The sound of silence in association football: Home advantage and referee bias decrease in matches played without spectators

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Abstract

Home advantage and referee bias are two well-documented phenomena in professional sports, especially in association football. Among the various factors determining them, the crowd noise is considered as one of the most relevant; yet, the majority of previous studies could not isolate its contribution. The possibility to study the effects of crowd noise – or, better, of its absence – in an ecological context was given by the matches played behind closed doors due to the COVID-19 pandemic. The aim of the present study was to investigate whether home advantage and referee bias still occur (and to what extent) during matches played in absence of spectators. In particular, the focus was on the first and second divisions of the top four countries in the UEFA ranking, for a total of 841 matches behind closed doors. The hypothesis was that, if these phenomena are largely due to the effect of crowd noise, the absence of spectators should reduce their occurrence. Various parameters for each of the two phenomena were considered, and the analyses revealed a reduction of home advantage and the absence of referee bias. The results bring further support to the claim that, among all the factors contributing to home advantage and referee bias, crowd noise has a relevant role. Thus, spectators can significantly contribute to determine the dynamics and the outcomes of professional football matches.

Keywords: Home advantage; referee bias; football; crowd noise; social pressure

It is well known that playing at home represents an advantage in professional sports. In scientific literature, this phenomenon is referred to as *home advantage*, and consists in a higher chance to win a game for the home team compared to the away team (Pollard, 1986; 2008). Another effect broadly investigated in sports sciences is the *referee bias*, which refers to the referees' decision bias in favor of the home team (Nevill, Balmer & Williams, 2002; Goumas, 2014). These two phenomena are related to each other, being the referee bias one of the potential factors contributing to the home advantage (Goumas 2014; Pollard, 1986). These phenomena have been extensively studied in a wide range of sports (Carron, Loughhead, & Bray, 2005; Courneya & Carron, 1992; Dohmen & Sauermann, 2016; Nevill & Holder, 1999). In the last 30 years, great attention has been dedicated to home advantage and referee bias in association football, where they have been consistently reported.

The first phenomenon examined in the present study is the home advantage, widely investigated by Pollard and colleagues (Pollard, 1986; Pollard & Gomez, 2009; Pollard & Gomez, 2014a; Pollard & Gomez, 2014b; Pollard & Pollard, 2005). Typically, home advantage is calculated as proposed by Pollard (1986), that is, as the percentage of points gained at home out of the total points gained both at home and away. For knock-out matches, the same formula can be applied to the number of goals scored (e.g., Pollard & Pollard, 2005). The home advantage has been observed in numerous studies: in national leagues of different countries worldwide (Leite & Pollard, 2018; Pollard & Gomez, 2014b), in international competitions (Goumas, 2017; Pollard & Pollard, 2005), and in both genders (Pollard & Gomez, 2014a). In addition to the consistent evidence regarding points and goals, some studies reported an advantage for the home teams also for performance-related statistics, such as a higher percentage of ball possession (Lago & Martin, 2007; Lago-Peñas & Lago-Ballesteros, 2011; Lago-Peñas et al., 2017; Liu et al., 2019), as well as a higher number of total shots (Armatas & Pollard, 2012; Lago-Peñas & Lago-Ballesteros, 2011; Lago-Peñas et al., 2017; Liu et al., 2019) and corner kicks (Liu et al., 2019; Tucker et al., 2005).

The home advantage has been attributed to several factors (Pollard, 1986; Pollard & Gomez, 2014b), which normally co-occur and consequently are difficult to disentangle. One of the most apparent factors is the crowd noise, with the majority of spectators supporting the home team and booing the away team. Another important variable is the referee bias, with referees biased in favor of home team when making decisions. Other factors include the fatigue of travelling, the familiarity with conditions such as pitch

dimensions and the pre-match routine (staying at one's own home vs. in a hotel), as well as several psychological factors, such as the different attitudes and thoughts of home vs. away players and coaches, due to the awareness of the home advantage (for a review, see Pollard, 2006).

