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The Effects of Match Congestion on Physical Performance in Football Referees

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Key words
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ABSTRACT

We examined the changes in performance during congested (two matches within a 7-day interval) and non-congested (one match within ≥7-day interval) fixtures in 17 elite football (soccer) referees during 181 official matches. External demands comprised 20 GPS-based metrics. Internal load was assessed by heart rate and rating of perceived exertion. Compared to non-congested fixtures, referees decreased their running distance at 21–24 km·h^{-1} (p = 0.027, effect size [ES] = 0.41) and > 24 km·h^{-1} (p = 0.037, ES = 0.28), the number of sprints (p = 0.012, ES = 0.29), and distance sprinting (p = 0.022, ES = 0.29) in congested matches. Most play metrics were lower in congested versus non-congested fixtures with low-to-moderate ES. During the 2nd half of non-congested fixtures, referees covered larger distances at low-speed running (p = 0.025, ES = 0.47). Match congestion due to officiating two matches less than a week apart caused a notable decrease in match running activity in professional football referees, especially at above 21 km·h^{-1}. These data reiterate the need for specific conditioning and post-match recovery strategies in high-level referees to ensure optimal judgment performance favouring the quality of the competition. Governing bodies should take these outcomes into account when designating referees for a match.

Introduction

Professional football (soccer) refereeing involves an optimal physical condition to ensure the correct course of the game during the explosive movements, changes of direction, and sprints performed by the players [1, 2]. During a match, football referees frequently cover ~12 km [2, 3], with ~2 km at high-speed running (from 18 to 24 km·h^{-1}) [3] distributed in 10 to 50 sprints at above 25 km·h^{-1} [4]. At the elite level, football referees may reach up to > 12 mmol·l^{-1} of blood lactate concentration [5]. As a consequence of these demands, professional referees present notable aerobic fitness levels with maximum oxygen uptake values above 50 ml·kg^{-1}·min^{-1}, and a maximal aerobic speed of 16 km·h^{-1} [6].

The chronic demands of the season that may entail fatigue in professional football referees have to be added to the acute demands of the match. On average, elite referees officiate from 17–41 matches in the season including national and international competitions

[7]. This means that the recovery period between two matches varies from 3–5 days (and often, with two matches within a week) to over 15 days [7], depending on the point in the season. Habitually, professional referees are exposed to congested scheduling, defined as matches played with < 3 days of recovery, or multi-match weeks with < 4 days of recovery between matches using the same nomenclature used for football players [8]. Successive matches over a short period may potentially induce a residual fatigue and underperformance due to insufficient time for physical and cognitive recovery [9]. Previous studies in football players suggested that a short recovery time between matches could reduce the number of accelerations [10] without affecting the distance covered at different speed thresholds [8, 11–13]. However, unlike football players, referees have to participate in all actions of the game, and they are not substituted in the match (unless an injury occurs). Although there are no data for professional football referees, incomplete recovery due to a congested calendar may increase the risk of injury during matches, as occurs in football players [8, 9].

Recent studies have identified the physiological match demands and associated fitness requirements in football referees [2, 6, 14, 15]. Nonetheless, there is no evidence on how match congestion may affect their performance. Although the referees' match activity profiles appear to be driven by the activity profiles of the football players [4], it is possible that residual fatigue due to limited recovery between successive matches could compromise physical performance in professional referees, and, as a consequence, their ability to keep up with play. Therefore, the main aim of the present study was to examine the effects of match congestion (one versus two matches within a week) on the internal and external match load in professional football referees.

