Professional football in times of COVID-19: did the home advantage effect disappear in European domestic leagues?

AUTHORS: Carlos H. Almeida[1], Werlayne S. Leite[2]

[1] CIDEF, ISHIP, ISMAT – Instituto Superior Manuel Teixeira Gomes, Portimão, Portugal
[2] Secretariat of Education of the State of Ceará (SEDUC), Fortaleza, Brazil

ABSTRACT: This study aimed to examine how the home advantage (HA) and home teams' performances changed in European football leagues (German Bundesliga, Spanish La Liga, English Premier League, Portuguese Primeira Liga and Italian Serie A) with the measures imposed by legal authorities to deal with the COVID-19 pandemic (no audience, five substitutions and "cooling breaks"). The HA (Pollard's rescaled method) and home performance-related statistics of matches contested before (n = 491) and after (n = 491) the 2019–2020 season break were calculated and compared, for each league and for all five, using the paired t-test or the Wilcoxon signed-rank test. Overall, the HA did not significantly decrease in European leagues (from 16.4% to 11.6%; trivial effect size [ES]); however, a one-sample t-test revealed that the HA after the COVID-19 break was significantly greater than 0% (small ES). While the HA completely disappeared in the Bundesliga (large ES), its effects remained stable in La Liga (small ES), Premier League and Primeira Liga (trivial ES), and even increased in Serie A (medium ES) after the return. Home teams' performances in these leagues were influenced to different extents by the COVID-19 situation, especially by playing behind closed doors. Altogether, significant decreases were observed for total shots, tackles (medium ES), shots on target and pass success (small ES). Therefore, the role of crowd support seems to vary depending on the context characteristics in which football is played. Also, the augmented "information transfer" from coaches to players during COVID-19 matches might have masked the crowd effects on the HA.

CITATION: Almeida CH, Leite WSS. Professional football in times of COVID-19: did the home advantage effect disappear in European domestic leagues? Biol Sport. 2021;38(4):693–701.

Received: 2020-08-22; Reviewed: 2021-03-02; Re-submitted: 2021-03-03; Accepted: 2021-03-06; Published: 2021-03-30.

Corresponding author:
Carlos Humberto Almeida
Postal address: CIDEF, ISHIP
Instituto Superior Manuel Teixeira Gomes, Rua Dr. Estêvão de Vasconcelos, n.º 33 A
8500-656 Portimão, Portugal
Tel.: + 351 967990275
E-mail: carlos.almeida@ismat.pt

ORCID:
Carlos Humberto Almeida
0000-0001-8066-8788

Werlayne S. Leite
0000-0002-0245-7042

Key words:
Soccer
Match location
Team performance
Crowd support
Coronavirus

INTRODUCTION

May 25, 2020. After two rounds contested in the German Bundesliga following the coronavirus disease 2019 (COVID-19) stoppage, the Spanish newspaper *Marca* posted a technical piece warning all La Liga clubs about the possible disappearance of the "home advantage effect", with implications for the final league-table classification. In accordance with *Marca* [1], before the COVID-19 pandemic declared by the WHO on March 11, 2020, the Bundesliga 2019–2020 registered a home win rate of 43.3%, which dramatically decreased to 16.7% after the return to play, with 18 matches undertaken without an audience (so-called "ghost matches"). The hypothesis of the home advantage (HA) disappearance in European domestic leagues was associated with the absence of spectators in the stadiums, a restrictive measure imposed by each national healthcare governmental system to mitigate the propagation of the virus.

Before the coronavirus outbreak, the HA effect had been considered a well-established phenomenon across most team sports, with particularly high magnitudes in association football [2–4]. This effect implies achieving better match outcomes when a team plays at its own ground (home) compared to playing at the opponents' facilities (away). The traditional method proposed by Pollard [5] for quantifying the HA – the number of points won at home expressed as a percentage of all points gained at home and away – led researchers to report up-to-date values between 57 and 62% at the top tier of major European domestic leagues [6–8]. This measure is always non-negative and varies from 0% (no points won at home) to 100% (no points won away), with a value of 50% representing an equal number of points won at home and away (i.e., no home advantage). Recently, Matos et al. [9] opined that it can be criticised on the basis that the obtained value does not properly relate to the advantage of playing at home, and that the reference point of no home advantage should be 0% rather than 50%. For that reason, Pollard's rescaled method (see [9]) was used in the present study.

Previous research has attempted to explain the HA as consequence of multiple (and interacting) factors. Besides psychological, physiological and social factors, the subjects of crowd effects, familiarity with local conditions, referee bias, travel effects, territoriality, special tactics, influence of rules and team composition have been under debate [3, 10]. When asked for the main causes of HA, football coaches and players rated stadium familiarity, crowd support and psychological factors as key contributors [11, 12]. However,

specifically addressing the influence of crowd support (e.g., size, density and/or proximity) on HA, the existing empirical evidence is still ambiguous. Whereas some studies have shown that increased crowd support is positively associated with points attained at home [10, 13, 14], others have found that HA is not affected by attendance increases [15, 16], and it even exists with small crowds [6, 8, 17] or in empty stadiums [18].

