The influence of spectators on home advantage and referee bias in national teams matches: insights from UEFA Nations League

Fabrizio Sors, Michele Grassi, Tiziano Agostini and Mauro Murgia

Department of Life Sciences, University of Trieste, Trieste, Italy

ABSTRACT

The home advantage and the subconscious referee bias regularly occur in professional sports, particularly in association football. The matches played behind closed doors in spring and summer 2020 highlighted that the crowd support is one of the main factors contributing to both phenomena in domestic leagues. The aim of the present study was to investigate whether the same applies also to national teams matches, given the different impact of the other factors determining the home advantage in such matches. To this purpose, the 2018–19 and the 2020–21 editions of the UEFA Nations League – 133 matches each – were analysed, the former played in front of spectators while the latter with no or limited attendance. In particular, we examined a set of indicators of home advantage (match outcome, points, goals scored, ball possession, total shots, shots on goal, corner kicks) and of referee bias (fouls, yellow cards, red cards, penalty kicks, extra time), controlling for the FIFA World Ranking points and the number of time zones crossed. Comparing home and away teams on these parameters within each edition, we observed the occurrence of both phenomena in 2018-19, as well as their absence in 2020-21. Moreover, the comparison between the two editions revealed a significant reduction of both phenomena. The results indicate that spectators have a decisive role in contributing to both the home advantage and the referee bias in national teams matches.

The *home advantage* is a phenomenon regularly occurring in professional sports (Jamieson, 2010; Schwartz & Barsky, 1977). It consists in the fact that, in competitions with a balanced home/away schedule, the proportion of points won at home (out of all points earned both at home and away) is normally higher than the proportion of points won away (Pollard, 1986, 2006a). This phenomenon and the factors determining it have been widely studied, and they are summarised in a theoretical model proposed by Courneya and Carron (1992; see also Carron et al., 2005). In this model, the game location (home/away) determines four game location factors (crowd, learning, travel and rules). These factors would influence the so called "critical psychological states" of all actors involved in a game (competitors, coaches and officials). In turn, such psychological

states would influence the "critical behavioral states" of the same actors, and consequently their performance outcomes. Similarly, Pollard (2006a, 2008) provided a model that describes a set of factors that directly and indirectly influence the home advantage: crowd support, travel, familiarity, referee bias, territoriality, tactics, and psychological factors.

Among the abovementioned factors, the crowd support is commonly thought as the most influential one, and empirical evidence actually highlighted its relevance (Dohmen, 2008; Downward & Jones, 2007; Goumas, 2014a; Page & Page, 2010; Pettersson-Lidbom & Priks, 2010; Picazo-Tadeo et al., 2017; Ponzo & Scoppa, 2018). Indeed, on the one hand the majority of spectators supports the home team and boo the away team, differently influencing the psychological states of home/away athletes and their consequent behavior. On the other hand, spectators would also exert a certain degree of social pressure on officials, inducing them to make more favorable decisions for the home team, thus contributing to enhance the home advantage (e.g., Boyko et al., 2007; but see also Riedl et al., 2015). The latter phenomenon is known as *subconscious referee bias*, and refers to the less strict treatment that referees subconsciously reserve to the home teams compared to the away teams (Dohmen & Sauermann, 2016; Goumas, 2014a; Unkelbach & Memmert, 2010). Due to its relevance in affecting competitions, the referee bias has also been studied as a phenomenon per se, in the broader domain of referees' decision-making processes (Balmer et al., 2007; Buraimo et al., 2010, 2012; Dawson et al., 2007; Nevill et al., 2002; Sors et al., 2019).

Both home advantage and referee bias have been widely studied in association football. In particular, as concerns the home advantage, it was consistently documented both in domestic leagues (Leite & Pollard, 2018; Pollard & Gomez, 2009, 2014) and in continental competitions for clubs (Goumas, 2014b; Pollard, 1986, 2006a). Other studies revealed that such an advantage does not materialise itself only in terms of points gained, but also in terms of some performance-related statistics, that is, goals scored, percentage of ball possession, number of shots and corner kicks (Armatas & Pollard, 2014; Lago-Peñas et al., 2017; Lago-Peñas & Lago-Ballesteros, 2011; Liu et al., 2019). As concerns the referee bias, it was observed that referees usually penalise less the home teams in terms of number of fouls, yellow cards, red cards, and penalty kicks (Armatas & Pollard, 2014; Balmer et al., 2007; Downward & Jones, 2007; Goumas, 2014a; Liu et al., 2019; Nevill et al., 2002; Pettersson-Lidbom & Priks, 2010; Sutter & Kocher, 2004; Unkelbach & Memmert, 2010). Also, referees tend to add less or more extra time depending on whether at 90' the home team is leading or trailing by one goal, respectively (Garicano et al., 2005; Sutter & Kocher, 2004).

Strong evidence in favor of the hypothesis that the crowd support is one of the main factors contributing to both the home advantage and the referee bias in football domestic leagues was provided by the matches played behind closed doors in the last portion of the 2019–20 season (spring and summer 2020), due to the COVID-19 pandemic. Indeed, various studies observed that, in these matches, both phenomena decreased with respect to previous seasons' matches played in presence of spectators. In particular, a systematic review by Leitner et al. (2022) showed that the majority of studies – 20 out of 26 – highlighted a significant decrease of the home advantage (Bryson et al., 2021; Correia-Oliveira & Andrade-Souza, 2021; Cross & Uhrig, 2020; Cueva, 2020; Dilger & Vischer, 2020; Endrich & Gesche, 2020; Ferraresi & Gucciardi, 2020, 2021; Fischer & Haucap, 2021; Hill

& Van Yperen, 2021; Jimenez Sanchez & Lavin, 2021; Konaka, 2021; Leitner & Richlan, 2021; Link & Anzer, 2021; McCarrick et al., 2021; Rovetta & Abate, 2021; Santana et al., 2021; Scoppa, 2021; Sors et al., 2021; Tilp & Thaller, 2020), while only six studies did not reveal a similar effect (Almeida & Werlayne, 2021; Benz & Lopez, 2021; Krawczyk & Strawinski, 2020; Matos et al., 2021; Ramchandani & Millar, 2021; Wunderlich et al., 2021), reasonably due to sampling and other methodological choices (e.g., leagues, number of matches, periods that were compared). Although all these studies could only rely on samples with unbalanced home-away schedules (a well-known methodological issue in this research field), the majority of them controlled for the relative strength of the teams playing against each other (e.g., correcting analyses for the points per match ratio), thus reducing the influence of the unbalanced schedules. Overall, Leitner and colleagues concluded that the absence of crowd support has a considerable impact on the home advantage. As for the referee bias, some of the studies included in the review by Leitner and colleagues – as well as other studies specifically focused on this phenomenon – consistently found that it did not occur in absence of spectators (e.g., Bryson et al., 2021; Endrich & Gesche, 2020; Scoppa, 2021; Sors et al., 2021).