As for the crowd noise, two studies are particularly interesting. The first one investigated the home advantage in 20 matches played behind closed doors in Italy in 2007 (van de Ven, 2011). Home advantage was maintained, even in absence of spectators. The author also reports the statistics of 64 same-stadium derbies: despite the higher number of supporters of the "home" team, no home advantage emerged; thus, the author concludes that crowd noise is not necessary for home advantage to occur. In contrast, a more recent work (Ponzo & Scoppa, 2018) analyzed 128 same-stadium derbies and found that home advantage was still present, attributing this effect to the crowd noise. Given the limited number of studies and the conflicting results, it is not clear how strong is the contribution of crowd noise in determining the home advantage.

The second phenomenon investigated in the present study, unavoidably related with crowd noise and home advantage, is the referee bias. There is a vast literature showing that referees tend to favor the home team (Dohmen & Sauermann, 2016). Specifically, evidence of referee bias has been reported in terms of number of fouls (Armatas & Pollard, 2012; Balmer et al., 2007; Liu et al., 2019; Nevill et al., 2002), yellow cards (Armatas & Pollard, 2012; Balmer et al., 2007; Downward & Jones, 2007; Goumas, 2014; Liu et al., 2019; Sutter & Kocher, 2004; Unkelbach & Memmert, 2010), red cards (Armatas & Pollard, 2012; Liu et al., 2019; Pettersson-Lidbom & Priks 2010), and penalty kicks (Armatas & Pollard 2012; Liu et al., 2019). Moreover, referees add more or less extra time to the matches, depending on whether the home team is behind or ahead by one goal (Garicano et al., 2005; Sutter & Kocher, 2004).

One of the most widely accepted explanations for the referee bias is the social pressure exerted by the crowd, given that the majority of spectators are typically supporters of the home team. In this regard, several studies investigated the crowd factors potentially increasing the social pressure on referees (Buraimo et al. 2010; 2012; Downward & Jones, 2007; Page & Page, 2010). According to Goumas (2014), the factor determining the referee bias is crowd density; indeed, after controlling for it, crowd size and proximity were not significant.

Some laboratory studies experimentally manipulated crowd noise to investigate its effects on referees' decisions. Nevill et al. (2002) reported that referees observing videos of tackles with crowd noise made more favorable decisions to the home team than to the away team by around 15%, compared to referees observing the same videos without crowd noise. Analogously, the referee bias was also observed in another laboratory experiment by Unkelbach & Memmert (2010). On the one hand, these studies provide important evidence in fully controlled laboratory conditions; on the other hand, they lack of ecological validity. In this regard, a natural experiment on the behavior of referees in absence of crowd noise is reported by Pettersson-Lidbom & Priks (2010), based on the same 20 matches behind closed doors studied by van de Ven (2011) for home advantage. The authors compared the decisions made by referees in terms of fouls, yellow cards and red cards during these matches with the decisions made in the other matches of the same season played with spectators. Significant differences emerged, towards a reduction of the referee bias in matches played behind closed doors. To the best of our knowledge, these results are the only empirical evidence on actual matches played without spectators, thus – also given the limited number of observations – further research would be necessary to confirm these findings.

To sum up, previous studies indicate that crowd noise may be one of the main factors determining home advantage and referee bias during football matches. Despite the large amount of research on these phenomena, only few studies could disentangle the contribution of crowd noise from that of other factors during actual matches. The possibility to study the effects of crowd noise – or, better, of its absence – in an ecological context was given by the matches played behind closed doors due to the COVID-19 pandemic. The aim of the present study is to investigate whether home advantage and referee bias still occur (and to what extent) during matches played in absence of spectators. The hypothesis is that, if these phenomena are largely due to crowd noise, the absence of spectators should reduce their occurrence.

Methods

Sample

The matches considered in the present study are all the regular season's ones played behind closed doors in the 2019-2020 season, in the first and second divisions of the top four countries in the UEFA

ranking, that is, Spain (1st), England (2nd), Germany (3rd), and Italy (4th). In total, the sample consists of 841 matches, distributed as reported in Table 1. Moreover, as a comparison for the distribution of home victories, draws, and away victories (and consequently for the home advantage for points), we considered the last three complete seasons with spectators (2016-2017, 2017-2018, and 2018-2019) of the same leagues.

