown measurement only showed a decrease in the running distance at 21–24 km h⁻¹ (P < .05), with no changes in the other speed thresholds. The post-lockdown measurement showed an increased distance covered at < 6 km h⁻¹ and the number of accelerations for both First and Second Division referees (P < .05). Referees' match activity was reduced due to the COVID-19 lockdown, while the effect on running parameters was more pronounced in First Division referees.

CITATION: Moreno-Pérez V, Martín-Sánchez ML, Del Coso J et al. Impact of COVID-19 lockdown on match activity and physical performance in professional football referees. Biol Sport. 2021;38(4):761–765.

Received: 2020-10-23; Reviewed: 2021-08-07; Re-submitted: 2021-08-11; Accepted: 2021-09-18; Published: 2021-10-27.

INTRODUCTION

Referees must possess optimal physical fitness to minimize the influence of fatigue on their judgements [1]. This is essential in professional football because referees cover between 10 and 12 km and make more than 100 decisions per match [1, 2]. In normal conditions, professional football referees are well prepared to keep up with play, allowing correct positioning during match play. The correct fitness is assured through the different battery of fitness testing carried out by referee governing bodies at several points of the season [1]. However, the first wave of the coronavirus disease 2019 (COVID-19) pandemic, caused by the SARS-CoV-2 virus, forced the suspension of professional sport competitions for weeks, having an unprecedented impact on sports and training routines [3, 4].

The health authorities of several European countries decreed lockdown measures to diminish the spread of the virus, which impeded professional referees, among other athletes, training outdoors and the use of sport facilitates. In Spain, the lockdown lasted for 8 weeks and, in an attempt to mitigate performance loss, professional referees followed customized training programmes at home during this period. In particular, the Referees Technical Committee from the Royal Spanish Football Federation provided specific guidelines and set up online conferences to maintain the physical fitness of professional referees. Despite these efforts, during COVID-19 home confinement, referees were likely exposed to some level of detraining that could induce negative consequences in physiological systems due to the insufficient stimuli and the absence of organized training and competition [5–8]. This was due to the lack of conditions in most homes to perform the specific actions of football refereeing.

The impact of insufficient training over 4 weeks or more may be evident in the decline of endurance capacity [9], sprint performance and force production at high velocities [10]. Longer periods of about 9 weeks lead to a loss of capacity to accelerate in professional football referees [11]. These decreases in performance may be critical for the quality of refereeing since referees are required to make fast and complicated decisions while covering long distances, including ~2 km at > 15 km h⁻¹ and ~40 sprinting actions at > 18 km h⁻¹ per game [2, 12, 13] to keep the pace of the match play. In Spain,
the professional football referees were allowed to return to their normal training routines after lockdown, and they had 4 complete weeks to prepare the remaining 11 matches to finish the competition [4]. There are however no data about the impact of the training alterations due to COVID-19 lockdown on the referees’ return to competition.

The aim of this study was to investigate the effect of COVID-19 lockdown on match-play metrics in professional football referees during official matches of the Spanish professional leagues.

**MATERIALS AND METHODS**

**Participants**

Forty-two professional referees from the Spanish First Division (n = 20; mean [SD] age, 37.8 [4.3] years; body mass, 75.1 [4.4] kg; height, 182.4 [5.0] cm) and from the Second Division (n = 22; mean [SD] age, 34.1 [3.6] years; body mass, 75.1 [4.4] kg; height, 182.1 [3.8] cm) volunteered to participate in this study. Active professional football referees with one match refereed before and after the lockdown due to the COVID-19 pandemic were included. Exclusion criteria were: a) history of pain or injury during the match; b) < 90 minutes of refereeing in a match. Written informed consent was obtained from all participants and the procedures were approved by the institutional Ethics Review Committee (ID: 489/24022020).