Materials and Methods

Experimental design

Data from 181 official competitive matches from the Spanish 2019–2020 1st division season, UEFA Champions, Europe League and Spanish King's Cup (from 06/08/2019 to 08/02/2020) were collected using a GPS-based tracking system. Matches were classified in congested (two matches within a 7-day interval) and non-congested (one match within ≥ 7-day interval or more) fixtures. The nature of the match prior to the analysed match varied from matches in the same league, to an international competition (such as UEFA Champions League or UEFA EuroLeague), or a national competition (such as the King's Cup). Data were paired so that the data from each referee's performance during congested fixtures were compared to the data from the same referee during a non-congested fixture. Data for the full match, and a sub-analysis of the 1st and the 2nd halves, were considered for this experiment. In the 24 h period before officiating the match, the referees performed a standardised tapering session and followed standard nutrition and fluid guidelines [16, 17]. Specifically, the strength and conditioning staff of the National Refereeing Committee provided them a standardized pre-match session to be performed the day before each match composed of light intensity running and agility drills with a duration > 45 min. In a regular week (i. e. weeks with only one match officiated), referees usually performed three days of field training that included physical conditioning exercises and two strength training sessions with free weights. The training plan included a standardized active recovery session after each match officiated. In the weeks with two matches in a week, referees usually performed one field training session and one strength training session to allow the same pattern of tapering and recovery before and after each match, respectively. Written informed consent was obtained from all participants and the procedures were approved by an institutional Ethics Review Committee (ID: 489/24022020). The current investigation meets the ethical standards of the journal [18].

Subjects

Professional referees of the Spanish 1st division were recruited with the help of the Royal Spanish Football Federation. Initially, all professional referees of the 1st division were invited to participate but we applied the following inclusion criteria to potential participants: being an active professional referee with > 5 years of experience in professional refereeing, participating in ≥ 10 official matches during the data collection phase and having a match schedule combining matches with > and < 7 days of recovery after a prior match. Exclusion criteria were: a) history of pain or injury during the match; b) < 90 minutes of refereeing in a match. Seventeen professional referees (age 38.7 ± 3.5 years; body mass 74.7 ± 3.6 kg; height 181.9 ± 4.1 cm) volunteered to participate in this study. Participants had 9.3 ± 3.8 years of experience in professional refereeing and trained an average of 13.0 ± 2.2 h per week, with a five-days-a-week training routine and a recovery session after each match during 10 months per year.

Time-motion analysis

External load was monitored using a 10-Hz portable global positioning system (GPS) unit (WIMU PRO, RealTrack Systems, Almeria, Spain). Internal load was measured using heart rate (HR) belts (Garmin Ltd., Olathe, Kansas, USA), which were synchronized with the GPS units, and by using the rating of perceived exertion (RPE 0 to 10-point scale). The GPS-based system has been proved reliable for the measurement of high speed running movements in team sports [19]. Each referee wore the same GPS device during the whole study period [20]. According to the manufacturer's recommendations, all devices were activated 15 minutes before data collection for proper acquisition of satellite signals and synchronisation. Football referees wore the GPS unit in several training sessions and in all matches performed during the preseason to familiarise themselves with the device. All the referees participated in the familiarization process. On the day of the match, referees performed a 20-min standardised warm-up before the matches and then placed the GPS heart-rate devices under their official clothes. Once the match had finished, the GPS was shut down and data were downloaded to a personal computer on a different day. All data were analysed using a customised software package (WIMU SPRO; RealTrack Systems, Almería, Spain). Initially, data from the match and from the 1st and 2nd halves were accurately extracted using the time of the match onset and the durations of each half. Therefore, the distances covered before the match or in the rest interval between halves were removed from the analysis. A total of 20 match-play metrics was collected per match: total running distance (TD) (m), distance at $< 6\,km \cdot h^{-1}$, between $6–12\,km \cdot h^{-1}$, between

12–18 km · h^{-1}, between 18–21 km · h^{-1}, between 21–24 km · h^{-1} and at > 24 km · h^{-1} (m), number of sprints (runs performed at > 24 km · h^{-1} with at least 1 s of duration) sprint distance (m), peak running speed (km · h^{-1}), the highest value of HR during the match (HRpeak, b · m^{-1}), the mean HR during the match in absolute (HRave, b · m^{-1}) and relative to HRpeak (i. e. %HRpeak), the number of accelerations and decelerations, the number of impacts at above 8 G, and high metabolic load distance (HMLD; distance covered when metabolic power showed a value > 25.5 W·kg^{-1}). Data from RPE was obtained 30 minutes after the end of each match [21], with 0 being equivalent to how they felt when sitting in a chair and a score of 10 being how they felt at the end of very intense exercise activity [22]. All matches were played on a natural grass surface with a pitch dimension of ~105 × 68 m.