Variables

The data for matches behind closed doors were retrieved from the official websites of the considered leagues and/or other trusted websites (e.g., BBC for Championship, as on the official website matches statistics are not reported). Instead, the data of the previous seasons were retrieved from the archive of soccerway.com.

Control variable. To allow for a fair interpretation of the outcomes, it was necessary to check for the relative strength of the teams playing at home and away. In this regard, the following data were considered:

- points per match: ratio between points earned and matches played in the current league by each team, until the match in question;

Home advantage variables. The potential occurrence of a home advantage for both outcome and performance-related parameters was investigated, comparing home and away teams:

- match outcome: home victory, draw, or away victory;

- home advantage for points: the percentage of points earned by home teams out of the total number of points earned by both home and away teams;

- goals: number of goals scored;

- ball possession (%): the duration when a team is in possession of the ball as a proportion of total duration when the ball is in play;

- shots: number of attempts to score a goal, either on or off target;

- corner kicks: number of corner kicks.

Referee bias variables. The potential occurrence of a referee bias for the following parameters was investigated, comparing home and away teams (all parameters refer to penalties against a team):

- fouls: number of infringements penalized as fouls by the referee;

- yellow cards: number of yellow cards – both first and second ones – issued by the referee against players on the pitch (i.e., not on the bench) within the end of the match (i.e., not after the final whistle);

- red cards: number of red cards – both double-yellow and straight ones – issued by the referee against players on the pitch within the end of the match (same as for yellow cards);

- penalty kicks: number of penalty kicks awarded by the referee;

- extra time: minutes of extra time played in the second half (for matches whose result at 90' had a difference of 1 goal).

Statistical analysis

As for the match outcome variable, we used the Chi-square test to examine the observed counts of the three mutually exclusive outcomes – home victory, draw, away victory. In particular, we tested whether the distribution of the outcomes of matches played behind closed doors in the 2019-2020 season significantly differ from the expected frequencies calculated based on the last three complete seasons with spectators (2016-2017, 2017-2018, and 2018-2019) of the same leagues. Based on the same data, we consequently calculated the home advantage for points (points HA%) in the matches played behind closed doors in the 2019-2020 season, and in the last three complete seasons with spectators.

As for all the other variables (points per match, goals, ball possession, shots, corner kicks, fouls, yellow and red cards, penalty kicks, and extra time), we computed the differences within each match conducting then a t-test on the average of the differences. Preliminarily, to correct for the influence of the points per match variable, we performed a regression analysis on each raw difference score to obtain a correction factor for each match. Then, we calculated adjusted scores by adding or subtracting the

contribution of the control variable. The assumption of normality was checked computing asymmetry and kurtosis indices, along with the result of Kolmogorov-Smirnov tests ($p > .05$).

For each of the aforementioned analyses, we also planned a Bayesian analysis computing the *null/alternative* Bayes Factor (BF_{01}) with values greater than 1 indicating how many times the data are in favor of a null-hypothesis compared to the alternative hypothesis (Jarosz & Wiley, 2014; Morey & Rouder, 2018). The strength of the support to the null hypothesis was described adopting the terms: "Anecdotal" – BF_{01} = 1-3, "Substantial" – BF_{01} = 3-10, "Strong" – BF_{01} = 10-30, "Very strong" – BF_{01} = 30-100, and "Decisive" – BF_{01} >100 (Jarosz & Wiley, 2014).

Furthermore, since with large sample sizes the effect can be statistically significant but practically irrelevant, we performed the equivalence analysis (Lakens, 2017a; Lakens, Scheel, Isager, 2018) testing the null hypothesis that a difference is at least as extreme as a boundary value expressed in standardized effect size (Cohen's *d*). If the null hypothesis can be rejected in two one-sided tests (TOST procedure; Lakens, 2017b), it should be concluded that the difference between home and away teams is statistically equivalent. For the present study, we set the equivalence benchmarks to a small effect size (Cohen's $d \pm .2$).