On the one hand, the crowd may influence the performance of a team by putting home players in a more positive and confident psychological state [8]. On the other hand, its support is also believed to indirectly influence the referees' decisions, creating a bias in favour of the home team [19], which receives significantly fewer penalties and disciplinary cards than the visiting team [10, 14]. All in all, these mechanisms along with others have operated since the dawn of organised football in the 19th century to produce the HA [17]. This ancestor effect developed a self-fulfilling prophecy among coaches that home teams win more often because they believe they have an advantage, thereby promoting more dominant, attacking and audacious strategies when playing at home [12]. In fact, home teams tend to exhibit higher values than visiting ones in diverse performance-related variables, such as goals scored, total shots, shots on target, ball possession, passing success, dribbles, aerial duels and ball recoveries [20–22]. Although HA and home performance represent distinct concepts, there is a close relationship between them: the HA usually reflects better performances of the home team.

Given the unprecedented times we are facing because of COVID-19, the decision of concluding several European football leagues opened up a singular opportunity to (r)evaluate and clarify the relative importance of crowd support on HA and home teams' performances. The comprehensive analysis of German "ghost matches" during this pandemic, conducted by Fisher and Haucap [23], was pioneering research on this topic. These authors showed that the HA completely vanished in the Bundesliga during "ghost matches", a finding which was not mirrored in the lower two divisions. Unlike the total crowd size, the reduced post COVID-19 occupancy rate to zero was found to be the main reason for the HA decrease [23]. Therefore, it seems reasonable to extend this research to other domestic leagues in Europe – did the HA effect suffer a similar reduction? More results should provide a deeper understanding of how modification of the home environment shapes the magnitude of HA in different playing contexts.

This exploratory study aimed to examine how the HA and home team's performances have changed across five European domestic leagues (German Bundesliga, Spanish La Liga, English Premier League, Portuguese Primeira Liga and Italian Serie A), as a function of the measures imposed by legal authorities to deal with the pandemic ("ghost matches", five substitutions allowed and "cooling breaks"). To that end, all dependent variables were compared before and after the COVID-19 suspension. Based on the aforesaid empirical evidence, three hypotheses were defined: (1) as the HA is a robust phenomenon since the inception of football, its effect did not vanish in "ghost matches" contested in Europe; (2) however, the magnitude of HA decreased in each domestic league analysed; (3) the values of one or more performance-related variables were significantly affected by the applied post-COVID-19 measures.

MATERIALS AND METHODS

Sample

The sample consisted of 982 matches contested by 96 club teams, during the 2019–2020 season, in five European domestic leagues (German Bundesliga, Spanish La Liga, English Premier League,

TABLE 1. Sample-related details and specific measures adopted for dealing with the COVID-19 pandemic in each European domestic league.

League (Nation)	Teams (n)	Matches Pre COVID-19 (n)	Matches Post COVID-19 (n)	Same home grounds?	Stadiums with audience?	Rounds followed the same order?	Cooling breaks?	Five substitutions?
Bundesliga (Germany)	18	81	81	Yes	No	Yes	Yes	Yes
LaLiga (Spain)	20	110	110	Yes, excepting one club team	No	No	Yes	Yes
Premier League (England)	20	90	90	Yes	No	No	Yes	Yes
Primeira Liga (Portugal)	18	90	90	Yes, excepting two club teams	No	Yes	Yes	Yes, excepting in round 25*
Serie A (Italy)	20	120	120	Yes	No	Yes	Yes	Yes
TOTAL	96	491	491	Almost always	No	Not always	Always	Almost always

* The five substitutions rule was not implemented in the first round after the return due to legal issues raised by two clubs.

Portuguese Primeira Liga and Italian Serie A). For each individual team, archival data of matches played against the same opponents before and after the COVID-19 suspension were collected from the publicly available website "WhoScored.com" (https://whoscored.com). The same number of matches was analysed before (n = 491, between August 16, 2019 and January 19, 2020) and after the COVID-19 outbreak (n = 491, between May 15, 2020 and August 2, 2020) for each domestic league and for all five. Table 1 indicates the sample-related details and the specific measures adopted by each league administrating body for dealing with the COVID-19 pandemic.

The website "ZeroZero" (https://zerozero.pt) was also consulted to confirm the soundness of the primary data source in terms of home and away records related to match outcomes (home wins, draws, losses, goals scored and goals conceded). The raw data did not present inconsistencies. After the return, teams played the home matches at their usual stadiums apart from three teams (La Liga: Real Madrid CF; Primeira Liga: Belenenses SAD and CD Santa Clara), comprising a total of 31 out of 491 matches after the COVID-19 break (6.3%) played on a less familiar ground. Since these teams prepared for the return to play in the alternative facilities, and later continued to practise in them, no match was excluded from the sample.

Prior to data collection, written permission from both website administrators was received, with the respective privacy policies being entirely respected. The methodological procedures conformed to the ethics guidelines of the local university, and the investigation was conducted in compliance with the principles expressed in the Declaration of Helsinki.

Variables and Procedures

The HA and home performance-related statistics (points, goals scored, goals conceded, total shots, shots on target, ball possession, pass success, aerial duels won, tackles and disciplinary cards) were the dependent variables of this study, whereas the COVID-19 situation was the independent variable.