The vast majority of studies on the home advantage concern club teams, either in domestic leagues or in continental competitions. However, national teams matches could provide further insights on this phenomenon. Indeed, in national teams matches the difference between home and away teams for two game locations factors described by Courneya and Carron (1992) – namely, learning and travel – is reduced compared to club matches. Specifically, as for learning factors, the familiarity with the physical characteristics of the playing facility is "flattened", since the majority of players of both home and away teams might be unfamiliar with the pitch and the stadium. As for travel factors, players of both home and away teams have to travel, so the fatigue might be somehow comparable across teams (especially for relatively short trips), and routine habits are disrupted for the players of both teams as well.

To the best of our knowledge, only a few studies investigated the home advantage in national teams matches. Brown and colleagues (2002) examined the thirty-two teams that participated in the 1998 World Cup; in particular, the researchers analysed all FIFA recognised matches played by these teams in the period between 1987 and the end of the World Cup itself. They observed a home winning percentage greater than 60%. These data were re-analysed by Pollard (2006a) considering also ties, yielding a home advantage of 59%, "but even the reliability of this figure is questionable due to the highly unbalanced schedule of games used in the analysis" (Pollard, 2006a, p. 173). A more recent study by Pollard and Armatas (2017) focused on the group stages of qualification for the 2006, 2010 and 2014 World Cups, thus considering matches with a fully balanced home-away schedule. The authors observed an overall home advantage of 61.8%, as well as five variables having a significant effect on home points, that is, the difference in FIFA ranking between teams, crowd size, altitude of the stadium, number of time zones crossed, and continental confederation. In particular, the lowest home advantage was observed in Europe (UEFA confederation), equal to 55.9%, while for the other confederations it ranged from the 58.8% of Asia (AFC) to the 69.6% of Africa (CAF). The lower value for Europe is due to the fact that, as qualification groups are created on the basis of the dissimilarity in the FIFA ranking, "many games are between teams of greatly differing ability. This lack of competitive balance in football has been shown to dilute HA because strong teams are

likely to defeat weak teams both at home and away and thus mask any HA" (Pollard & Armatas, 2017, pp. 129–130). Interestingly, Pollard and Armatas (2017) found no evidence of a higher home advantage for the Balkan countries, a phenomenon typically observed in club teams matches and known as "Balkan effect" (e.g., Pollard, 2006b; Pollard & Gomez, 2014). In addition, Pollard and Armatas' study is the only one that investigated the referee bias in national teams matches, reporting a higher number of penalties and red cards against the away teams.

The chance to study a relatively large number of matches between European national teams of comparable strength with a balanced home/away schedule is given by the most recent official competition introduced by UEFA, that is, the Nations League. Indeed, for its inaugural edition (2018-19), the fifty-five European national teams were divided into four leagues according to their UEFA coefficient at the time, with the highest-ranked teams to play in League A, and so on. Then, within each league, a draw determined groups of three or four teams; for all groups, a home-and-away round-robin schedule was used, plus a "final four" knockout stage to assign the title (UEFA, 2017). For the second edition (2020-21), the teams were allocated to the four leagues based on the overall ranking of the inaugural edition; the number of teams per league was rearranged bringing to an increase in the number of matches, yet the same schedule format was maintained (UEFA, 2019).

In light of the format of the UEFA Nations League, as well as of the attendance limitations during the 2020–21 edition due to the continuation of the COVID-19 pandemic (UEFA, 2020a, 2020b), the aim of the present study is to investigate the influence of spectators on home advantage and subconscious referee bias in matches between national teams of comparable strength, in which learning and travel factors are comparable for home and away players. Notably, this is the first comparison ever between two complete editions of the same competition, one with spectators and the other one with no or severely limited attendance. Based on previous studies, the hypotheses are as follows: (a) in the 2018–19 edition (with spectators), both home advantage and referee bias would emerge; (b) in the 2020–21 edition (with limited attendance), both phenomena would be weak, or would not occur at all; (c) comparing the two editions, a significant reduction of both phenomena would emerge in the 2020–21 edition.

Methods

Sample

The 2018–19 edition of the Nations League consisted of 142 matches, but nine matches were not considered in the present study (five because they were played behind closed doors – due to punishments against the home team – plus the four of the final knockout stage). Thus, the final sample for the 2018–19 edition consisted of 133 matches; the attendance ranged from a minimum of 736 people to a maximum of 81,392 people, with an average of 17,592 ± 18,787.

The 2020–21 edition consisted of 164 matches; after preliminarily excluding nine matches (five because they were played on neutral venues, plus again the four of the final knockout stage), 155 matches remained to be potentially considered. In light of the aim of the study, it was decided to consider the matches behind closed doors and

those with less attendance than the abovementioned minimum of the 2018–19 edition. Thus, the final sample for the 2020–21 edition consisted of 133 matches[1]: 115 were played in total absence of spectators, while in the remaining 18 ones the attendance ranged from a minimum of 60 people to a maximum of 696 people, with an average of 299 ± 214.

Variables

The variables included in the analyses are reported in Table 1. The home advantage and referee bias variables were based on matches' data, which were retrieved from the UEFA website. As for control variables, the FIFA World Ranking points for each team were retrieved from the FIFA website (on August 16th, 2018 for the 2018–19 edition, and on July 16th, 2020 for the 2020–21 edition), while the number of time zones crossed was counted based on the map on www.timeanddate.com/time/map Furthermore, two other variables were included only in some additional analyses: the attendance (both absolute number of spectators and percentage with respect to the total capacity of the stadium) exclusively for the 2018–19 edition; the geographical location (Balkan area[2] vs. rest of Europe).

Statistical analysis

Preliminarily, as for the Home advantage and Referee bias variables, we computed the within matches difference: *Home team – Away team*, and calculated adjusted scores by correcting for the influence of the Control variables, obtained by means of a regression analysis performed on each raw difference score.