All the statistical analyses were performed using R (R Core Team, 2019); p-values reported are based on a two-tailed alternative hypothesis.

Results

Observed frequencies for home victories, draws and away victories (see table 2) were significantly different from the expected frequencies calculated based on the last three complete seasons with spectators (Chi-square = 12.16, df = 2, $p = .002$). In particular, the observed frequency of home victories was significantly lower (standardized Pearson residual = -2.83, $p = .002$; $BF_{01} = .94$) and the observed frequency of away victories was significantly higher (standardized Pearson residual = 4.40, $p < .001$; $BF_{01} = .03$), compared to the expected distribution. As for the home advantage for points, Figure 1 clearly shows how the sample value of "points HA%" = 54.68 falls far below the value of 59.82, calculated from the last three complete seasons with spectators.

The results for all the other variables are reported in Table 3. The points per match control variable did not statistically differ between home and away teams (not significant p-values on paired t-tests), with strong support for the null hypothesis ($BF_{01} > 10$) and a statistically equivalent difference, as shown by the two significant p-values on the TOST results. Linear regression slopes used to correct variables' raw difference scores were statistically significant for all the variables ($p < .001$) but red cards ($p = .351$) and penalty kicks ($p = .948$).

For the performance-related home advantage variables, mixed results emerged. Ball possession and corner kicks were not statistically different between home and away teams, although the support for the null hypothesis was only anecdotal. Differences were also statistically equivalent as shown by the two significant p-values on the TOST results. The goals and shots variables were statistically different between home and away teams, and the TOST procedure yielded nonsignificant results on the upper bound (set to Cohen's $d \geq .2$). The equivalence test was therefore nonsignificant, and we cannot reject the null hypothesis that the true effect size is at least small.

For all the referee bias variables, there were no statistically significant differences between home and away teams, with substantial to decisive support to the null hypothesis. Furthermore, the differences between home and away teams were also statistically equivalent, with the only exception of the extra time variable.

Discussion

In sports, the higher chance for the home team to win a game compared to the away team (*home advantage*) and the bias of referees' decisions in favor of the home team (*referee bias*) are two well-known, interrelated phenomena attributed to several factors. Among these factors, crowd noise would have an important role. In the present study, we examined 841 matches played behind closed doors due to the COVID-19 pandemic, and investigated whether home advantage and referee bias still occurred. We hypothesized that, if these phenomena are mainly due to crowd noise, the absence of spectators would reduce their occurrence. The results confirmed our hypothesis, suggesting that the home advantage was reduced and the referee bias did not occur.

As for the home advantage, data revealed that there was still a higher percentage of points gained by the home teams (54.68%), but this advantage was lower than the average value observed in the last three complete seasons of the same leagues played with spectators (59.82%). Indeed, when analyzing how data distributed across the three possible outcomes (home victory, draw, away victory) in matches played without spectators, it was observed a lower number of home victories and a higher number of away victories, compared to the expected distribution based on matches of previous seasons played with spectators. As for the performance-related parameters, no home advantage was found for ball possession and corner kicks, while a significant difference emerged in favor of the home teams for goals and total number of shots. It is noteworthy that in the latter cases, despite the significant differences, the observed effect sizes were small. Overall, it seems that a certain degree of home advantage is still present even without spectators, likely due to other factors such as fatigue of travelling, familiarity with the pitch, and pre-match routines (Pollard, 2006). It is also evident that the advantage for the home team is reduced by the absence of spectators, whose influence remains a factor considerably contributing to this phenomenon.

Only few studies addressed the specific contribution of crowd noise to the home advantage in football. Van de Ven (2011) examined twenty matches played behind closed doors and found that home advantage still occurred; his observation was further supported by the lack of the home advantage in same-stadium derbies, in which the higher number of supporters for the "home" team was not sufficient to determine the home advantage. Ponzo & Scoppa (2018) examined a higher number of same-stadium derbies, and found that the home advantage did occur, thus attributing this result to the crowd noise. The results of the present study are partly consistent with Van de Ven (2011), but seems more in line with the observations by Ponzo & Scoppa (2018). Indeed, similar to Van de Ven (2011), our evidence indicates that home advantage is still present in matches played behind closed doors; however similar to Ponzo & Scoppa (2018), we conclude that the spectators' influence constitutes an important factor contributing to home advantage to a significant extent.