**Time-motion analysis**

Data were collected during 564 official competitive matches of the Spanish 2019–2020 First and Second Division seasons. Referees’ movements and HR were monitored using 10-Hz portable Global Positioning System (GPS) units (WIMU PRO, RealTrack Systems, Almería, Spain) and a GARMIN band (Garmin Ltd., Olathe, Kansas, United States). Each referee wore the same GPS device during the whole study period [14]. According to the manufacturers’ recommendations, all devices were activated 15 minutes before data collection to allow acquisition of satellite signals and synchronization of the GPS clock with the satellite’s atomic clock. Data were downloaded to a personal computer and analysed using a customized software package (SPRO, RealTrack Systems, Almería, Spain). A total of 17 match activity metrics were collected per match: total distance, distance < 6 km·h⁻¹ (m), distance 6–12 km·h⁻¹ (m), distance 12–18 km·h⁻¹ (m), distance 18–24 km·h⁻¹ (m), distance > 24 km·h⁻¹ (m), number of accelerations/decelerations (n), peak acceleration/deceleration (m·s⁻²), sprint distance (m), number of sprints (n), peak speed (km·h⁻¹), average HR (b·m⁻¹), HRmax (b·m⁻¹) and %HRmax. A sprint was defined as an action with a running speed above 24 km/h. All matches were conducted on a natural grass surface within pitch dimensions of −100 × 70 m.

**TABLE 1.** Changes in match-play metrics in football referees from the Spanish first and second divisions before and after the COVID-19 lockdown.

| Match-play metrics        | First Division       | 95% CI Diff     | P-value | Second Division      | 95% CI Diff     | P-value |
|---------------------------|----------------------|-----------------|---------|----------------------|-----------------|---------|
|                           | Pre-Lockdown         | Post-Lockdown   |         | Pre-Lockdown         | Post-Lockdown   |         |
| Total distance (m)        | 10463 (943)          | 10073 (1039)    | -674 to -106 | 10381 (745)          | 10644 (688)     | 81 to 444 |
| Distance < 6 km·h⁻¹ (m)  | 3545 (632)           | 3907 (780)      | 153 to 570  | 3200 (414)           | 3457 (411)      | 151 to 364 |
| Distance 6–12 km·h⁻¹ (m) | 3486 (473)           | 3137 (588)      | -505 to -191| < .001*              | 3524 (495)      | 3548 (450) |
| Distance 12–18 km·h⁻¹ (m) | 2504 (556)           | 2223 (771)      | -482 to -78 | .007*                | 2688 (436)      | 2734 (411) |
| Distance 18–21 km·h⁻¹ (m) | 530 (158)            | 477 (137)       | -106 to 0.1 | .047*                | 579 (142)       | 550 (132) |
| Distance 21–24 km·h⁻¹ (m) | 271 (111)            | 234 (129)       | -71 to 1    | .039*                | 281 (94)        | 254 (95)  |
| Distance > 24 km·h⁻¹ (m) | 128 (89)             | 96 (79)         | -57 to 8    | .010*                | 106 (67)        | 100 (61) |
| Accelerations (n)         | 2809 (251)           | 3010 (231)      | 134 to 267  | < .001*              | 2742 (265)      | 2949 (192) |
| Decelerations (n)         | 2809 (251)           | 3011 (231)      | 135 to 268  | < .001*              | 2742 (265)      | 2949 (193) |
| Peak acceleration (m·s⁻²) | 4.6 (.92)            | 4.3 (.91)       | -52 to 1.0  | .045*                | 4.4 (.64)       | 4.4 (.72) |
| Peak deceleration (m·s⁻²) | 5.3 (.83)            | 5.0 (1.0)       | -11 to 63   | .008*                | 5.2 (6.3)       | 5.1 (7.1) |
| Sprint distance (m)       | 229 (135)            | 174 (125)       | -92 to -14  | .005*                | 205 (104)       | 188 (84) |
| Sprints (n)               | 10.5 (6.1)           | 8.1 (6.0)       | .72 to 4.1  | .005*                | 9.7 (4.5)       | 8.7 (3.7) |
| Peak speed (km·h⁻¹)       | 28.7 (2.1)           | 28.0 (2.9)      | -1.5 to 12  | .075                 | 28.5 (1.9)      | 28.3 (2.2) |
| Peak HR (b·m⁻¹)           | 171 (9)              | 170 (7)         | -3.8 to 1.3 | .276                 | 179 (9)         | 179 (7)   |
| Average HR (b·m⁻¹)        | 146 (12)             | 142 (9)         | -6.5 to 32  | .023*                | 153 (12)        | 150 (8)   |
| HRmax (%)                 | 82.3 (6.9)           | 81.2 (3.9)      | -2.5 to 34  | .132                 | 82.7 (5.7)      | 81.5 (4.3) |

