

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

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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 $> 6 \text{ km} \cdot \text{h}^{-1}$ after lockdown ($P < .05$). In the Second Division referees, the post-lockdown measurement only showed a decrease in the running distance at $21\text{--}24 \text{ km} \cdot \text{h}^{-1}$ ($P < .05$), with no changes in the other speed thresholds. The post-lockdown measurement showed an increased distance covered at $< 6 \text{ km} \cdot \text{h}^{-1}$ 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.

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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 physical 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 facilities. 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 $\sim 2 \text{ km}$ at $> 15 \text{ km} \cdot \text{h}^{-1}$ and ~ 40 sprinting actions at $> 18 \text{ km} \cdot \text{h}^{-1}$ 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, Almeria, 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, Almeria, 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 18–21 km·h⁻¹ (m), distance 21–24 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				Second Division			
	Pre-Lockdown	Post-Lockdown	95% CI Diff	P-value	Pre-Lockdown	Post-Lockdown	95% CI Diff	P-value
Total distance (m)	10463 (943)	10073 (1039)	-674 to -106	.007*	10381 (745)	10644 (688)	81 to 444	.005*
Distance < 6 km·h ⁻¹ (m)	3545 (632)	3907 (780)	153 to 570	.001*	3200 (414)	3457 (411)	151 to 364	< .001*
Distance 6–12 km·h ⁻¹ (m)	3486 (473)	3137 (588)	-505 to -191	< .001*	3524 (495)	3548 (450)	-95 to 142	.696
Distance 12–18 km·h ⁻¹ (m)	2504 (556)	2223 (771)	-482 to -78	.007*	2688 (436)	2734 (411)	-62 to 153	.402
Distance 18–21 km·h ⁻¹ (m)	530 (158)	477 (197)	-106 to .01	.047*	579 (142)	550 (132)	-5 to 64	.098
Distance 21–24 km·h ⁻¹ (m)	271 (111)	234 (129)	-71 to -1	.039*	281 (94)	254 (95)	2 to 51	.034*
Distance > 24 km·h ⁻¹ (m)	128 (89)	96 (79)	-57 to -8	.010*	106 (67)	100 (61)	-23 to 11	.465
Accelerations (n)	2809 (251)	3010 (231)	134 to 267	< .001*	2742 (265)	2949 (192)	-261 to -152	< .001*
Decelerations (n)	2809 (251)	3011 (231)	135 to 268	< .001*	2742 (265)	2949 (193)	-262 to -152	< .001*
Peak acceleration (m·s ⁻²)	4.6 (.92)	4.3 (.91)	-.52 to .01	.045*	4.4 (.64)	4.4 (.72)	-.11 to .20	.358
Peak deceleration (m·s ⁻²)	5.3 (.83)	5.0 (1.0)	-.11 to -.63	.008*	5.2 (.63)	5.1 (.71)	-.32 to .12	.203
Sprint distance (m)	229 (135)	174 (125)	-92 to -14	.005*	205 (104)	188 (84)	-10 to 42	.172
Sprints (n)	10.5 (6.1)	8.1 (6.0)	.72 to 4.1	.005*	9.7 (4.5)	8.7 (3.7)	-.11 to 2.0	.064
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)	-.42 to .81	.498
Peak HR (b·m ⁻¹)	171 (9)	170 (7)	-3.8 to 1.3	.276	179 (9)	179 (7)	-2.6 to -2.4	.952
Average HR (b·m ⁻¹)	146 (12)	142 (9)	-6.5 to -.32	.023*	153 (12)	150 (8)	-.34 to 5.4	.078
HRmax (%)	82.3 (6.9)	81.2 (3.9)	-2.5 to -.34	.132	82.7 (5.7)	81.5 (4.3)	-.21 to 2.5	.085

*Significant differences between pre- and post-lockdown at P -value < .05. HR: Heart rate. CI: Confidence interval. Sprints: runs > 24km·h⁻¹.