As for the referee bias, the analyses of the present study did not reveal any referee bias in favor of the home teams in terms of fouls, yellow cards, red cards, penalty kicks and extra time. The Bayes factor values indicate that the null-hypothesis is the most likely one, with decisive evidence for fouls, very strong evidence for red cards, and substantial evidence for penalty kicks and extra time. As for yellow cards, the

Bayes factor value indicates a decisive support to the null hypothesis; this is particularly interesting since the referee bias for this variable is perhaps the most consistent result observed in matches with spectators (Armatas & Pollard, 2012; Balmer et al., 2007; Downward & Jones, 2007; Goumas, 2014; Liu et al., 2019; Sutter & Kocher, 2004; Unkelbach & Memmert, 2010). The absence of a referee bias in favor of the home teams for yellow cards indicates that this factor might be particularly affected by the presence/absence of social pressure by spectators.

The role of social pressure on referee bias was experimentally investigated by Nevill et al. (2002) and Unkelbach & Memmert (2010), showing that the presence/absence of crowd noise in laboratory settings influenced referees' decisions. Pettersson-Lidbom & Priks (2010) brought further evidence, finding that the referee bias did not occur in twenty matches played behind closed doors. The data of the present study support this observation, showing consistent results in all considered variables and in a much larger sample of matches. These outcomes, together with those of Pettersson-Lidbom & Priks (2010), represent a countercheck of the nature of referee bias: this phenomenon seems to be mainly evoked by the spectators' pressure. Thus, it seems that crowd noise (and its related social pressure) plays a central role in the occurrence of the referee bias.

The home advantage and referee bias are logically interrelated, since the occurrence of the latter would contribute to the occurrence of the former. The actual existence of this association and its strength have been largely debated (Boyko, Boyko & Boyko, 2007; Johnston, 2008; Page & Page, 2010). In the present study, it can be observed that the absence of spectators considerably affects both effects. We can speculate that the absence of crowd noise has a direct effect on the referee bias (due to the absence of social pressure), and both a direct and an indirect effect on the home advantage: the direct effect would be due to the lack of support for the home team (and of booing for the away team); the indirect effect would be due to the lack of the referee bias.

In our opinion, the main strength of the present study is the numerosity of analyzed matches without spectators. Indeed, although our sample is smaller than those of previous studies on home advantage and referee bias in normal conditions on complete seasons, it is much larger than those of any other published study analyzing the same phenomena in matches behind closed doors (i.e., Pettersson-Lidbom & Priks 2010;

van de Ven, 2011). Also, with respect to the latter studies, the present one is not limited to a single country/league, as it includes matches of different national leagues. A limitation of the present study is that we did not consider some factors that might contribute to home advantage and referee bias, such as travel fatigue for the former (Pollard & Pollard, 2005) and within-game events for the latter (Buraimo et al., 2010; 2012). Another important aspect that was not possible to consider is referees' anxiety, which is known to have a role in their decisions (Balmer et al., 2007; Sors et al., 2019).

To conclude, in the present study we found a reduced home advantage and no referee bias in football matches played behind closed doors. This outcome brings further support to the claim that, among all the factors contributing to these phenomena, crowd noise has a relevant role. The majority of previous studies could not isolate its effect or did it only partially. Only few studies analyzed matches played behind closed doors, with small samples and reporting results not always in line with each other. Compared to these studies, the present one could rely on a much higher number of matches played behind closed doors, providing coherent results between the two phenomena and reconciling results of previous literature, which appeared contradictory. Overall, it is highlighted that spectators can significantly contribute to determine the dynamics and the outcomes of professional football matches.

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Ethical statement

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

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Data availability statement

The raw data are provided as supplemental material.