Pre- and post-COVID-19 HA were quantified for each European league and for all five using Pollard's rescaled method. This method produces a value of 0% when the same number of points are won at home and away (no home advantage), with the advantage then being measured on a scale between 0% to 100%, while negative values indicate a home disadvantage [9]. The formula adopted is the following:

$$\text{HA (\%)} = \frac{(\textit{Home points} - \textit{Away points})}{(\textit{Home points} + \textit{Away points})} \times 100 \qquad (1)$$

For an unbiased calculation of HA, this method requires a balance schedule of matches, in which teams play against the others twice, once at home and once away. The full set of rounds was not studied for each European league; nevertheless, any given team faced the same opponents before and after the COVID-19 break, thereby assuring unbiased estimates of HA when both time points are compared. Furthermore, the crossover design associated with this "natural experiment" in the 2019/2020 season implies that each individual team serves as its own matched control, obviating the need for additional procedures to control for confounding variables of HA, such as team ability, quality of opposition or travel distance/fatigue. Other potential confounding variables such as local derbies, new coaches, within-week matches, time of the match, altitude and fitness levels

TABLE 2. Operational definitions of performance-related variables used in this study (adapted from WhoScored.com).

Performance-related variable	Operation Definition
Points (n)	Number of points won per match played at home.
Goals Scored (n)	Number of goals scored per match played at home.
Goals Conceded (n)	Number of goals conceded per match played at home.
Total Shots (n)	Number of attempts to score a goal, made with any (legal) part of the body, either on or off target per match played at home.
Shots on Goal (n)	Number of attempts to score which required intervention to stop it going in or resulted in a goal/shot which would go in without being diverted per match played at home.
Ball Possession (%)	Mean of the duration when a team takes over the ball from the opposing team without any clear interruption, as a proportion of total duration when the ball was in play in home matches.
Pass Success (%)	Mean percentage of attempted passes that successfully found a teammate in matches played at home.
Aerial Duels Won (%)	Mean percentage of headers won in direct contests with an opponent in matches played at home.
Tackles (n)	Number of actions for dispossessing an opponent, whether the tackling player comes away with the ball or not, per match played at home.
Cards (n)	Number of disciplinary cards (yellow and red) received by players per match played at home.

were recently demonstrated not to influence the HA in "ghost matches" of the German Bundesliga [23]. Factors regarding the stadiums' features (i.e., capacity, occupancy rate and existence of running track) may affect the HA [3, 10, 23], but they were not controlled for in this research.

The performance-related statistics intended to provide a general picture of teams' performances when playing at home, as a function of different COVID-19 periods. Table 2 displays the operational definitions of home performance-related variables used in the study.

A Microsoft 365 Excel (Microsoft Corporation, USA) spreadsheet was arranged to automatically calculate the HA based on home wins, draws and losses, and total points gained in the analysed pre- and post-COVID-19 matches. The home performance-related statistics were registered on a match-by-match routine, and then divided by the total number of matches contested at home. These match statistics were retrieved from the website "WhoScored.com", which uses data supplied by OPTA Sports. The inter-operator reliability of OPTA's observational system was previously assessed and considered reliable [24], attaining acceptable values in several agreement scales (Kappa, ICC, *r* and SEM). Two categorical variables were added to the spreadsheet to facilitate data analyses: European league (1 – Bundesliga, 2 – La Liga, 3 – Premier League, 4 – Primeira Liga and 5 – Serie A) and COVID-19 situation (1 – Pre, 2– Post). The database was finally exported to SPSS 24.0 (IBM SPSS Statistics, IBM Corp., Armonk) for statistical treatment.

Statistical Analysis

The data were primarily verified through descriptive statistics (means, standard errors of the mean or standard deviations). To visualise the pre- and post-COVID-19 break differences, error bars adjusted for repeated-measures designs were computed for each league and for all five [25]. The effects of the COVID-19 situation on HA and home performance-related variables were examined through paired t-tests. The assumption of normality was verified for each dependent variable, as the difference between Post and Pre conditions, using Shapiro-Wilk ($n < 50$) and Kolmogorov-Smirnov tests, and by checking if skewness and kurtosis z-scores fell between -1.96 and 1.96. If the normality assumption was violated, the non-parametric Wilcoxon signed-rank test was applied. The existence of HA before and after COVID-19 was examined for each league and for all five through one-sample t-tests comparing the observed HA with a null value of 0% indicating no HA. Once again, the assumption of normality was ascertained before applying the above-stated procedures.

The effect sizes (ES) were calculated for the one-sample t-test, paired t-test and Wilcoxon signed-rank test employing equations 2, 3 and 4, respectively, as suggested by Field [25]:

$$d = \frac{(M - \mu)}{SD} \quad (2)$$

where *d* expresses Cohen's *d* measure of ES, *M* the sample mean, μ the population mean (0%), and *SD* the sample standard deviation.

$$d = \frac{(MPost - MPre)}{SDPre} \quad (3)$$

where *d* expresses Cohen's *d* measure of ES, *MPost* the post-COVID-19 sample mean, *MPre* the pre-COVID-19 sample mean, and *SDPre* the pre-COVID-19 standard deviation.

$$r = \frac{Z}{\sqrt{N}} \quad (4)$$

where *r* is the ES estimate for the Wilcoxon signed-rank test, *Z* the *z*-score produced by SPSS and *N* the number of total observations on which *Z* is based.

The interpretation of ES relied on the benchmarks proposed by Cohen [26]: small, $d = 0.2$ or $r = 0.1$; medium, $d = 0.5$ or $r = 0.3$; large, $d = 0.8$ or $r = 0.5$. The level of significance was set at $p \leq 0.05$.