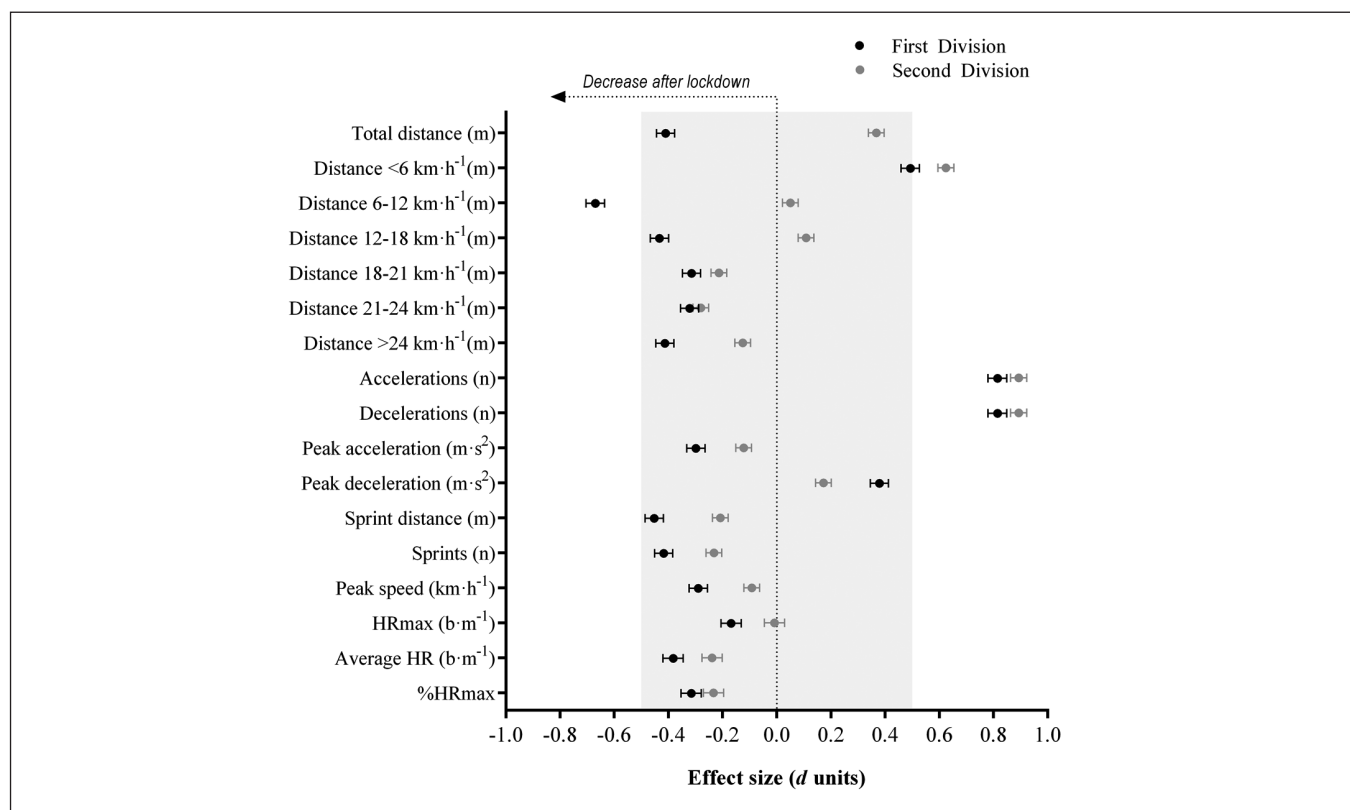


FIG. 1. Effect size ($\pm 95\%$ confidence intervals) for match-play demands in football referees from the Spanish First and Second Divisions before and after lockdown due to COVID-19. Negative values represent performance decrements after lockdown.

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 $> 6 \text{ km} \cdot \text{h}^{-1}$, peak acceleration and deceleration, distance and number of sprints, and the average heart rate ($P < .05$) but increases in the distance covered at $< 6 \text{ km} \cdot \text{h}^{-1}$ and the number of accelerations ($P < .05$)

after the lockdown. Second Division referees showed lower total running distance and distance at $21\text{--}24 \text{ km} \cdot \text{h}^{-1}$ ($P < .05$) but higher running distance at $< 6 \text{ km} \cdot \text{h}^{-1}$ 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 $6 \text{ km} \cdot \text{h}^{-1}$. However, in both categories, the distance covered below $6 \text{ km} \cdot \text{h}^{-1}$ 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 ($< 3.6 \text{ km} \cdot \text{h}^{-1}$) 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 $> 21 \text{ km} \cdot \text{h}^{-1}$. 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.

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Conflict of interest

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

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