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Table 1

Distribution of the matches constituting the sample

Country	League	Matches
Spain	LaLiga	111
	LaLiga 2	120[a]
England	Premier League	92
	Championship	108
Germany	Bundesliga	83
	2. Bundesliga	81
Italy	Serie A	129[b]
	Serie B	117
TOTAL		841

Notes. [a] The matches Rayo Vallecano-Albacete BP and RC Deportivo-CF Fuenlabrada were excluded from the sample: for the former, the first half was played on 15/12/2019 with spectators, while the second half on 10/06/2020 behind closed doors; the latter was postponed twice as a total of 28 members of CF Fuenlabrada team and staff tested positive for COVID-19, and was finally played before all of the players could recover. [b] The match Sampdoria-Genoa was excluded from the sample as it was a same-stadium derby.

Table 2

Comparison between expected and observed frequencies of matches outcomes

	Complete seasons with spectators from 2016-17 to 2018-19			
	Home victories	Draws	Away victories	Total
Frequencies	4337	2599	2628	9564
Prob. (%)	45.35	27.17	27.48	100.00
	Matches without spectators in 2019-20			
	Home victories	Draws	Away victories	Total
Observed	349	216	276	841
Expected	381.37	228.54	231.09	841.00
Pearson's residuals (*Z*)	-2.83**	-1.12	4.40***	$\chi^2 = 12.16$**

Notes. The section above shows the frequencies of home victories, draws, and away victories in the last three complete seasons with spectators. In the section below, based on percentages retrieved from matches with spectators, the expected frequencies were calculated and compared with the observed frequencies of matches played without spectators.

*** $p < .001$; ** $p < .01$; * $p < .05$.

Table 3

Statistical tests between home and away teams for control, home advantage, and referee bias variables