RESULTS

Considering all the sample, the mean pre- ($M = 16.41\%$; $t(95) = 5.055$, $p < 0.001$, $d = 0.52$) and post-COVID-19 break HA values (11.64%; $t(95) = 2.964$, $p = 0.002$, $d = 0.3$) were significantly greater than 0%. The observed decrease of HA after the COVID-19 interruption was not significant in European professional football, $t(95) = -0.940$, $p = 0.349$, $d = -0.15$. Hence, the first hypothesis was confirmed: the HA effect did not disappear in matches played behind closed doors in Europe following the coronavirus outbreak.

The comparison of mean pre- and post-COVID-19 values of HA for each domestic league and for all five is presented in Figure 1.

The measures employed to deal with the pandemic only promoted a significant change in the Bundesliga; the magnitude of HA declined from 20.26% to -9.81%, revealing a large effect,

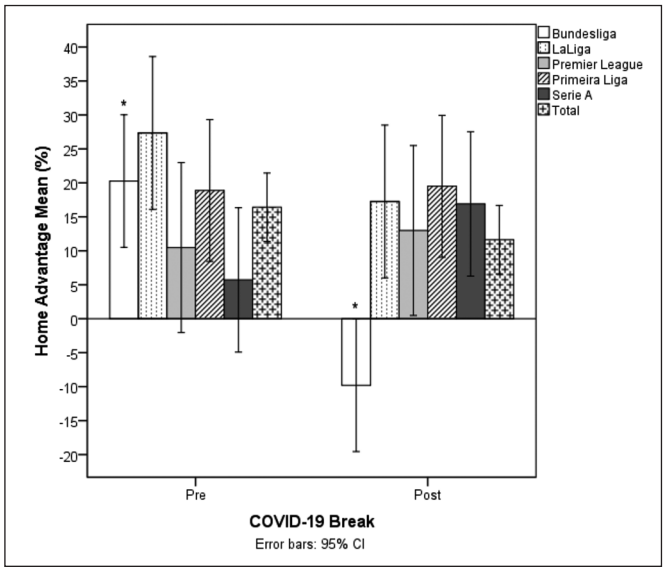

FIG. 1. Home advantage (mean ± error bars) in Bundesliga, La Liga, Premier League, Primeira Liga and Serie A, and in total, both before and after the COVID-19 break. *Significant differences ($p < 0.05$) between Pre- and Post-COVID-19 conditions.

$t(17) = -3.059$, $p = 0.007$, $d = -0.84$. The HA medium-sized effect before COVID-19, $t(17) = 2.404$, $p < 0.014$, $d = 0.57$, totally disappeared after the return to play, yet the negative value did not significantly differ from 0%, $t(17) = -0.975$, $p = 0.172$, $d = -0.23$. A small and non-significant decrease occurred in La Liga (mean difference: -10.09%; $t(19) = -0.891$, $p = 0.384$, $d = -0.29$), although the post-COVID-19 HA effect remained significantly greater than 0%, $W_s = 115.50$, $z = 1.847$, $p = 0.033$, $r = 0.41$.

Compared to the pre-COVID-19 period, the values of HA increased to different extents in the Premier League, Primeira Liga and Serie A after the return (mean differences: 2.51%, 0.62% and 11.18%, respectively). Even though the differences were non-significant, the COVID-19 situation produced a medium-sized effect on HA in Serie A (Premier League: $t(19) = 0.199$, $p = 0.844$, $d = 0.08$; Primeira Liga: $t(17) = 0.059$, $p = 0.954$, $d = 0.02$; Serie A: $t(19) = 1.045$, $p = 0.309$, $d = 0.53$). Moreover, distinct HA fluctuations were identified in these leagues. No HA effects (i.e., values significantly greater than 0%) were found in the Premier League for pre-, $t(19) = 1.464$, $p = 0.08$, $d = 0.33$, and post-COVID-19 periods, $t(19) = 1.417$, $p = 0.087$, $d = 0.32$. A HA effect persisted in Primeira Liga throughout the 2019/2020 season, with a medium ES noted after COVID-19, $t(17) = 2.287$, $p = 0.018$, $d = 0.54$. A non-existent pre-COVID-19 HA effect in Serie A, $t(19) = 1.221$, $p = 0.119$, $d = 0.27$, gave place to an almost medium-sized HA effect after the stoppage, $t(19) = 2.102$, $p = 0.025$, $d = 0.47$. In the light of these facts, the second hypothesis – the magnitude of HA decreased in each domestic league analysed – was rejected.

Tables 3 and 4 show the descriptive and inferential statistics for all performance-related variables, as a function of the COVID-19 situation, for each European league and for all five.

The impact of the measures associated with the return to play on home performance-related variables differed in each European league. For instance, in home matches of the Bundesliga medium-sized decreases were found for points won ($p < 0.01$), total shots and shots on target ($p < 0.05$), while goals conceded and cards received had medium-sized increases ($p > 0.05$). Although non-significant, small reductions were still observed for goals scored, ball possession and tackles, along with a small increase for pass success. When playing at home in La Liga, negative ESs were associated with total shots ($p < 0.05$, medium ES), goals scored and shots on target

TABLE 3. Descriptive (mean ± standard deviation) and inferential statistics (paired t-test or Wilcoxon signed-rank test) for all performance-related variables of Bundesliga, La Liga and Premier League, as a function of two different time points – pre- and post-COVID-19 break.