Statistical analysis

Means, standard deviations (M ± SD) and a 95 % confidence interval for the mean differences (MD 95 % CI) were calculated from the raw database to compare congested and non-congested fixtures. Data distributions were tested using the Kolmogorov-Smirnov test. Paired *t*-tests were conducted to identify significant differences ($p < 0.05$) between congested versus non-congested fixtures. A two-way analysis of variance (ANOVA) for repeated measures adjusted by age (covariate) was used to determine the main effect of congestion × halves and their interaction. An LSD post-hoc analysis was applied in the case of a significant main effect. Partial eta^2 and Cohen's *d* were computed as measures of the effect sizes (ES). Calculations were performed with SPSS v.21 (IBM Corp., Armonk, NY, USA). Figures were designed using GraphPad Prism 6.0 (GraphPad Software Inc., San Diego, California, USA).

Results

Congested matches were officiated after 4.3 ± 1.8 days of recovery (34 % before 72 h from the prior match) while non-congested matches were officiated after 17.0 ± 7.6 days of recovery. Match duration was similar between congested (98.2 ± 2.6 min) and non-congested matches (98.4 ± 2.4 min).

▶**Table 1** shows the means for match-play metrics when comparing congested and non-congested matches whereas ▶**Fig. 1** depicts effect sizes. Overall, match congestion caused a low-to-moderate impact on match-play metrics showing a decrease in running speed at 21–24 km · h^{-1} ($p = 0.027$; $d = 0.41$), > 24 km · h^{-1} ($p = 0.037$; $d = 0.28$), the number of sprints ($p = 0.012$; $d = 0.29$) and the distance covered at sprint velocity ($p = 0.022$; $d = 0.29$; ▶**Table 1**, ▶**Fig. 1**). ▶**Table 2** shows the means for each variable in each half and ▶**Table 3** contains the results for the ANOVA tests. There was a main effect of match congestion on the running distances above 21 km · h^{-1}, the number of sprints, the distance covered at sprint velocity and on HRpeak ($p < 0.050$). Additionally, there was a main effect of the match half on the distance covered at < 6 km · h^{-1}, on the number of accelerations and on the number of decelerations. ($p < 0.050$). However, there was no congestion × halves interaction in the variables analysed. The post-hoc analysis revealed that, in comparison with the 1st half, referees covered larger distances at < 6 km · h^{-1} during the 2nd half of non-congested matches ($p = 0.025$, $d = 0.37$). Professional football referees made more accelerations and decelerations ($p < 0.001$; $d = 1.45$) during the 2nd half in both congested and non-congested matches (▶**Table 2**, ▶**Fig. 2**). Covariate analysis revealed that changes in performance were consistent across referees' ages (changes in partial eta^2 < 0.05).

▶**Table 1** Match-play metrics in professional soccer referees (n = 17) in non-congested matches (more than one week of recovery after the prior match) and congested matches (less than one week of recovery after prior match).