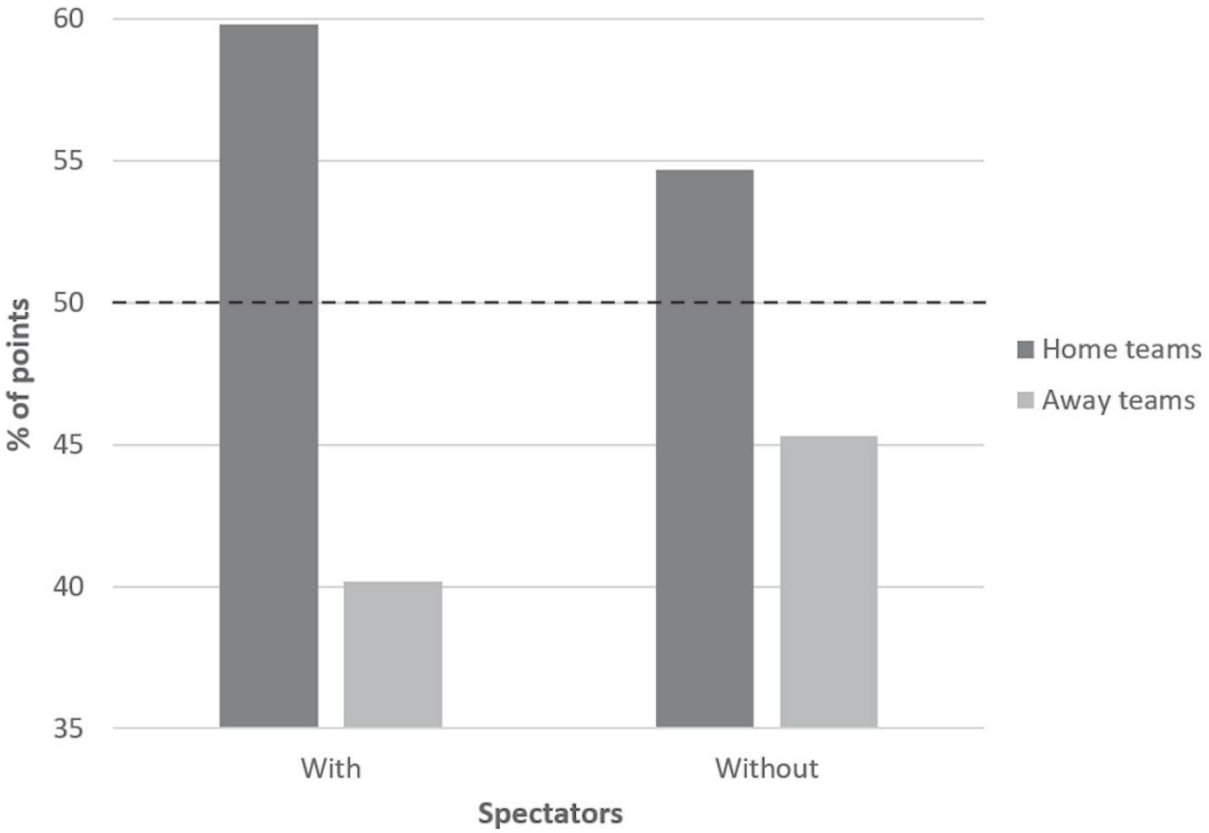
	Descriptive Statistics				Paired *t*-tests						TOST results for statistical equivalence H0: (d ≤ - .2 U d ≥ .2) vs H1: (- .2 < *d* < .2)		
	Home		Away										
	M	SD	M	SD	*t*	df	*p*	*d*	Bayes Factor (H_0/H_1)[a]		Lower Bound	Upper Bound	Equivalence
Control variable:													
points per match	1.36	0.38	1.37	0.38	-0.52	840	n.s.	0.02	22.54	Strong	*t* = 5.28 (df=840) ***	t = -6.32 (df = 840) ***	X
Home advantage variables:													
goals	1.45	1.22	1.25	1.17	3.31	840	**	0.11	0.10		*t* = 9.11 (df=840) ***	t = -2.49 (df = 840) *n.s.*	
ball possession	50.80	10.10	49.20	9.96	2.26	840	*n.s.*	0.08	1.90	Anecdotal	*t* = 8.06 (df=840) ***	t = -3.54 (df = 840) **	X
shots	12.00	4.48	11.00	4.47	4.36	840	***	0.15	0.01		*t* = 10.20 (df=840) ***	t = -1.44 (df = 840) *n.s.*	
corner kicks	4.92	2.68	4.61	2.63	2.12	840	*n.s.*	0.07	2.54	Anecdotal	*t* = 7.92 (df=840) ***	t = -3.68(df = 840) **	X
Referee bias variables:													
fouls	13.70	4.18	13.50	4.36	1.41	840	*n.s.*	0.05	109.44	Decisive	*t* = 7.21 (df=840) ***	t = -4.39 (df = 840) ***	X
yellow cards	2.16	1.41	2.04	1.35	2.11	840	*n.s.*	0.07	144.18	Decisive	*t* = 7.91 (df=840) ***	t = -3.69 (df = 840) **	X
red cards	0.11	0.34	0.10	0.30	0.57	840	*n.s.*	0.02	70.31	Very Strong	*t* = 6.37 (df=840) ***	t = -5.23 (df = 840) ***	X
penalty kicks against	0.16	0.40	0.19	0.43	-1.56	840	*n.s.*	0.05	7.45	Substantial	*t* = 4.24 (df=840) ***	t = -7.36 (df = 840) ***	X
extra time[b]	6.12	1.43	6.30	1.47	-1.13	320	*n.s.*	0.13	4.62	Substantial	*t* = 2.92 (df=320) *	t = -0.654 (df = 320) *n.s.*	

Notes. [a] Calculated considering a one-sided null hypothesis of a null to small advantage for away teams (Cohen's $0 \leq d \leq .2$). [b] For this variable it was run an independent samples *t*-test with equal variances assumed on the 322 matches whose result at 90' had a difference of 1 goal (176 home team winning vs. 146 away team winning).

Bonferroni corrected *p*-values: *** $p < .001$; ** $p < .01$; * $p < .05$.

Figure 1

Home advantage for points in matches with and without spectators



Note. The percentages were calculated on the last three complete seasons (2016-17, 2017-18, 2018-19) for matches with spectators, and on the matches played behind closed doors in the 2019-20 season for matches without spectators.