Performance-related variables	Bundesliga				La Liga				Premier League			
	Pre	Post	*p*	*d* / *r*	Pre	Post	*p*	*d* / *r*	Pre	Post	*p*	*d* / *r*
Points (n)	1.7 ± 0.77	1.21 ± 0.78	0.048	-0.64	1.69 ± 0.59	1.5 ± 0.62	0.277	-0.17	1.53 ± 0.78	1.62 ± 0.9	0.648	0.12
Goals Scored (n)	1.83 ± 0.98	1.48 ± 0.78	0.379	-0.15	1.63 ± 0.76	1.26 ± 0.49	0.044	-0.49	1.63 ± 0.79	1.57 ± 0.96	0.652	-0.08
Goals Conceded (n)	1.37 ± 0.56	1.69 ± 0.75	0.162	0.57	1.07 ± 0.51	1.08 ± 0.47	0.892	0.02	1.38 ± 0.55	1.17 ± 0.66	0.161	-0.38
Total Shots (n)	15.7 ± 3.67	13.5 ± 2.67	0.012	-0.62	13.1 ± 2.83	11.3 ± 1.43	0.012	-0.63	14.3 ± 2.93	11.9 ± 2.93	0.001	-0.53
Shots on Target (n)	5.89 ± 2.09	4.63 ± 1.37	0.014	-0.6	4.77 ± 1.75	3.99 ± 1.07	0.041	-0.45	5.08 ± 0.89	4.07 ± 1.65	0.01	-1.13
Ball Possession (%)	52.8 ± 8.85	50.6 ± 7.75	0.094	-0.28	50.3 ± 7.01	52.1 ± 8.01	0.182	0.26	51.2 ± 8.47	49.6 ± 8.95	0.489	-0.19
Pass Success (%)	78.1 ± 5.66	79.2 ± 5.26	0.255	0.2	76.8 ± 6.82	77.1 ± 7.79	0.655	0.05	78.7 ± 5.55	78.3 ± 6.1	0.753	-0.08
Aerial Duels Won (%)	50.7 ± 4.68	50.2 ± 3.55	0.586	-0.09	50.3 ± 5.98	49.2 ± 8.17	0.616	-0.20	50.7 ± 4.66	49.4 ± 4.45	0.253	-0.27
Tackles (n)	16.6 ± 2.83	15.9 ± 3.19	0.511	-0.25	14.5 ± 2.28	14.1 ± 1.77	0.479	-0.18	16.5 ± 2.45	14.7 ± 2.91	0.008	-0.71
Cards (n)	1.8 ± 0.79	2.23 ± 0.89	0.118	0.54	2.64 ± 0.56	2.66 ± 0.74	0.916	0.04	1.72 ± 0.66	1.53 ± 0.49	0.029	-0.29

Note: *p* – p-value; *d* – effect size for paired t-test; *r* – effect size for Wilcoxon signed-rank test. The use of Wilcoxon signed-rank tests is highlighted in grey cells, while white cells display results of paired t-tests.

TABLE 4. Descriptive (mean ± standard deviation) and inferential statistics (paired t-test or Wilcoxon signed-rank test) for all performance-related variables of Primeira Liga and Serie A, and in total, as a function of two different time points – pre- and post-COVID-19 break.

Performance-related variables	Primeira Liga				Serie A				TOTAL (all five leagues)			
	Pre	Post	*p*	*d* / *r*	Pre	Post	*p*	*d* / *r*	Pre	Post	*p*	*d* / *r*
Points (n)	1.6 ± 0.63	1.58 ± 0.64	0.899	-0.03	1.43 ± 0.64	1.53 ± 0.66	0.544	0.16	1.59 ± 0.68	1.49 ± 0.73	0.245	-0.15
Goals Scored (n)	1.34 ± 0.68	1.5 ± 0.77	0.535	0.19	1.56 ± 0.74	1.78 ± 0.6	0.272	0.3	1.6 ± 0.79	1.52 ± 0.74	0.319	-0.1
Goals Conceded (n)	1.0 ± 0.57	1.18 ± 0.52	0.370	-0.38	1.31 ± 0.42	1.49 ± 0.57	0.232	0.43	1.23 ± 0.54	1.32 ± 0.63	0.224	0.17
Total Shots (n)	13.3 ± 3.74	11.8 ± 2.57	0.073	-0.4	16.3 ± 4.07	14.4 ± 3.23	0.015	-0.46	14.6 ± 3.64	12.6 ± 2.85	< 0.001	-0.54
Shots on Target (n)	4.32 ± 1.54	3.93 ± 1.47	0.269	-0.25	5.38 ± 1.72	5.24 ± 1.64	0.707	-0.08	5.01 ± 1.69	4.38 ± 1.51	< 0.001	-0.42
Ball Possession (%)	51.3 ± 6.57	50.2 ± 7.25	0.498	-0.16	51.1 ± 5.63	50.2 ± 6.02	0.413	-0.17	51.3 ± 7.27	50.6 ± 7.55	0.31	-0.1
Pass Success (%)	76.2 ± 6.09	77.9 ± 5.41	0.181	0.28	80.7 ± 4.2	82.8 ± 3.66	0.001	0.51	78.1 ± 5.83	79.1 ± 6.05	0.009	-0.19
Aerial Duels Won (%)	49.5 ± 5.97	50.1 ± 6.3	0.731	0.11	51.4 ± 4.98	50.5 ± 6.64	0.539	-0.22	50.5 ± 5.21	49.9 ± 5.98	0.386	-0.06
Tackles (n)	16.6 ± 1.85	14.5 ± 2.42	0.006	-1.09	14.9 ± 1.99	13.0 ± 2.06	0.001	-0.94	15.8 ± 2.44	14.4 ± 2.63	< 0.001	-0.32
Cards (n)	2.6 ± 0.67	2.84 ± 0.63	0.247	0.36	2.76 ± 0.52	2.25 ± 0.44	0.004	-0.98	2.31 ± 0.77	2.29 ± 0.79	0.837	-0.03

Note: *p* – p-value; *d* – effect size for paired t-test; *r* – effect size for Wilcoxon signed-rank test. The use of Wilcoxon signed-rank tests is highlighted in grey cells, while white cells display results of paired t-tests.