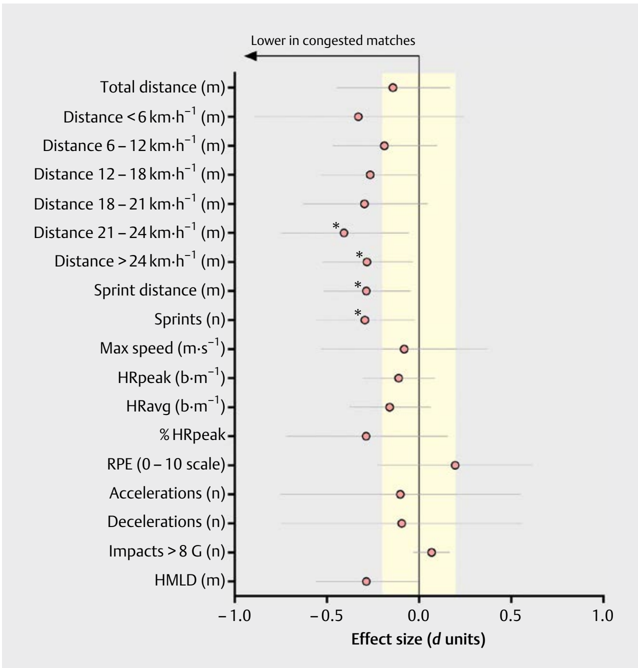
Match-play metric	Non-congested matches	Congested matches	MD (95 % CI)
Total distance (m)	10401 (618)	10299 (812)	− 102.2 (− 348.3 to 144)
Distance < 6 km · h^{-1} (m)	3492 (262)	3669 (458)	177.1 (− 56.1 to 410.3)
Distance 6–12 km · h^{-1} (m)	3450 (369)	3369 (485)	− 80.5 (− 213.6 to 52.6)
Distance 12–18 km · h^{-1} (m)	2516 (434)	2399 (450)	− 117.6 (− 245 to 9.8)
Distance 18–21 km · h^{-1} (m)	537 (103)	502 (132)	− 35.6 (− 78.2 to 7.1)
Distance 21–24 km · h^{-1} (m)	278 (66)	249 (76) *	− 29.2 (− 54.5 to − 3.8)
Distance > 24 km · h^{-1} (m)	127 (56)	110 (64) *	− 16.5 (− 31.8 to − 1.1)
Sprint distance (m)	226 (83)	200 (98) *	− 26.2 (− 48.2 to − 4.3)
Sprints (n)	10.2 (3.1)	9.1 (4.3) *	− 1.0 (− 2.0 to 0.04)
Max speed (m · s^{-1})	28.2 (0.9)	28.1 (1.5)	− 0.1 (− 0.8 to 0.5)
HRpeak (b · m^{-1})	170 (8)	169 (10)	− 1.2 (− 3.0 to 0.6)
HRavg (b · m^{-1})	144 (11)	142 (14)	− 1.9 (− 4.8 to 1.0)
%HRpeak	82 (4)	81 (6)	− 1.4 (− 3.7 to 0.9)
RPE (0–10 scale)	7.0 (0.8)	7.2 (1.2)	0.1 (− 0.4 to 0.6)
Accelerations (n)	2828 (90)	2815 (156)	− 13.2 (79.7 to − 106.1)
Decelerations (n)	2828 (91)	2816 (156)	− 12.3 (81.3 to − 106.0)
Impacts > 8 G (n)	214 (289)	234 (301)	19.5 (− 12.5 to 51.5)
HMLD (m)	1986 (373)	1873 (413)	− 113.2 (− 229 to 2.6)

* Statistically significant differences ($p < 0.05$). CI: confidence interval; MD: mean difference; HR: heart rate; RPE: rating of perceived exertion; HMLD: high metabolic load distance.