Analyses by single edition. We firstly describe the global pattern of effects separately for the 2018–19 and for the 2020–21 editions. To this purpose, we conducted a one-sample *t*-test on the average difference (formally equivalent to a paired-samples t-test), imposing a one-sided null-hypothesis since there were prior hypotheses specifying the expected direction of the effect (i.e., a positive Home – Away average difference for the Home advantage variables, and a negative average difference for the Referee bias variables). The assumption of normality was checked computing asymmetry and kurtosis indices; deviation from normality due to the presence of outliers was investigated by using box-plots. Given the excessively skewed and kurtotic (> 1) distributions for some variables, as well as the presence of some outliers, we opted for a robust *t*-test, based on linear robust estimation algorithm (M-estimation method) and implemented in the MASS software package for the R statistical framework (R Core Team, 2020; Venables & Ripley, 2002). Additionally, only for the 2018–19 edition, we checked the importance of the impact of

Table 1. Variables considered and their grouping.

Group of variables	Variables
Control variables	FIFA World Ranking points, Number of time zones crossed
Home advantage variables	Match outcome, Home advantage for points, Goals scored, Ball possession, Total shots, Shots on goal, Corner kicks
Referee bias variables	Fouls, Yellow cards[a], Red cards[b], Penalty kicks, Extra time[c]

[a]Both first and second yellow cards, issued against players on the pitch within the end of the match.
[b]Both double-yellow and straight red cards, issued against players on the pitch within the end of the match.
[c]Minutes of extra time played in the second half of matches whose result at 90′ had a difference of 1 goal.

spectators by regressing the Home – Away difference on the number of spectators (absolute number and percentage with respect to the total capacity of the stadium) for the home advantage variables and for the referee bias variables.

Comparison between the two editions. As for the match outcome variable, we compared the distribution of the three mutually exclusive outcomes – home victory, tie, and away victory – observed in the 2020–21 edition with the expected frequencies observed in the 2018–19 edition, by means of a Chi-square test. Based on the same data, we also calculated the home advantage for points in the two editions. Moreover, we investigated the effect of the interaction between the Home/Away factor (2 levels; within-matches) and the edition factor (2 levels; between-matches) by means of a robust two samples *t*-test comparing the average *Home–Away* within match difference between the two editions. We performed this test (formally equivalent to the 2X2 interaction term in a mixed-model ANOVA) for all the home advantage and referee bias variables. In light of the hypothesised decrease of the home advantage and referee bias in the 2020–21 edition, the *t*-tests were one-sided. For the various t-tests carried out, we quantified the effect size using the Cohen's *d*, with thresholds of 0.2, 0.5, and 0.8 indicating small, medium, and large effects, respectively.

Additional analyses: the Balkan effect. As previous studies on club teams identified a particularly strong effect of spectators in matches played in the Balkan area (so-called "Balkan effect"; e.g., Pollard, 2006b; Pollard & Gomez, 2014), we additionally tested whether a similar effect occurred for national teams as well. To this purpose, we conducted a robust two-samples t-test contrasting the Home – Away average difference calculated from matches with teams from the Balkan area playing at home (25 matches in the 2018–19 edition; 26 matches in the 2020–21 edition) against all the other matches.

For all statistical analyses, we explored complementary results based on Bayesian inference, especially in case of non-significant results potentially flawed by low-powered tests. Particularly, the strength of the support to the null hypothesis was quantified by the null/alternative Bayes Factor (BF_{01}), a continuous statistical index whose values greater than 1 provide evidence in favor of H0 over H1 (Jarosz & Wiley, 2014; Morey & Rouder, 2018). Although the BF_{01} is a continuous measure, common labels for the strength of the evidence supporting the null hypothesis are as follows: [1-3] = "Anecdotal", [3-10] = "Substantial", [10-30] = "Strong", [30-100] = "Very strong", and [$BF_{01} > 100$] = "Decisive" (Jarosz & Wiley, 2014).

Results

The results of the within match differences between the Home and Away team for all the home advantage and referee bias variables, along with the results of one-sample *t*-tests and Bayesian inference, are reported in Table 2. The linear regression slopes used to correct the raw difference scores for the FIFA World Ranking points were statistically significant for all the variables ($p < .01$) but three, i.e., Extra time (2018-19 edition, $p = .969$; 2020–21 edition, $p = .476$), Penalty kicks (2018-19 edition, $p = .532$; 2020–21 edition, $p = .602$), and Red cards (2018-19 edition, $p = .081$; 2020–21 edition, $p = .659$). As for the correction for the number of time zones crossed, the linear regression slopes used to correct the raw difference scores were not statistically significant for all the variables ($p > .109$).

Table 2. Statistical tests between home and away teams for home advantage and referee bias variables.

	Descriptive Statistics				Robust one-sample *t*-tests [a]					Support to H0[a]	
	Home		Away								
	M	SD	M	SD	Est. Diff.	*t*	df	*p*	*d*	BF_{01}	Labels
2018–19 edition (with spectators)											
Goals scored	1.47	1.31	0.98	1.12	0.469	3.141	132	***	0.27	0.06	
Ball possession	51.70	11.31	48.30	11.54	3.545	1.657	132	*	0.15	1.20	Anecdotal
Total shots	13.60	6.96	10.92	5.47	2.082	2.227	132	*	0.25	0.09	
Shots on goal	4.68	2.90	3.31	2.28	1.316	3.798	132	***	0.35	0.01	
Corner kicks	5.49	3.38	4.32	3.23	1.073	2.356	132	**	0.22	0.27	
Fouls	13.42	3.66	13.54	4.81	0.072	0.156	132	ns	0.02	8.34	Substantial
Yellow cards	1.73	1.25	2.35	1.42	−0.646	−4.245	132	***	−0.37	0.01	
Red cards	0.04	0.21	0.10	0.31	−0.003	−1.225	132	ns	−0.16	1.02	Anecdotal
Pen. kicks against	0.13	0.36	0.11	0.32	−0.000	−0.121	132	ns	−0.03	13.43	Strong
Extra time	4.42	1.06	5.05	1.81	−0.466	−1.375	43[b]	ns	−0.43	0.76	
2020–21 edition (limited attendance)											
Goals scored	1.24	1.22	1.08	1.03	0.093	0.753	132	ns	0.10	5.82	Substantial
Ball possession	51.26	9.63	48.74	9.43	2.209	1.290	132	ns	0.13	3.18	Substantial
Total shots	11.54	5.12	10.16	4.67	1.175	1.530	132	ns	0.17	1.64	Anecdotal
Shots on goal	4.05	2.62	3.46	2.10	0.427	1.325	132	ns	0.17	1.59	Anecdotal
Corner kicks	4.48	2.31	4.27	2.73	0.352	0.953	132	ns	0.05	11.21	Strong
Fouls	13.72	4.01	14.03	3.73	−0.213	−0.458	132	ns	−0.06	10.09	Strong
Yellow cards	2.20	1.33	2.19	1.28	−0.033	−0.224	132	ns	−0.01	19.38	Strong
Red cards	0.15	0.38	0.09	0.29	0.001	0.720	132	ns	0.13	11.29	Strong
Pen. kicks against	0.14	0.41	0.19	0.45	−0.001	−0.973	132	ns	−0.08	8.01	Substantial
Extra time	4.74	1.01	4.88	1.18	−0.294	−1.137	60[c]	ns	−0.13	4.13	Substantial

[a]Calculated considering a one-sided null hypothesis.