($p < 0.05$, small ES), points and aerial duels ($p > 0.05$, small ES). A non-significant and small increase was noted for post-COVID-19 ball possession. Pertaining to the Premier League, home teams executed fewer total shots ($p = 0.001$, large ES), shots on target ($p = 0.01$, large ES) and tackles ($p < 0.01$, medium ES), received fewer disciplinary cards ($p < 0.05$, small ES), conceded more goals ($p < 0.05$, small ES) and had a smaller percentage of aerial duels won ($p > 0.05$, small ES).

A large decline was found for tackles in Primeira Liga's home matches after the COVID-19 outbreak ($p < 0.01$). While small, non-significant decreases were detected for goals conceded, total shots and shots on target, small positive effects were observed for pass success and cards ($p > 0.05$). In Serie A, the average number of tackles ($p = 0.001$, large ES), cards ($p < 0.01$, large ES) and total shots ($p < 0.05$, medium ES) at home were negatively affected by the COVID-19 situation; however, a medium-sized positive effect occurred for pass success ($p = 0.001$). Small effects were also observed for goals scored, goals conceded and aerial duels won ($p > 0.05$). Altogether, post-COVID-19 home matches suffered a significant reduction in total shots and tackles ($p < 0.001$, medium ES), shots on target ($p < 0.001$, small ES) and pass success ($p < 0.01$, small ES). The third research hypothesis was confirmed: some home performance-related measures were influenced by the applied post-COVID-19 measures.

DISCUSSION

On May 25, 2020, the sports media hypothesised the possible disappearance of the HA in European professional football as a consequence of policies employed by legal authorities to decelerate the coronavirus propagation [1]. Indeed, the home wins in the German Bundesliga dramatically dropped after the return to play [1, 23]. Further research was then suggested to clarify whether the HA in other European domestic leagues followed an identical post-COVID-19 decline. This study analysed how the post-COVID-19 measures (no audience, five substitutions and "cooling breaks") influenced the HA and home teams' performances in five different European leagues.

Instead of the traditional method, Pollard's rescaled method was used for quantifying the HA, because it enables an unequivocal interpretation based on a scale where 0% represents no HA. Thus, the HA values previously obtained using the traditional method were

converted with the formula proposed by Matos et al. [9] for comparative purposes. The mean values of HA before the COVID-19 stoppage were identical to those found by Leite and Pollard [8], between seasons 2010–2011 and 2016–2017, for the Bundesliga (20.3 vs. 17.2%), La Liga (27.34 vs. 21.62%), Premier League (10.48 vs. 17.92%) and Primeira Liga (18.88 vs. 15.6%). The same was not verified for Serie A (5.72 vs. 19.36%), which may be due to short-term fluctuations that have been proved to occur in a league [6, 19, 27].

The hypothesis of the HA disappearing in European professional football raised by early data [1, 23] was not confirmed. Despite a subtle decrease provoked by the packet of measures applied to control the pandemic, the HA effect has endured when considering the whole sample. This finding sustains the robustness of the HA phenomenon, which has been documented since the inception of organised football [17]. By analysing each domestic league, our results provided further evidence that the COVID-19 situation induced a significant and large effect on the HA of the Bundesliga. In short, the HA disappeared in the German major league, a fact mainly attributed to the striking drop in the stadium occupancy rates, but which was not reproduced in the divisions immediately below [23]. Furthermore, the COVID-19 measures elicited distinct non-significant effects on HA magnitudes in the other European leagues. A small decrease was noted in the Spanish La Liga, although the HA effect has lasted after the COVID-19 break, as it did in the Portuguese Primeira Liga. Over the 2019/2020 season, no HA effects were found in the English Premier League in both pre- and post-COVID-19 periods. The period following the outbreak promoted a medium-sized positive effect on the HA of Italian Serie A; a non-existent pre-COVID-19 HA was superseded by a significant effect after the return. Hence, the supposition of an equivalent decreasing trend across all five European leagues was rebutted.

Although the crowd influence was rated one of the leading causes of HA by football players, coaches and fans [11, 12], our findings do not completely endorse such perceptions. The crowd may exert a direct influence on players, by encouraging their team and/or by intimidating the opposing one, and indirectly operate by interfering with the referees' decisions [3, 4, 10]. Apart from the effect of "ghost matches" in the Bundesliga, the HA remained stable or even increased in the other leagues during COVID-19 times, when matches were played in empty stadiums. Similar results were recently observed at lower levels of German professional football [23], whilst prior evidence revealed that home teams participating in Italian leagues still had an advantage in matches contested without spectators [18]. These facts are reinforced by studies that have failed to prove the HA is enhanced with larger attendance [8, 15, 16]. Regarding regularity, the role of crowd support is at least questionable, because it appears to vary depending on the contexts in which the game is played [4, 10, 19].