Discussion

This study presents novel data about the impact of match congestion on professional football referees' physical performance when officiating matches during national and international competitions. The findings revealed a notable congestion effect, with professional referees reducing high-speed running and sprinting when comparing matches officiated in a congested (less than a week from prior match) to a non-congested fixture (more than a week from the prior match). These outcomes suggest that professional football referees present some signs of fatigue when officiating matches with less than a week of recovery in between. Fatigue was more evident when running above 21 km · h⁻¹, as the running distance covered above this threshold was reduced in congested matches. Additionally, peak HR in the congested fixture was lower than in the non-congested scenario when taking into account the changes in the first and second halves of the match. Lower peak HR in the match with less than a week of recovery from the prior match is another sign of physical fatigue because it potentially indicates that referee's exercise intensity during the match in the congested calendar was not enough to reach peak HR. All this information together indicates that football referees have a reduced ability to keep up with play when they officiate two matches with less than one week of recovery in between. This may affect their ability to keep at a short distance from the ball during match play with fast movements such as in counterattacks. To the best of our knowledge, this is the first study reporting such existing variations with match congestion in professional football referees and, from a practical perspective, it may indicate that football refereeing governing bodies should take these outcomes into account when designating referees for a match.

Performance impairments during congested fixtures in professional referees were evident in the reduction of the high-speed/sprint running distance by ~10–15 % when compared to the non-congested/control fixture. These decrements might be explained by the insufficient time for recovery between matches during congested weeks (i. e. 4 days of recovery on average for the congested fixture). Insufficient time for recovery and regeneration between officiated matches expose referees to the risk of training and refereeing whilst not entirely recovered, as happens to professional football players [23]. In particular, high-intensity running actions in football match-play result in muscle damage (especially in type II fibres), which has been linked to sprinting performance impairments in football players [24]. Accordingly, a recent meta-analysis



▶ **Fig. 1** Forest plot for 1st division professional football referees showing the effects of match congestion on match-play metrics. Data are effect size (ES) in Cohen's units and 95 % confidence interval. HR: heart rate; RPE: rating of perceived exertion; HMLD: high metabolic load distance.

▶ **Table 2** Match-play metrics in the first and second halves of a match in professional soccer referees (n = 17) officiating in non-congested matches (more than one week of recovery from the prior match) and in congested matches (less than one week of recovery from prior match).