[b, c]For this variable it was run an independent samples (robust) *t*-test with equal variances assumed on the matches whose result at 90′ had a difference of 1 goal (2018-19 edition: 29 home team winning vs. 16 away team winning; 2020–21 edition: 26 home team winning vs. 36 away team winning).

Notes: M, Mean; SD, Standard Deviation; Est. Diff., Robust estimates of Home – Away differences; BF_{01} = Bayes Factor, Null/Alternative likelihood ratios. *P*-values legend: $p < .05$, *; $p < .01$, **; $p < .001$, ***; $p > .05$, ns.

The 2018–19 edition. In the 2018–19 edition, all the performance-related home advantage variables were statistically different between home and away teams, with a positive estimated difference in line with the hypothesised direction, and an average effect size Cohen's $d = .25$. The Bayesian inference supported the existence of a positive average difference between home and away teams performance (all $BF_{01}s \leq .27$) for all the performance-related variables but Ball possession, although for this variable the support to the null hypothesis was only anecdotal ($BF_{01} = 1.20$). Regression analyses showed that when the absolute number of spectators increases, the positive difference between home and away teams significantly increases for Shots on goal ($\beta = .167$, $df = 131$, $t = 1.895$, $p = .030$, BF_{01}=.98). No significant effects were found using the percentage of spectators with respect to the total stadium capacity.

As for the referee bias, in the 2018–19 edition the largest differences were observed for Yellow cards, Red cards and Extra time variables, with a negative estimated difference in line with the hypothesised direction. The average effect size for these three variables was Cohen's $d = -.32$, but the effect was statistically significant for the Yellow cards only. The Bayesian inference supported the existence of a negative average difference between home and away teams for Yellow cards ($BF_{01} = .01$) and Extra time ($BF_{01} = .76$), but not for Red cards ($BF_{01} = 1.02$). No referee bias emerged for Fouls and Penalty kicks. As for the regression analyses, when the absolute number of spectators increases, the

minutes of extra time played in the second half of matches whose result at 90' had a difference of 1 goal in favour of the away team significantly increase ($\beta = .713$, $df = 14$, $t = 3.854$, $p = .001$, $BF_{01} = .03$). No significant effects emerged using the percentage of spectators with respect to the total stadium capacity.

The 2020–21 edition. In the 2020–21 edition, differences between home and away teams for all the performance-related home advantage variables were not statistically significant, and the average effect size was Cohen's $d = .12$. As for the Bayesian inference, all BF_{01} indices were greater than 1, thus supporting the null hypothesis. In particular, the support to the absence of a difference was substantial ($BF_{01} > 3$) for Goals scored and Ball possession, and strong ($BF_{01} > 10$) for Corner kicks. For all the referee bias variables, there were no statistically significant differences between home and away teams, with substantial to strong support to the null hypothesis (average $BF_{01} = 10.58$). Furthermore, the average effect size corresponded to a very small value of Cohen's $d = -.03$.

Comparison between the 2018–19 and the 2020–21 editions. In the 2020–21 edition, the observed frequencies for home victories (n = 49), ties (n = 35) and away victories (n = 49) were significantly different from the expected frequencies based on the 2018–19 edition (n = 64, n = 31, n = 38, respectively; χ^2 (2, N = 266) = 7.216, $p = .027$). In particular, the observed frequency of home victories was significantly lower (standardised Pearson residual = -2.97, $p = .001$; $BF_{01} = .18$) and the observed frequency of away victories was significantly higher (standardised Pearson residual = 2.83, $p = .002$; $BF_{01} = .62$), compared to the distribution of the 2018–19 edition. As for the home advantage for points, Figure 1 clearly shows how the value dramatically dropped from 60.6% in the 2018–19 edition to 50% in the 2020–21 edition.

The results of the two-sample *t*-tests comparing the average Home – Away within match differences between the two editions further supported the decrease of the home advantage and referee bias in the 2020–21 edition. In particular, the reduction of the performance-related home advantage was statistically significant for Goals scored

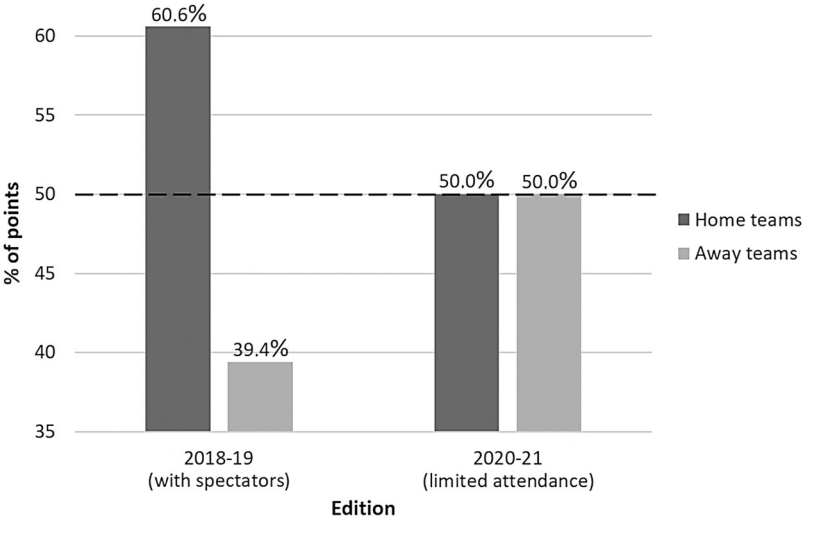

Figure 1. Home advantage for points in the two editions of the UEFA Nations League.

(Estimated difference = -.361, t = -1.935, df = 264, p = *.027*, Cohen's d = -.19; BF_{01} = 1.29, Support to H0 = "Anecdotal") and for Shots on goal (Estimated difference = -.881, t = −1.865, df = 264, p = *.032*, Cohen's d = -.21; BF_{01} = 1.03, Support to H0 = "Anecdotal"). As for the referee bias, the negative bias toward the away teams decreased for Yellow cards (Estimated difference = .621, t = 2.901, df = 264, p = *.002*, Cohen's d = .37; $1/BF_{01}$ = 21.26, Support to H1 = "Strong") and Red cards (Estimated difference = .113, t = 2.322, df = 264, p = *.01*, Cohen's d = .28; $1/BF_{01}$ = 3.38, Support to H1 = "Substantial").