The temporal dispositions may alter the HA in a sporting context [6, 17]. Interestingly, Fisher and Haucap [23] found that the initial tremendous negative effect of "ghost matches" on the HA of the Bundesliga had attenuated over time, a change probably related to the home players becoming more familiar with playing in vacant stadiums. In the present research, the domestic leagues that ended first displayed decreases in post-COVID-19 HA (Bundesliga and La Liga), while the HA of the last three to finish (Premier League, Primeira Liga and Serie A) increased to different extents, suggesting an intriguing adaptative response of home teams to cope with the lack of exogenous support. The data corroborate the view that crowd support is not a necessary precondition for HA, and other factors, such as the familiarity with local conditions (e.g., stadium environment, pitch surface and dimensions), are actually more relevant for its expression [15, 18], as previously recognised by players and coaches [11, 12].

There is a close relationship between HA and home performance; therefore, it would be expected to find some modifications in the performances of home teams following the COVID-19 interruption. Overall, significant decreases were observed for total shots, tackles (medium ES), shots on target and pass success (small ES). The performance variables related to goal scoring (total shots and/or shots on target) were negatively affected in all European leagues, except for the Primeira Liga. The number of tackles executed by home teams significantly decreased in the Premier League, Primeira Liga and Serie A. Consequently, the disciplinary cards received by home teams also decreased in the Premier League and Serie A. Even though the global pass success has diminished, in the Italian league this variable had a surprising medium-sized increase. Apparently, the presence of a crowd in the stadium encourages the home players to perform more goal-scoring actions, a result of the mobilisation of collective attentional focus to achieve victory [11, 14]. The decremental post-COVID-19 trend observed for home tackles (and cards in two leagues) indicates that the public may be a potential mediator of players' aggressiveness, which ultimately had an impact on goals conceded and on match outcome as well. These results tend to support the view that successful football teams sustain their defensive performance through actions aiming to (re)gain the ball directly from the opponents [28]. In addition, the crowd support did not seem to bias the referees' decision-making in favour of home teams in major European leagues [8, 29].

So far, the differences in HA and home performance-related statistics have been exclusively discussed based on a unique factor – crowd support. Any match outcome or team performance is determined by a myriad of factors, many of them difficult to control for. Through a regression analysis, Fisher and Haucap [23] revealed that the "ghost game" effect on HA was quite insensitive to the inclusion of a variety of confounding variables (i.e., rest time, fitness measures, within-week matches, latest teams' performances, local derbies, new coaches, travel fatigue and altitude). However, it is worth noting that the missing noise from the home crowd, alongside the five substitutions allowed and the introduction of "cooling breaks" in the post-COVID-19 period, have strengthened the "information transfer"

hypothesis [29]. Augmented interference of coaches in players' actions during competitive matches, by means of audible verbal instructions, tactical adjustments during stoppages and substitutions, might have diluted part of the advantage typically attributed to home teams.

This exploratory study provided another piece for the complex HA puzzle; nonetheless, we are aware that the statistical analysis employed, which was previously called "naive" [23], has limitations concerning the explanation of mechanisms underlying the HA. Since the HA is a multifactorial phenomenon, related data should be treated as such using multivariate statistical procedures and, preferably, controlling for confounding variables as covariates (e.g., team ability, stadium capacity and occupancy, fitness data and number of substitutions made before and after the COVID-19 break). Future studies should seek empirical validation for our findings by applying multivariate analyses, including away performance-related statistics, and expanding the comparison between pre- and post-COVID-19 periods to different European and non-European domestic leagues, international club tournaments (e.g., UEFA Champions League) and national team events.

CONCLUSIONS

This was one of the first studies to examine the impact of COVID-19 measures on the HA and home teams' performances across five European domestic leagues. Contrasting with what was speculated by international football-related media, the HA did not disappear in European professional football. Apart from the German Bundesliga, the post-COVID-19 HA effect remained stable or even increased in the other leagues. Nevertheless, the performances of home teams were influenced by the COVID-19 conditions, specifically by the absence of crowds in stadiums, since decreases in goal-scoring actions and tackles were common across almost every league. Finally, whereas the role of crowd support seems to be susceptible to the context characteristics in which football is played, the augmented interference of coaches in players' behaviours during "ghost matches", along with the inclusion of five substitutions and "cooling breaks", might have diluted the crowd effect on the expression of HA.

Conflict of Interest Declaration

No potential conflict of interest was reported by the authors.