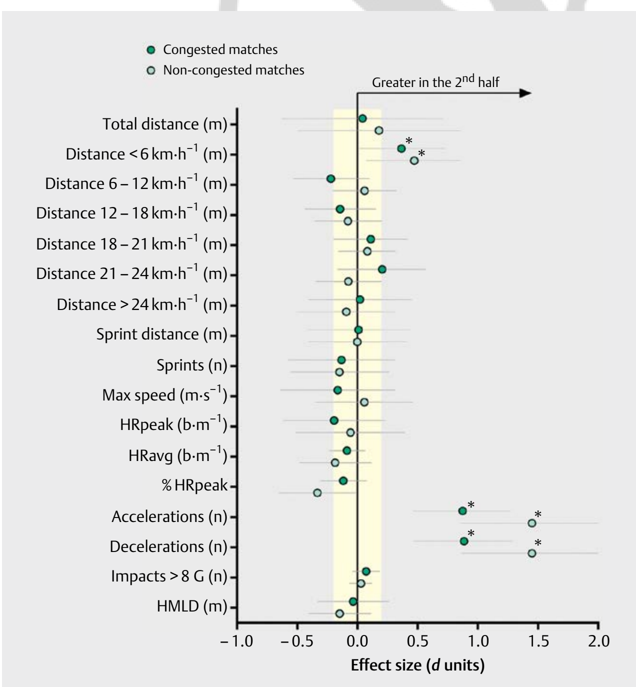
Match-play metric	Non-Congested matches			Congested matches		
	1st Half	2nd Half	MD (95 % CI)	1st Half	2nd Half	MD (95 % CI)
Total distance (m)	5183 (327)	5242 (334)	59.4 (– 75.5 to 194.3)	5140 (482)	5159 (377)	18.5 (– 142.3 to 179.2)
Distance < 6 km · h⁻¹ (m)	1710 (150)	1775 (126) *	65.7 (9.1 to 122.2)	1788 (245)	1881 (259)	92.3 (– 19.8 to 204.4)
Distance 6–12 km · h⁻¹ (m)	1733 (198)	1745 (199)	11.9 (– 54.5 to 78.4)	1713 (257)	1656 (258)	– 56.7 (– 147.6 to 34.2)
Distance 12–18 km · h⁻¹ (m)	1267 (231)	1250 (204)	– 17.2 (– 76.1 to 41.8)	1217 (265)	1182 (209)	– 34.5 (– 119.8 to 50.7)
Distance 18–21 km · h⁻¹ (m)	266 (54)	270 (50)	4.3 (– 11.1 to 19.7)	247 (77)	255 (66)	7.9 (– 21.5 to 37.4)
Distance 21–24 km · h⁻¹ (m)	141 (35)	138 (35)	– 2.6 (– 17.1 to 11.8)	120 (44)	129 (40)	8.6 (– 10.6 to 27.9)
Distance > 24 km · h⁻¹ (m)	66 (30)	63 (29)	– 2.7 (– 14.7 to 9.2)	55 (33)	56 (37)	0.8 (– 13.2 to 14.7)
Sprint distance (m)	114 (45)	114 (43)	– 0.1 (– 18.4 to 18.3)	100 (54)	100 (52)	0.5 (– 19.5 to 20.5)
Sprints (n)	5.2 (2.0)	5.5 (2.0)	– 0.3 (– 0.8 to 0.8)	4.8 (2.5)	4.5 (2.0)	0.2 (– 0.6 to 1.1)
Max speed (m · s⁻¹)	27.8 (1.0)	27.8 (1.0)	0.1 (– 0.5 to 0.7)	27.6 (1.9)	27.3 (1.5)	– 0.3 (– 1.0 to 0.5)
HRpeak (b · m⁻¹)	169 (9)	168 (9)	– 0.5 (– 2.9 to 1.8)	168 (10)	166 (11)	– 2.0 (– 4.6 to 0.6)
HRavg (b · m⁻¹)	145 (9)	143 (14)	– 2.2 (– 5.4 to 1.1)	143 (14)	142 (15)	– 1.2 (– 4.8 to 2.3)
%HRpeak	83 (3)	82 (5)	– 1.5 (– 3.5 to 0.6)	81 (6)	81 (6)	– 0.7 (– 2.8 to 1.4)
Accelerations (n)	1375 (57)	1454 (52) *	78.9 (45.3 to 112.4)	1371 (92)	1444 (74) *	73.4 (41.8 to 104.9)
Decelerations (n)	1375 (58)	1455 (52) *	78.9 (45.2 to 112.6)	1371 (92)	1445 (74) *	73.5 (72.2 to 104.9)
Impacts > 8 G (n)	102 (144)	106 (138)	4.1 (– 5.5 to 13.6)	111 (149)	122 (153)	10.9 (– 4.3 to 26.1)
HMLD (m)	1008 (190)	980 (182)	– 27.3 (– 73.6 to 19.1)	940 (231)	933 (198)	– 7.7 (– 71.7 to 56.3)

* Statistically significant differences ($p < 0.05$). CI: confidence interval; HR: heart rate; HMLD: high metabolic load distance.

▶ Table 3 Main effects and their interaction in the two-way analysis of variance (ANOVA) for repeated measures used to determine the main effects of congestion and match half on match-play metrics in professional football referees (n = 17).