*Significant differences between pre- and post-lockdown at P-value < .05. HR: Heart rate. CI: Confidence interval. Sprints: runs > 24km·h⁻¹.
Statistical analysis
The mean (SD) and 95% confidence interval for the mean differences (95% CI) were calculated for all variables before and after lockdown. Linear regression analysis with contract coding (1: pre-lockdown, -1: post-lockdown) was performed to determine the effect of the lockdown on match activity metrics. The unpaired t-test was performed to identify significant differences ($P < .05$) between pre-lockdown ($n = 181$ and $236$ matches for First and Second Division seasons, respectively) and post-lockdown ($n = 69$ and $78$ matches for First and Second Division seasons, respectively). Effect size (ES) was determined by Cohen’s $d$ and interpreted as trivial (< .20), small (.20–.49), medium (.50–.79), and large ($\geq .80$).

RESULTS
The lockdown had a negative effect on match activity in both categories (Table 1, Figure 1), with a greater impact in the First Division ($R^2 = .269, P < .001$) than the Second ($R^2 = .227, P < .001$). Among referees of the First Division there were decreases in the total running distance, distance covered at all speed thresholds $> 6$ km·h$^{-1}$, peak acceleration and deceleration, distance and number of sprints, and the average heart rate ($P < .05$) but increases in the distance covered at $< 6$ km·h$^{-1}$ and the number of accelerations ($P < .05$) after the lockdown. Second Division referees showed lower total running distance and distance at 21–24 km·h$^{-1}$ ($P < .05$) but higher running distance at $< 6$ km·h$^{-1}$ and number of accelerations ($P < .05$) after the lockdown.

DISCUSSION
The current investigation shows that, despite the efforts of both staff and referees to maintain their physical condition during the lockdown due to the first wave of the COVID-19 pandemic, professional referees showed impaired match performance during the post-lockdown matches in comparison with pre-lockdown matches. The negative effect of the lockdown was more evident in First Division referees as they showed reduced total running distance and the distance covered at all speed thresholds above 6 km·h$^{-1}$. However, in both categories, the distance covered below 6 km·h$^{-1}$ was increased, together with a higher number of accelerations. These data suggest that professional football referees spend more time at low intensity running in an attempt to maintain the distance covered at high intensity running, while they need to increase the number of accelerations to keep up with play and to have correct positioning during match play. A possible explanation for the present results could be the insufficient and/or inappropriate training stimuli due to the drastic reduction in the
level of physical activity during home confinement. In fact, logistical constraints, and the difficulty to implement sport-specific exercise strategies outdoors, made it difficult to provide training solutions comparable to those adopted under normal circumstances [7].

The training routines performed at home by professional referees during confinement included strength-based activities with body load, proprioceptive activities, and high-intensity and intermittent routines, mostly with changes of direction, performed at very short distances. However, it was unfeasible to perform long lasting running activities and sprints that replicate those performed during match play in most cases. Hence, although football referees had 4 weeks to retrain after lockdown, the current data suggest that it was an insufficient training stimulus to compensate the detraining effect of 8 weeks of home confinement. These performance decrements coincided with the decline in cardiovascular and functional performance in elite athletes with more than 5 weeks of exercise inactivity [15]. This is further confounded by the fact that physical performance is lower at the beginning of the season and the teams needed approximately 8–10 matchdays to reach a steady-state running performance, as recently identified in professional players [4].

Another interesting finding within the investigation is the greater negative effect of the lockdown on match activity in the referees from the First Division compared to the Second Division (Table 1, Figure 1). Possibly, referees of the Second Division were exposed to matches with greater competitiveness compared to the First Division referees. Specifically, up to nine Second Division teams played to avoid relegation or to be promoted to the First Division until the last match, while only two teams were contending for the championship in the First Division. Although previous studies reported that top level referees showed better physical performance than lower level referees [16, 17], several factors such as contesting teams’ ranking [18] have been identified as influencing factors of the external physical demands in football referees during matches. Castillo et al. [18] reported that football referees who officiated matches between teams placed in the top 10 positions toward the end of a professional competitive season covered greater distance at low walking speed (< 3.6 km·h⁻¹) and performed a greater percentage of high-intensity accelerations and decelerations than those who officiated lower ranked teams’ matches. Furthermore, it must be noted that referees’ performance might be influenced by the football players’ physical performance, teams’ playing styles and technical-tactical performance demands [19–21]. Indeed, fatigue-induced changes in physical performance during a football match are multifactorial and strongly related to the specific demands of each match [22]. However, recent data suggest that a team’s running performance in LaLiga was maintained after suspension of the competition due to COVID-19, to levels similar to before suspension and to the previous season [23]. The differences in the effect of the lockdown between referees and players may be explained by the fact that football authorities allowed up to five substitutions for the matchdays after lockdown [24], while no measure was established to reduce the physical strain of football referees during official matches. Hence, it seems that the decline in the activity metrics of professional football players in the Spanish professional leagues was a result of lower physical fitness due to the lockdown and it was not associated with a change in the demands of the game.