Additional results: the Balkan effect. In the 2018–19 edition, when a Balkan team was playing at home, the Home – Away difference in Ball possession increased significantly (Home-Away within match average difference: Balkan = 13.22%, SD = 17.00; Non-Balkan = 1.14%, SD = 22.83; robust two-samples t = 2.336, df = 131, p = *.011*, Cohen's d = .60, $1/BF_{01}$ = 3.62, Support to H1 = "Substantial"). Moreover, when a Balkan team was playing at home, the Home – Away difference in Fouls decreased significantly (Home-Away within match average difference: Balkan = −3.69, SD = 5.40; Non-Balkan = .70, SD = 5.19; robust two-samples t = −3.704, df = 131, p < *.001*, d = -.83, $1/BF_{01}$ = 114.25, Support to H1 = "Decisive"), indicating a higher number of fouls awarded against the away team. Instead, in the 2020–21 edition, the presence of a home team from the Balkans did not produce any statistically significant change in the Home – Away differences for all home advantage and referee bias variables considered. Finally, although the frequencies of games with Balkan teams playing at home are very low (n = 25 in 2018-19; n = 26 in 2020-21), the descriptive statistics indicate a home advantage for points of 72.60% in the 2018–19 edition, and of 45.83% in the 2020–21 edition.

Discussion

The matches played behind closed doors in spring and summer 2020 clearly highlighted that the crowd support is one of the main factors contributing to both the home advantage and the referee bias in football domestic leagues (see the review by Leitner et al., 2022). The aim of the present study was to investigate whether the same applies also to national teams matches, in a competition where teams playing against each other are of comparable strength, and learning and travel factors are comparable for home and away players. To this purpose, the 2018–19 and the 2020–21 editions of the UEFA Nations League were analysed, the former played in front of spectators while the latter with no or severely limited attendance. We hypothesised that, in the 2018–19 edition, both home advantage and referee bias would emerge, while in the 2020–21 edition, both phenomena would be weak or even absent, thus decreasing compared to the previous edition. Overall, the results support these hypotheses, thus suggesting that spectators – or their absence – can significantly contribute to determine the dynamics and the outcomes also of national teams matches, in which learning and travel factors have a reduced impact.

In the 2018–19 edition (with spectators), a home advantage for points of 60.6% was observed. This value is higher than the 55.9% observed by Pollard and Armatas (2017) in the European group stages of qualification for the World Cups: this can be attributed to the fact that all Nations League matches were played between teams of comparable strength, thus home advantage was not diluted like in matches between teams of greatly differing ability. As for the performance-related parameters, all of them were

significantly higher for the home teams, thus highlighting a home advantage also in terms of performances. Moreover, a higher absolute number of spectators was positively associated with an increase in the number of shots on goal by the home team; instead, no similar effects emerged considering the stadium fill percentage as a predictor. This might be due to the high variability of stadiums' capacity in the Nations League: indeed, there were small stadiums (e.g., 5,000 seats) that can reach high fill percentages with a very small absolute number of spectators, and big stadiums (e.g., 70,000 seats) that can have lower fill percentages with a much higher absolute number of spectators. As for the referee bias, the yellow cards against the away teams were more numerous than those against the home teams, and the Bayesian analysis revealed a similar trend against the away teams also for extra time: these results do confirm the occurrence of the bias, but for different sanctions than those observed by Pollard and Armatas (2017), that is, penalty kicks and red cards. Another interesting result is the association between the absolute number of spectators and the increase of extra time when the home team is trailing by one goal. Taken together, these results confirm that the presence of spectators affects referees' decisions.

In the 2020–21 edition (with no or limited attendance), no home advantage was observed, as highlighted both by the 50% of points gained at home (thus the same as away), and by the absence of any significant difference between home and away teams in terms of performance-related parameters. These results seem to support the facts that: (i) crowd support is one of the main factors contributing to the home advantage also in national teams matches; and (ii) in such matches, the difference between home and away teams for learning and travel factors is actually reduced compared to club matches (otherwise, a certain degree of home advantage should have occurred). As for the referee bias, no significant difference between home and away teams emerged for any of the considered variables, thus highlighting an unbiased behavior of the referees in absence of spectators.

A direct comparison between matches' outcomes in the two editions revealed that their distributions significantly differ between each other, with less home victories and more away victories in the 2020–21 edition as compared to the 2018–19 one. This indicates that the home advantage percentages deriving from these distributions – 60.6% for 2018–19 versus 50% for 2020–21 – are substantially different, thus supporting the hypothesised reduction of home advantage for points in absence (or limited presence) of spectators. Moreover, a significant reduction of the home advantage was observed also in terms of goals scored and shots on goal. Finally, the negative bias toward away teams significantly decreased for both yellow and red cards, thus also the hypothesised reduction of referee bias in absence (or limited presence) of spectators – and of the social pressure they exert – is supported.

Other interesting results were provided by the control variables. The FIFA World Ranking points had a significant influence on all performance-related parameters and also on two referee sanctions (fouls and yellow cards); these results are in line with the findings by Pollard and Armatas (2017), and highlight that even small differences in teams strength not only affect their performances, but also seems to influence some referee decisions. Instead, the number of time zones crossed did not have an effect on any variable, and this result does not support Pollard and Armatas' findings: this might be due to the fact that they considered all continents, while we considered exclusively

Europe. Moreover, this result seems to support that, in national teams matches (in Europe), travelling does not affect the away teams more than the home ones.

Further interesting results emerged investigating the possible occurrence of the Balkan effect. In the 2018–19 edition, we found a home advantage of 72.60% for Balkan teams; moreover, a Balkan effect also emerged in terms of both ball possession and fouls. This evidence is in contrast with Pollard and Armatas (2017), possibly due to the balanced groups composition characterising the Nations League. Instead, in the 2020–21 edition, the home advantage for Balkan teams dropped below 50% (45.83%), and for none of the examined variables a Balkan effect emerged. Overall, these results indicate that not only the mere presence of spectators contributes to home advantage and referee bias, but also the "intensity" of the support seems to have an important role.

It is worth noting that, differently from domestic leagues where a certain degree of home advantage was still present even behind closed doors (e.g., Bryson et al., 2021; Jimenez Sanchez & Lavin, 2021; Scoppa, 2021; Sors et al., 2021), with national teams it completely disappeared in absence, or very limited presence, of spectators. As mentioned in the introduction, in national teams matches the familiarity with the playing facility is "flattened", and players of both home and away teams have to travel and their routine habits are disrupted. Considering that the fourth game location factor described by Courneya and Carron (1992), i.e., rules, is not relevant for association football (as there are no rules favoring the home team, like for example last line change in hockey), it is possible to claim that the results of the present study bring new support to the validity of their model. Indeed, in absence of the first factor (crowd), and with the other two ones (learning and travel) having a similar impact on both home and away teams, it was reasonable to expect a (very) small home advantage: the data revealed its complete absence. As for the referee bias, the results of the present study further confirm the relevant role of spectators in determining it, also in national teams matches.