Match-play metrics	Within-subjects effect					
	Congestion		Halves		Congestion × Halves	
	P	***Partial eta²***	***P***	***Partial eta²***	***P***	***Partial eta²***
Total distance (m)	0.390	0.05	0.378	0.05	0.577	0.02
Distance < 6 km · h⁻¹ (m)	0.126	0.15	0.049 *	0.23	0.432	0.04
Distance 6–12 km · h⁻¹ (m)	0.217	0.10	0.485	0.03	0.190	0.11
Distance 12–18 km · h⁻¹ (m)	0.068	0.21	0.474	0.03	0.483	0.03
Distance 18–21 km · h⁻¹ (m)	0.096	0.17	0.456	0.04	0.857	< 0.01
Distance 21–24 km · h⁻¹ (m)	0.027 *	0.29	0.420	0.04	0.423	0.04
Distance > 24 km · h⁻¹ (m)	0.037 *	0.26	0.884	< 0.01	0.967	< 0.01
Sprint distance (m)	0.022 *	0.30	0.674	0.01	0.665	0.01
Sprints (n)	0.012 *	0.35	0.938	< 0.01	0.160	0.13
Max speed (m · s⁻¹)	0.356	0.06	0.827	< 0.01	0.256	0.09
HRpeak (b · m⁻¹)	0.047 *	0.24	0.195	0.11	0.277	0.08
HRavg (b · m⁻¹)	0.182	0.12	0.200	0.11	0.639	0.02
%HRpeak	0.220	0.10	0.169	0.12	0.527	0.03
Accelerations (n)	0.764	0.01	< 0.001 *	0.72	0.925	< 0.01
Decelerations (n)	0.783	0.01	< 0.001 *	0.72	0.927	< 0.01
Impacts > 8 G (n)	0.214	0.10	0.092	0.18	0.508	0.03
HMLD (m)	0.055	0.22	0.572	0.02	0.738	0.01

* Significant differences (ANOVA $p < 0.05$). HR: heart rate; HMLD: high metabolic load distance.



▶ Fig. 2 Forest plot for 1st division professional football referees showing the effects of match halves during congested (dark markers) and non-congested matches (light markers) on match-play metrics. Data are effect size (ES) in Cohen's units and 95 % confidence interval. HR: heart rate; HMLD: high metabolic load distance.

evidences that straight sprint performance and muscle damage induced by a match require more than 3 days for adequate post-match recovery in football players [25]. Although there are no such data for professional football referees, it can be assumed that more than 4 days are needed to completely restore homeostatic balance after refereeing a match, particularly to allow referees to maintain their high intensity running and sprinting during matches.

Decrements in performance due to congested fixtures also might be attributable to the referee's age. A previous study demonstrated that running distance, high intensity running, the number of sprints, and peak running speed during a match progressively decrease as the referees age, while the rating of perceived exertion increases [26]. The decline in running performance is evident in referees older than 43 years when compared to younger counterparts [26]. In the current investigation, the professional football referees were 38.7 years old on average (range 33–45 years); therefore, they were likely at the age that allows adequate running performance. In fact, covariate analysis revealed that referees were similarly affected by the lower time of recovery between matches regardless of their age. All this information suggests that the deleterious effect of a congested fixture on referees' running performance is independent of referees' ages.

It is worth noting that the internal workload, assessed by HR and self-perceived exertion, was similar to the values described previously in studies with similar aims [27–29]. In the current study, RPE remained unaltered despite match congestion (▶ **Table 1**). Although very practical, self-reports are subject to being altered by the extrinsic factors associated with the match, for instance, after a tense match [30]. In addition, the use of RPE at the end of the match may be affected by the intensity of the play in the last phases of the match. Thus, although session RPE might be a practical measure to estimate the overall load, this tool may not be sensitive enough to detect fluctuations in external load performed between congested and non-congested matches in referees. On the other hand, GPS data collection and assessment are a more effective strategy for detecting running fatigue due to match congestion as it was valid to detect decreases in running distances at high intensity. However, obtaining GPS data is a time-consuming task that may limit its application to aid decision-making on readiness status on a daily basis [23]. Thus, staff and referees should weigh the cost–benefit among available tools to have an optimal flow of information and use it according to their interests. In the light of the current results, we suggest the use of GPS during officiated matches to create normalised running patterns for each professional football referee to aid in the detection of phases where these officials may experience chronic fatigue due to match congestion or due to the accumulation of matches during the season.