REFERENCES

1. Marca y CIHEFE. Home advantage becomes a non-factor in Germany Marca in English. Available online https://www.marca.com/futbol/bundesliga/2020/05/25/5eca9ab022601d904c8b4600.html (accessed on May 25, 2020)
2. Jamieson JP. Home field advantage in athletics: A meta-analysis. J Appl Soc Psychol. 2010;40(7):1819–1848. https://doi.org/10.1111/j.1559-1816.2010.00641.x
3. Pollard R. Home advantage in football: A current review of an unsolved puzzle. Open Sports Sci J. 2008;1:12–14. https://doi.org/10.2174/1875399X00801010012
4. Pollard R, Prieto J, Gómez M-Á. Global differences in home advantage by country, sport and sex. Int J Perform Anal Sport. 2017;17(4):586–599. https://doi.org/10.1080/24748668.2017.1372164
5. Pollard R. Home advantage in soccer: A retrospective analysis. J Sports Sci. 1986;4(3):237–248. https://doi.org/10.1080/02640418608732122
6. Almeida CH, Volossovitch A. Home advantage in Portuguese football: Effects of level of competition and mid-term trends. Int J Perform Anal Sport. 2017;17(3):244–255. https://doi.org/10.1080/24748668.2017.1331574
7. Lago-Peñas C, Gómez-Ruano M, Megias-Navarro D, Pollard R. Home advantage in football: Examining the effect of scoring first on match outcome in the five major European leagues. Int J Perform Anal Sport. 2016;16(2):411–421. https://doi.org/10.1080/24748668.2016.11868897
8. Leite W, Pollard R. International comparison of differences in home advantage between level 1 and level 2 of domestic football leagues. Ger J Exerc Sport Res. 2018;48(2):271–277. https://doi.org/10.1007/s12662-018-0507-2
9. Matos R, Amaro N, Pollard R. How best to quantify home advantage in team sports: An investigation involving male senior handball leagues in Portugal and Spain. Rev Int de Cienc del Deporte. 2020;16(59):12–23. https://doi.org/10.5232/ricyde2020.05902
10. Pollard R, Armatas V. Factors affecting home advantage in football World Cup qualification. Int J Perform Anal Sport. 2017;17(1–2):121–135. https://doi.org/10.1080/24748668.2017.1304031
11. Anderson M, Wolfson S, Neave N, Moss M. Perspectives on the home advantage: A comparison of football players, fans and referees. Psychol Sport Exerc. 2012;13(3):311–316. https://doi.org/10.1016/j.psychsport.2011.11.012
12. Staufenbiel K, Lobinger B, Strauss B. Home advantage in soccer – A matter of expectations, goal settings and tactical decisions of coaches? J Sports Sci. 2015;33(11):1932–1941. https://doi.org/10.1080/02640414.2015.1018929
13. Goumas C. Modelling home advantage in sports: A new approach. Int J Perform Anal Sport. 2013;13(2):428–439. https://doi.org/10.1080/24748668.2013.11868659
14. Ponzo M, Scoppa V. Does the home advantage depend on crowd support? Evidence from same-stadium derbies. J Sports Econom. 2018;19(4):562–582. https://doi.org/10.1177/1527002516665794
15. Belchior CA. Fans and match results: Evidence from a natural experiment in Brazil. J Sports Econom. 2020;21(7):663–687. https://doi.org/10.1177/1527002520930812
16. Pollard R, Pollard G. Home advantage in soccer: A review of its existence and causes. Int J Soccer Sci. 2005;3(1):28–38.
17. Pollard R, Pollard G. Long-term trends in home advantage in professional team sports in North America and England (1876–2003). J Sports Sci. 2005;23(4):337–350. https://doi.org/10.1080/02640410400021559
18. van de Ven N. Supporters are not necessary for the home advantage: Evidence from same-stadium derbies and games without an audience. J Appl Soc Psychol. 2011;41(12):2785–2792. https://doi.org/10.1111/j.1559-1816.2011.00865.x
19. Pollard R, Gómez MÁ. Home advantage in football in South-West Europe: Long term trends and regional variation. Eur J Sport Sci. 2009;9(6):341–352. https://doi.org/10.1080/17461390903009133
20. Gómez MÁ, Gómez-Lopez M, Lago C, Sampaio J. Effects of game location and final outcome on game-related statistics in each zone of the pitch in professional football. Eur J Sport Sci. 2012;12(5):393–398. https://doi.org/10.1080/17461391.2011.566373

21. Lago-Peñas C, Lago-Ballesteros J. Game location and team quality effects on performance profiles in professional soccer. J Sport Sci Med. 2011; 10(3):465–471.
22. Tucker W, Mellalieu DS, James N, Taylor BJ. Game location effects in professional soccer: A case study. Int J Perform Anal Sport. 2005;5(2):23–35. https://doi.org/10.1080/24748668.2005.11868325
23. Fisher K, Haucap J. Does crowd support drive the home advantage in professional soccer? Evidence from German Ghost Games during the COVID-19 pandemic. DICE Discussion Paper. 2020;344. Düsseldorf Institute for Competition Economics (DICE), Düsseldorf. http://hdl.handle.net/10419/222278
24. Liu H, Hopkins W, Gómez MA, Molinuevo JS. Inter-operator reliability of live football match statistics from OPTA Sportsdata. Int J Perform Anal Sport. 2013;13(3):803–821. https://doi.org/10.1080/24748668.2013.11868690
25. Field A. Discovering statistics using IBM SPSS Statistics. 5th Ed. London: SAGE Publications Ltd; 2018.
26. Cohen J. A power primer. Psychol Bull. 1992;112(1):155–159. https://doi.org/10.1037/0033-2909.112.1.155
27. Marques AC. Estimating quality in home advantage and competitive balance in the Portuguese football league. J Quant Anal Sports. 2009;5(3). https://doi.org/10.2202/1559-0410.1139
28. Almeida CH, Ferreira AP, Volossovitch A. Effects of match location, match status and quality of opposition on regaining possession in UEFA Champions League. J Hum Kinet. 2014;41:203–214. https://doi.org/10.2478/hukin-2014-0048
29. Jacklin PB. Temporal changes in home advantage in English football since the Second World War: What explains improved away performance? J Sports Sci. 2005;23(7):669–679. https://doi.org/10.1080/0264041040002194