Paradoxically, both the strengths and limitations of the present study lie in its sample. Indeed, on the one hand, the Nations League offers a unique and "experimentally precious" set of matches between European national teams of comparable strength with a balanced home/away schedule, where also learning and travel factors are somehow naturally controlled for; on the other hand, the numerosity is (relatively) limited. However, this is the first comparison ever between two complete editions of the same competition, one with spectators and the other one with no or severely limited attendance. A countercheck of the robustness of the observed results will be provided in any case by the next edition of the Nations League (2022-23), be it with spectators – as desirable – or without them.

To conclude, in the present study we observed the occurrence of both home advantage and subconscious referee bias in national teams matches played in the presence of spectators (UEFA Nations League 2018-19), as well as the absence of both phenomena in matches played in absence, or very limited presence, of spectators (UEFA Nations League 2020-21). These results highlight that the crowd support has a decisive role in determining both phenomena in national teams matches, in which learning and travel effects are comparable for home and away teams. From a practical perspective, the present results provide national federations with some elements to consider when deciding the stadiums where to play home matches. In particular, they should be aware that maximising the attendance of (home) spectators in absolute (but not in fill percentage) terms could promote an advantage, especially in matches against a team of similar

strength. In addition to the capacity, another useful criterion to choose the stadium could be the familiarity of home/away players with it, namely choosing a stadium where most of the home (but not the away) players normally play with their club teams.

Notes

1. In the 22 excluded matches, the attendance ranged from a minimum of 812 people to a maximum of 17,753 people, with an average of 4,405±4,316.
2. Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Greece, Kosovo, (North) Macedonia, Montenegro, Serbia, and Turkey.

Acknowledgments

We thank Elisa Gariuolo for her precious contribution to data collection.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

The authors received no specific funds for the present study.

Ethical statement

The study reported in the present article does not involve any human participants.

Data availability statement

The raw data are provided as supplemental material.

ORCID

Fabrizio Sors http://orcid.org/0000-0002-3803-1772
Michele Grassi http://orcid.org/0000-0001-9512-1427
Tiziano Agostini http://orcid.org/0000-0003-0105-2999
Mauro Murgia http://orcid.org/0000-0002-8450-1157

References

Almeida, C. H., & Werlayne, S. L. (2021). Professional football in times of COVID-19: Did the home advantage effect disappear in European domestic leagues? *Biology of Sport*, *38*(4), 693–701. https://doi.org/10.5114/biolsport.2021.104920

Armatas, V., & Pollard, R. (2014). Home advantage in Greek football. *European Journal of Sport Science*, *14*(2), 116–122. https://doi.org/10.1080/17461391.2012.736537

Balmer, N. J., Nevill, A. M., Lane, A. M., Ward, P., Williams, A. M., & Fairclough, S. H. (2007). Influence of crowd noise on soccer refereeing consistency in soccer. *Journal of Sport Behavior*, *30*(2), 130–145.

Benz, L. S., & Lopez, M. J. (2021). Estimating the change in soccer's home advantage during the COVID-19 pandemic using bivariate poisson regression. *AStA – Advances in Statistical Analysis*, https://doi.org/10.1007/s10182-021-00413-9

Boyko, R. H., Boyko, A. R., & Boyko, M. G. (2007). Referee bias contributes to home advantage in English premiership football. *Journal of Sports Sciences*, *25*(11), 1185–1194. https://doi.org/10.1080/02640410601038576

Brown, T. D., Van Raalte, J. L., Brewer, B. W., Winter, C. R., Cornelius, A. E., & Andersen, M. B. (2002). World Cup soccer home advantage. *Journal of Sport Behavior*, *25*(2), 134–144.

Bryson, A., Dolton, P., Reade, J. J., Schreyer, D., & Singleton, C. (2021). Causal effects of an absent crowd on performances and refereeing decisions during COVID-19. *Economics Letters*, *198*, 109664. https://doi.org/10.1016/j.econlet.2020.109664

Buraimo, B., Forrest, D., & Simmons, R. (2010). The 12th man? Refereeing bias in English and German soccer. *Journal of the Royal Statistical Society: Series A (Statistics in Society)*, *173*(2), 431–449. https://doi.org/10.1111/j.1467-985X.2009.00604.x

Buraimo, B., Simmons, R., & Maciaszczyk, M. (2012). Favoritism and referee bias in European soccer: Evidence from the Spanish league and the UEFA champions league. *Contemporary Economic Policy*, *30*(3), 329–343. https://doi.org/10.1111/j.1465-7287.2011.00295.x

Carron, A. V., Loughhead, T. M., & Bray, S. R. (2005). The home advantage in sport competitions: Courneya and carron's (1992) conceptual framework a decade later. *Journal of Sports Sciences*, *23*(4), 395–407. https://doi.org/10.1080/02640410400021542

Correia-Oliveira, C. R., & Andrade-Souza, V. A. (2021). Home advantage in soccer after the break due to COVID-19 pandemic: Does crowd support matter? *International Journal of Sport and Exercise Psychology*, https://doi.org/10.1080/1612197x.2021.1934716

Courneya, K. S., & Carron, A. V. (1992). The home advantage in sport competitions: A literature review. *Journal of Sport and Exercise Psychology*, *14*(1), 13–27. https://doi.org/10.1123/jsep.14.1.13

Cross, J., & Uhrig, R. (2020). Do fans impact sports outcomes? A COVID-19 natural experiment. *SSRN*, https://doi.org/10.2139/ssrn.3705085

Cueva, C. (2020). Animal spirits in the beautiful game. Testing social pressure in professional football during the COVID-19 lockdown. *OSF*, https://doi.org/10.31219/osf.io/hczkj

Dawson, P., Dobson, S., Goddard, J., & Wilson, J. (2007). Are football referees really biased and inconsistent? Evidence on the incidence of disciplinary sanction in the English Premier league. *Journal of the Royal Statistical Society: Series A (Statistics in Society)*, *170*(1), 231–250. https://doi.org/10.1111/j.1467-985X.2006.00451.x

Dilger, A., & Vischer, L. (2020). *No home bias in ghost games*. ECONSTOR. http://hdl.handle.net/10419/223208