Another contribution of this study is the comparisons between match halves, where it showed that the professional referees covered larger distances at low speed $<6\,km\cdot h^{-1}$ (3.6 %) during the second half of non-congested fixtures, when compared to the performance data obtained in the first half. In addition, in line with previous studies [31, 32], no significant differences between halves were observed on other match load variables when examining both halves during non-congested weeks. The evolution of the physical responses of high-level referees during the first and second half of official matches has been previously studied with contradictory results [26]. A possible reason for these contradictions may be the competitive level of the referees [15, 33, 34]. In fact, in lower-level categories of refereeing, the physical response of the referees is influenced by the level of the football players [15]. Particularly in this study, all the matches were officiated in top-level national and international competitions, and therefore the lower running distance at low-intensity in the second half of the congested match was not associated with the referee's level [34]. In fact, this may be another sign of fatigue, indicating that football referees were only able to cover greater running distances at low intensity in the second half during non-congested fixtures. Further information is needed to determine if the effect of match congestion of football referees' running patterns influences the distance they maintain from the ball during the match.

During the 2nd half of both congested and non-congested matches, referees performed a large number of accelerations and decelerations. Arguably, these increments could be related to higher competitiveness during the last minutes of close matches [35], and also be influenced by the football players' physical performance, teams' playing styles and technical-tactical performance demands [10, 36, 37]. Indeed, fatigue-induced changes in physical performance during a football match are multifactorial and highly related to the specific demands of each match [38]. Our results differ from a previous study examining Spanish 3rd Division referees [39], which reported more accelerations and decelerations during the 1st half compared to the 2nd half. This difference between studies may be related to the higher physical fitness in our sample of first-division professional referees, as compared to the 3rd Division referees. Further studies are needed to clarify how the external factors of a match, such as the presence of public, the match result, and the game styles of the teams, affect referees' running performance when officiating high-level football matches.

Despite the practical implications of the outcomes, this study presents some potential limitations that must be recognised. First, the data from the current investigation has not been analysed in terms of referees' fitness status to explain whether performance impairment during the congested fixture is lower in referees with high physical conditioning. Nonetheless, given the particularities of the sample (professional referees from the top football league), an optimal physical status can be assured in all participants because they pass tests periodically during the season. Additionally, the current analysis is a repeated-measures experiment and the physical status of the referee likely had minimal influence on the study outcomes. Second, the present results are based on data collected during the competition, whereas the potential influence of accumulative training workload remains unknown. In this regard, all professional football referees in the Spanish football league followed a similar training pattern provided by the National Refereeing Committee, which entails proper tapering before and recovery after each match. However, the current study did not include the accumulated training load which could have influenced the results. Future studies should confirm whether the combination of training and match load in the congested week is responsible for the outcomes of this investigation rather than a competition-only effect. Third, although the current sample comprised both national and international matches, we were unable to examine the effects of the type of competition owing to the reduction of statistical power. Further studies addressing whether the combination of officiating in international and national competitions in a week produces higher levels of fatigue in professional referees – in comparison to the combination of national competitions – are warranted. Last, further studies should examine physiological parameters (e. g. creatine kinase or ammonium concentrations) and physical tests (e. g. loss in jumping ability or isometric strength) performed before and after a match to provide a better understanding of the mechanisms associated with fatigue due to match congestion in professional referees.

In conclusion, match congestion due to officiating two matches with less than a week in between caused notable signs of high-intensity running fatigue in professional football referees. These data suggest the need for specific conditioning and post-match recovery strategies in high-level referees to ensure optimal judgment performance favouring the quality of the competition, especially when officiating matches in congested calendars. Based on studies with professional football players [40], the use of compression garments, cold water immersion and sleep hygiene may aid in the recovery process, although investigations are needed to confirm the effectiveness of these post-match recovery methods to reduce match congestion-associated fatigue in referees. Additionally, football governing bodies should take into account the results of this investigation to designate the referees for a match, paying special attention to avoid congested fixtures in professional refereeing.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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