While the results of this study have provided information regarding the most important external physical demands in football referee performance and the influence of the COVID-19 lockdown, some limitations of the study must be acknowledged. Firstly, as the study was performed in a specific sample of professional football referees who play in the Spanish Football League, these findings may not be extended to other football referees or to the general population. Second, changes in the metrics due to external factors such as adverse weather condition were not examined. Nonetheless, considering the large number of matches included in the study, a significant influence of the weather is not expected. Additional limitations that researchers could study in future are the influence of physical work carried out during the week and the teams’ level (ranking) on referee performance during the competition.

CONCLUSIONS

In summary, referees’ match activity was reduced due to the COVID-19 lockdown, while the effect on running parameters was more pronounced in First Division referees than in Second Division referees. Future studies should determine what the best training guidelines are to maintain referees’ physical fitness during home confinement and analogous situations. Additionally, it is necessary to establish the plan standards to regain physical conditioning for referees who show signs of detraining due to either home confinement, injury or lack of match refereeing activity.

PRACTICAL APPLICATIONS

Most of the match activity metrics from professional football referees were notably reduced after the COVID-19 lockdown, with a greater impact in the First Division referees and in actions performed at > 21 km·h⁻¹. On the other hand, professional referees covered greater distance at low intensity running and performed a higher number of accelerations. Physical trainers and medical staff should take special cautions for an optimal return to competition in the case of a new lockdown. In this potential scenario, referees’ physical trainers during the retraining period should focus on improving high-intensity running and the capacity to repeat sprints through a combination of anaerobic-based intermittent routines and endurance running activities.

Acknowledgements

We are very grateful to the referees who participated in this study for their efforts and commitment during such a challenging situation.

Conflicts of interest

The authors declare that they have no conflict of interest derived from the outcomes of this study.
REFERENCES