Dohmen, T., & Sauermann, J. (2016). Referee bias. *Journal of Economic Surveys*, *30*(4), 679–695. https://doi.org/10.1111/joes.12106

Dohmen, T. J. (2008). The influence of social forces: Evidence from the behavior of football referees. *Economic Inquiry*, *46*(3), 411–424. https://doi.org/10.1111/j.1465-7295.2007.00112.x

Downward, P., & Jones, M. (2007). Effects of crowd size on referee decisions: Analysis of the FA Cup. *Journal of Sports Sciences*, *25*(14), 1541–1545. https://doi.org/10.1080/02640410701275193

Endrich, M., & Gesche, T. (2020). Home-bias in referee decisions: Evidence from "ghost matches" during the Covid19-pandemic. *Economics Letters*, *197*, 109621. https://doi.org/10.1016/j.econlet.2020.109621

Ferraresi, M., & Gucciardi, G. (2020). *Team Performance and Audience: Experimental Evidence from the Football Sector*. EconPapers. https://EconPapers.repec.org/RePEc:ipu:wpaper:94

Ferraresi, M., & Gucciardi, G. (2021). Who chokes on a penalty kick? Social environment and individual performance during COVID-19 times. *Economic Letters*, *203*, 109868. https://doi.org/10.1016/j.econlet.2021.109868

Fischer, K., & Haucap, J. (2021). Does crowd support drive the home advantage in professional soccer? Evidence from German ghost games during the COVID-19 pandemic. *Journal of Sports Economics*, *22*(8), 982–1008. https://doi.org/10.1177/15270025211026552

Garicano, L., Palacios-Huerta, I., & Prendergast, C. (2005). Favoritism under social pressure. *Review of Economics and Statistics*, *87*(2), 208–216. https://doi.org/10.1162/0034653053970267

Goumas, C. (2014a). Home advantage and referee bias in European football. *European Journal of Sport Science*, *14*(sup1), S243–S249. https://doi.org/10.1080/17461391.2012.686062
Goumas, C. (2014b). Tyranny of distance: Home advantage and travel in international club football. *International Journal of Performance Analysis in Sport*, *14*(1), 1–13. https://doi.org/10.1080/24748668.2014.11868698
Hill, Y., & Van Yperen, N. W. (2021). Losing the home field advantage when playing behind closed doors during COVID-19: Change or chance? *Frontiers in Psychology*, *12*, 658452. https://doi.org/10.3389/fpsyg.2021.658452
Jamieson, J. P. (2010). The home field advantage in athletics: A meta-analysis. *Journal of Applied Social Psychology*, *40*(7), 1819–1848. https://doi.org/10.1111/j.1559-1816.2010.00641.x
Jarosz, A. F., & Wiley, J. (2014). What are the odds? A practical guide to computing and reporting Bayes factors. *Journal of Problem Solving*, *7*(1), 2–9. https://doi.org/10.7771/1932-6246.1167
Jimenez Sanchez, A., & Lavin, J. M. (2021). Home advantage in European soccer without crowd. *Soccer & Society*, *22*(1-2), 152–165. https://doi.org/10.1080/14660970.2020.1830067
Konaka, E. (2021). Home advantage of European major football leagues under COVID-19 pandemic. arXiv. https://arxiv.org/abs/2101.00457v2
Krawczyk, M., & Strawinski, P. (2020). *Home advantage revisited. Did COVID level the playing fields?* EconPapers. https://EconPapers.repec.org/RePEc:war:wpaper:2020-36
Lago-Peñas, C., Gomez, MÁ, & Pollard, R. (2017). Home advantage in elite soccer matches. A transient effect? *International Journal of Performance Analysis in Sport*, *17*(1-2), 86–95. https://doi.org/10.1080/24748668.2017.1304024
Lago-Peñas, C., & Lago-Ballesteros, J. (2011). Game location and team quality effects on performance profiles in professional soccer. *Journal of Sports Science & Medicine*, *10*(3), 465–471. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3737821/
Leite, W., & Pollard, R. (2018). International comparison of differences in home advantage between level 1 and level 2 of domestic football leagues. *German Journal of Exercise and Sport Research*, *48*(2), 271–277. https://doi.org/10.1007/s12662-018-0507-2
Leitner, M. C., Daumann, F., Follert, F., & Richlan, F. (2022). The cauldron has cooled down: A systematic literature review on home advantage in football during the COVID-19 pandemic from a socio-economic and psychological perspective. *Management Review Quarterly*, https://doi.org/10.1007/s11301-021-00254-5
Leitner, M. C., & Richlan, F. (2021). No fans–no pressure: Referees in professional football during the COVID-19 pandemic. *Frontiers in Sports and Active Living*, *3*, 720488. https://doi.org/10.3389/fspor.2021.720488
Link, D., & Anzer, G. (2021). How the COVID-19 pandemic has changed the game of soccer. *International Journal of Sports Medicine*, *43*(1), 83–93. https://doi.org/10.1055/a-1518-7778
Liu, T., García-De-Alcaraz, A., Zhang, L., & Zhang, Y. (2019). Exploring home advantage and quality of opposition interactions in the Chinese football super league. *International Journal of Performance Analysis in Sport*, *19*(3), 289–301. https://doi.org/10.1080/24748668.2019.1600907
Matos, R., Monteiro, D., Antunes, R., Mendes, D., Botas, J., Clemente, J., & Amaro, N. (2021). Home-Advantage during COVID-19: An analysis in Portuguese football league. *International Journal of Environmental Research and Public Health*, *18*(7), 3761. https://doi.org/10.3390/ijerph18073761
McCarrick, D., Bilalic, M., Neave, N., & Wolfson, S. (2021). Home advantage during the COVID-19 pandemic: Analyses of European football leagues. *Psychology of Sport and Exercise*, *56*, 102013. https://doi.org/10.1016/j.psychsport.2021.102013
Morey, R. D., & Rouder, J. N. (2018). BayesFactor: Computation of Bayes Factors for Common Designs. R package version 0.9.12-4.2. https://CRAN.R-project.org/package=BayesFactor
Nevill, A. M., Balmer, N. J., & Williams, A. M. (2002). The influence of crowd noise and experience upon refereeing decisions in football. *Psychology of Sport and Exercise*, *3*(4), 261–272. https://doi.org/10.1016/S1469-0292(01)00033-4
Page, K., & Page, L. (2010). Alone against the crowd: Individual differences in referees' ability to cope under pressure. *Journal of Economic Psychology*, *31*(2), 192–199. https://doi.org/10.1016/j.joep.2009.08.007

Pettersson-Lidbom, P., & Priks, M. (2010). Behavior under social pressure: Empty Italian stadiums and referee bias. *Economics Letters*, *108*(2), 212–214. https://doi.org/10.1016/j.econlet.2010.04.023
Picazo-Tadeo, A. J., González-Gómez, F., & Guardiola, J. (2017). Does the crowd matter in refereeing decisions? Evidence from Spanish soccer. *International Journal of Sport and Exercise Psychology*, *15* (5), 447–459. https://doi.org/10.1080/1612197X.2015.1126852
Pollard, R. (1986). Home advantage in soccer: A retrospective analysis. *Journal of Sports Sciences*, *4*(3), 237–248. https://doi.org/10.1080/02640418608732122
Pollard, R. (2006a). Home advantage in soccer: Variations in its magnitude and a literature review of the inter-related factors associated with its existence. *Journal of Sport Behavior*, *29*(2), 169–189.
Pollard, R. (2006b). Worldwide regional variations in home advantage in association football. *Journal of Sports Sciences*, *24*(3), 231–240. https://doi.org/10.1080/02640410500141836
Pollard, R. (2008). Home advantage in football: A current review of an unsolved puzzle. *The Open Sports Sciences Journal*, *1*(1), 12–14. https://doi.org/10.2174/1875399X00801010012
Pollard, R., & Armatas, V. (2017). Factors affecting home advantage in football World Cup qualification. *International Journal of Performance Analysis in Sport*, *17*(1-2), 121–135. https://doi.org/10.1080/24748668.2017.1304031
Pollard, R., & Gomez, M. A. (2009). Home advantage in football in South-West Europe: Long-term trends, regional variation, and team differences. *European Journal of Sport Science*, *9*(6), 341–352. https://doi.org/10.1080/17461390903009133
Pollard, R., & Gomez, M. A. (2014). Components of home advantage in 157 national soccer leagues worldwide. *International Journal of Sport and Exercise Psychology*, *12*(3), 218–233. https://doi.org/10.1080/1612197X.2014.888245
Ponzo, M., & Scoppa, V. (2018). Does the home advantage depend on crowd support? Evidence from same-stadium derbies. *Journal of Sports Economics*, *19*(4), 562–582. https://doi.org/10.1177/1527002516665794
Ramchandani, G., & Millar, R. (2021). Investigating the "twelfth Man" effect in five European domestic football leagues: A COVID-19 induced natural experiment. *Journal of Global Sport Management*, https://doi.org/10.1080/24704067.2021.1951614
R Core Team. (2020). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/
Riedl, D., Strauss, B., Heuer, A., & Rubner, O. (2015). Finale furioso: Referee-biased injury times and their effects on home advantage in football. *Journal of Sports Sciences*, *33*(4), 327–336. https://doi.org/10.1080/02640414.2014.944558
Rovetta, A., & Abate, A. (2021). The impact of cheering on sports performance: Comparison of serie A Statistics before and during COVID-19. *Cureus*, *13*(8), e17382. https://doi.org/10.7759/cureus.17382
Santana, H. A. P., Bettega, O. B., & Dellagrana, R. A. (2021). An analysis of Bundesliga matches before and after social distancing by COVID-19. *Science and Medicine in Football*, *5*(sup1), 17–21. https://doi.org/10.1080/24733938.2021.1903540
Schwartz, B., & Barsky, S. F. (1977). The home advantage. *Social Forces*, *55*(3), 641–661. https://doi.org/10.2307/2577461
Scoppa, V. (2021). Social pressure in the stadiums: Do agents change behavior without crowd support? *Journal of Economic Psychology*, *82*, 102344. https://doi.org/10.1016/j.joep.2020.102344
Sors, F., Grassi, M., Agostini, T., & Murgia, M. (2021). The sound of silence in association football: Home advantage and referee bias decrease in matches played without spectators. *European Journal of Sport Science*, *21*(12), 1597–1605. https://doi.org/10.1080/17461391.2020.1845814
Sors, F., Tomé Lourido, D., Parisi, V., Santoro, I., Galmonte, A., Agostini, T. A., & Murgia, M. (2019). Pressing crowd noise impairs the ability of anxious basketball referees to discriminate fouls. *Frontiers in Psychology*, *10*, 2380. https://doi.org/10.3389/fpsyg.2019.02380
Sutter, M., & Kocher, M. G. (2004). Favoritism of agents–the case of referees' home bias. *Journal of Economic Psychology*, *25*(4), 461–469. https://doi.org/10.1016/S0167-4870(03)00013-8
Tilp, M., & Thaller, S. (2020). COVID-19 has turned home-advantage into home-disadvantage in the German soccer bundesliga. *Frontiers in Sports and Active Living*, *2*, 593499. https://doi.org/10.3389/fspor.2020.593499

Union of European Football Associations – UEFA. (2017, September 20). *UEFA Nations League format confirmed*. UEFA.com. https://www.uefa.com/uefanationsleague/news/0253-0d81ea357a91-d294c1ca65c7-1000–uefa-nations-league-format-confirmed/?referrer=%2Fnews%2Fnewsid%3D2501767

Union of European Football Associations – UEFA. (2019, September 24). *Format change for 2020/21 UEFA Nations League*. UEFA.com. https://www.uefa.com/insideuefa/about-uefa/news/0255-0e99f578e557-a64ea0ed91c9-1000–format-change-for-2020-21-uefa-nations-league/

Union of European Football Associations – UEFA. (2020a, August 19). *UEFA meets general secretaries of member associations*. UEFA.com. https://www.uefa.com/insideuefa/mediaservices/mediareleases/news/0260-102b2c2ace44-637fb4a08f89-1000/

Union of European Football Associations – UEFA. (2020b, October 1). *UEFA allows return of fans at maximum 30% of capacity pending approval of local authorities*. UEFA.com. https://www.uefa.com/insideuefa/mediaservices/mediareleases/news/0262-1081de31d4dc-eb42ed3fe9e8-1000–return-of-fans-at-maximum-30-of-capacity-pending-local-approval/

Unkelbach, C., & Memmert, D. (2010). Crowd noise as a cue in referee decisions contributes to the home advantage. *Journal of Sport and Exercise Psychology*, *32*(4), 483–498. https://doi.org/10.1123/jsep.32.4.483

Venables, W. N., & Ripley, B. D. (2002). *Modern Applied Statistics with S* (4th Ed). Springer.

Wunderlich, F., Weigelt, M., Rein, R., & Memmert, D. (2021). How does spectator presence affect football? Home advantage remains in European top-class football matches played without spectators during the COVID-19 pandemic. *PLoS ONE*, *16*(3), e0248590. https://doi.org/10.1371/journal.pone.0248590