1. Weston M, Castagna C, Impellizzeri FM, Bizzini M, Williams AM, Gregson W. Science and medicine applied to soccer refereeing: An update. Sport Med. 2012; 42(7):615–631. doi:10.2165/11632360-000000000-00000
2. Krustup P, Helsen W, Randers MB, et al. Activity profile and physical demands of football referees and assistant referees in international games. J Sports Sci. 2009;27(11):1167–1176. doi:10.1080/02640410903220310
3. Eirale C, Biscotti G, Corsini A, Baudot C, Saillant G, Chalabi H. Medical recommendations for home-confined footballers’ training during the COVID-19 pandemic: from evidence to practical application. Biol Sport. 2020;37(2):203–207. doi:10.5114/biolsp.2020.94348
4. de Souza DB, González-Garcia J, Campo RL-D, et al. Players’ physical performance in LaLiga when the competition resumes after COVID-19: insights from previous seasons. Biol Sport. 2021;38(1):3–7. doi:10.5114/biolsp.2020.96856
5. Jukic I, Calleja-González J, Cos F, et al. Strategies and Solutions for Team Sports Athletes in Isolation due to COVID-19. Sports. 2020;8(4):56. doi:10.3390/sports8040056
6. Chen P, Mao L, Nassis GP, Harmer P, Ainsworth BE, Li F. Coronavirus disease (COVID-19): The need to maintain regular physical activity while taking precautions. J Sport Heal Sci. 2020;9(2):103–104. doi:10.1016/j.js.hs.2020.02.001
7. Sarto F, Impellizzeri FM, Spörri J, et al. Impact of Potential Physiological Changes due to COVID-19 Home Confinement on Athlete Health Protection in Elite Sports: a Call for Awareness in Sports Programming. Sport Med. 2020;50(8):1417–1419. doi:10.1007/s40279-020-01297-6
8. Muriel X, Courel-Ibáñez J, Cerezuela-Espejo V, Pallarés JG. Training Load and Performance Impairments in Professional Cyclists During COVID-19 Lockdown. Int J Sports Physiol Perform. Published online August 20, 2020:1–4. doi:10.1123/ijjsp.2020-0501
9. Mujika I, Padilla S. Detraining: Loss of training induced physiological and performance adaptation. Part II. Long term insufficient training stimulus. Sport Med. 2000;30(3):145–154. doi:10.2165/000007256-200030030-00001
10. Silva JR, Brito J, Akenhead R, Nassis GP. The Transition Period in Soccer: A Window of Opportunity. Sport Med. 2016;46(3):305–313. doi:10.1007/s40279-015-0419-3
11. Castillo D, Cámara J, Castagna C, Yanci J. Effects of the off-Season Period on Field and Assistant Soccer Referees’ Physical Performance. J Hum Kinet. 2017;56(1):159–166. doi:10.1515/hukin-2017-0033
12. Weston M, Castagna C, Helsen W, Impellizzeri F. Relationships among field-test measures and physical match performance in elite-standard soccer match referees. J Sports Sci. 2009;27(11):1177–1184. doi:10.1080/02640410903110982
13. Barberó-Álvarez JC, Boulosa D, Nakamura FY, Andrin G, Weston M. Repeated acceleration ability (RAA): A new concept with reference to top-class field and assistant soccer referees. Asian J Sports Med. 2014;5(1):63–66. doi:10.5812/asjams.34235
14. Castellano J, Casamichana D, Calleja-González J, Román JS, Ostojic SM. Reliability and Accuracy of 10 Hz GPS Devices for Short-Distance Exercise. J Sports Sci Med. 2011;10(1):233–234.
15. García-Pallarés J, Sánchez-Medina L, Pérez CE, Izquierdo-Gabarren M, Izquierdo M. Physiological effects of tapering and detraining in world-class kayakers. Med Sci Sports Exerc. 2010;42(6):1209–1214. doi:10.1249/MSS.0b013e3181e9228c
16. Bartha C, Petridis L, Hamar P, Puhl S, Castagna C. Fitness test results of Hungarian and international-level soccer referees and assistants. J Strength Cond Res. 2009;23(1):121–126. doi:10.1519/JSC.0b013e31818ebb84
17. Yanci J, Los Arcos A, Grande I, Casajús J. Change of direction ability test differentiates higher level and lower level soccer referees. Biol Sport. 2016;33(2):173–177. doi:10.5604/20831862.1198637
18. Castillo D, Castagna C, Cámara J, Iturricastillo A, Yanci J. Influence of team’s rank on soccer referees’ external and internal match loads during official matches. J Strength Cond Res. 2018;32(6):1715–1722. doi:10.1519/JSC.0000000000002040
19. Arruda AF, Carling C, Zanetti V, Aoki MS, Coutts AJ, Moreira A. Effects of a very congested match schedule on body-load impacts, accelerations, and running measures in youth soccer players. Int J Sports Physiol Perform. 2015;10:248–252. doi:10.1123/ijssp.2014-0148
20. Bradley PS, Carling C, Archer D, Roberts J, Dodds A, di Mascio M, Paul D, Diaz AG, Peart D, Krustup P. The effect of playing formation on high-intensity running and technical profiles in English FA premier League soccer matches. J Sports Sci. 2011;29:821–830. doi:10.1080/02640414.2011.561868
21. Carling C. Interpreting physical performance in professional soccer match-play: Should we be more pragmatic in our approach? Sports Med. 2013;43:655–663. doi:10.1007/s40279-013-0055-8
22. Marqués-Jiménez D, Calleja-González J, Arratibel I, Delextrat A, Terrados N. Fatigue and Recovery in Soccer: Evidence and Challenges. Open Sports Sci J. 2017;10:52–70. doi:10.2174/1875399x01710010051
23. Herrero-González H, Martín-Acero R, Del Coso J, Lalin-Novoa C, Pol R, Martín-Escudero P, et al. Position statement of the Royal Spanish Football Federation for the resumption of football activities after the COVID-19 pandemic (June 2020). Br J Sports Med. 2020;54(19):1133–4. doi:10.1136/bjsports-2020-102640
24. Brito de Souza D, López-Del Campo R, Resta R, Moreno-Perez V, Del Coso J. Running Patterns in LaLiga Before and After Suspension of the Competition Due to COVID-19. Front Physiol. 2021;12:535. doi:10.3389/fphys.2021.666593.