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# Sport Psychological Effects of Missing Supporters in European Elite Football during the COVID-19 Pandemic

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## Abstract

Due to the COVID-19 pandemic, European top football (soccer) leagues played the final rounds of season 2019/20 without or strongly limited attendance of supporters (i.e., “ghost games”). From a sport psychological perspective this situation poses a unique opportunity to investigate the crowd’s influence on sports professionals’ behavior and performance.

A total of 1286 matches - played in the top leagues of Spain, England, Germany, Italy, Russia, Turkey, Austria and the Czech Republic - were analyzed for results, points, goals, fouls, bookings and reasons for bookings and contrasted between respective matchdays of season 2018/19 (regular attendance) and season 2019/20 (“ghost games”).

There are two main findings. First, the overall home advantage effect in the respective elite leagues - identified in the respective matches of the regular 2018/19 season - vanishes almost completely in the “ghost games” of the 2019/20 season. Consequently, home teams lose significantly more matches, whereas away teams win significantly more matches. Second, home teams are booked significantly more often with yellow cards for committing fouls in “ghost games” relative to regular games. Furthermore, our results provide evidence that this effect is independent on whether the home teams are leading, trailing, or drawing in score.

We conclude that missing supporters in European elite football leagues dissolve the “home advantage” effect. This missing support of the “home crowd” has a significant psychological effect on the experience, behavior and performance of home teams and/or officials. The effect is evident in the awarding of yellow cards for fouls for home teams, but not for away teams. There are (at least) three possible explanations: (1) Due to missing supporters, players experience an unfamiliar reduction of arousal and drive, (2) players lack the positive support from the home crowd, resulting in increased dysfunctional aggressive behavior and/or (3) without the pressure from the ranks, referees act more objectively in their decision making.

## Introduction

Due to the COVID-19 pandemic, European top football (soccer) leagues paused competition around the middle of March 2020. The first league to restart was the “German Bundesliga" on May 16th. Ultimately, 11 of 15 European’s top leagues resumed competition and finished the season (Spain, England, Germany, Italy, Portugal, Russia, Ukraine, Turkey, Austria and Czech Republic). France, Belgium, Netherlands and Scotland suspended their leagues and aborted (“ORF Sport. Frühlingserwachen in Europas Ligen,” 2020; “Spiegel Sport. So planen Europas Fussballligen den Neustart,” 2020).

The fundamental requirement for restarting competition was to play matches without the attendance of supporters; so-called “ghost games”. Only the Russian league chose to let a limited number of supporters - 10% of each stadium's capacity - attend matches (MDZ. Im Alleingang gegen die Geisterspiele,” 2020). From a sport psychological perspective, the circumstance of missing supporters on a large scale in Europe’s elite football leagues poses a unique situation in the history of professional football to investigate the crowd’s influence on sports professionals’ behavior and performance.

Based on Allport’s Social Facilitation Theory (Allport, 1924) and Zajonc’s Drive Theory (Zajonc, 1965) football players' arousal and drive should decrease in “ghost games” due to missing external stimulation by supporters. Because reduced arousal decreases the probability of executing trained automated sportive actions, it can be hypothesized that missing supporters lead to difficulties in reaching usual levels of performance and performance-related behavior. In that vein, it was found that “ghost games” have a direct effect on the (nonverbal) behavior of professional football players, staff and officials on pitch during games (Leitner & Richlan, in press). There were 19.5% fewer documented emotional situations in “ghost games” than in “regular games”, meaning that players got less involved in behavior like “words fights” and “discussions” with other players or officials. Additionally, results from the “Austrian Bundesliga” indicate that “ghost games” have an effect on “home advantage” with fewer “home-wins” and more “away-wins” and “draws” in “ghost games” (Leitner & Richlan, in press).

In their conceptual framework, Courneya and Carron (1992) define home advantage as *“the term used to describe the consistent finding that home teams in sport competitions win over 50% of the games played under a balanced home and away schedule”* (p.13). Accordingly, Jamieson found in a meta study across sport disciplines that home teams win significantly more often than away teams (Jamieson, 2010). Allen and Jones (2014) state that *“a large body of research has confirmed that athletes and teams perform considerably better when they compete*

*at home compared with away from home. [...] Specifically, home teams are more successful in the presence of a large audience that displays positive (encouraging) behavior."* (p.48f). Based on this conceptual framework of home advantage, the missing crowd in "ghost games" has an effect on "Game Location Factors" (Carron, Loughhead & Bray, 2005), that is considered by the authors to *"influence first critical psychological states and then critical behavioural states of three groups of actors involved in the outcome - coaches, competitors and officials."* (p.396). Current studies support the concept that missing supporters have an impact on the home advantage. CIES Football Observatory investigated 63 leagues worldwide and concluded that between April and August 2020 the overall home advantage (home win percentage) decreased in 41 of 63 leagues by -2.1% in total ("CIES. Football Observatory. What about the home advantage," 2020).

Similar to the present COVID-19 situation preventing spectators from attending football matches, another study documented the effects of a measles epidemic causing eleven North American Atlantic Conference basketball games being played without supporters. Results showed that both home and away teams benefited from playing in front of empty ranks regarding total points scored, field goal percentage, and free throw percentage, while the effect was even larger for the away team (Moore & Brylinsky, 1993). This finding is interesting because other studies found that crowd size (Nevill, Newell & Gale, 1996) and crowd density (Agnew & Carron, 1994) positively correlated with the magnitude of the home advantage. In this context, another relevant finding was reported by Varca (1980). Results from this study showed that home and away teams differed significantly in interactive behavior. Specifically, the home teams showed more "functionally aggressive behavior" (e.g., steals, blocked shots, rebounds), whereas the away teams showed more dysfunctionally aggressive behavior (e.g., fouls). This finding goes well in line with the hypothesis that home games lead to higher levels of testosterone in players, which, in turn, potentially facilitates risk-taking behavior, increases metabolism and improves spatial abilities (Neave & Wolfson, 2003). In addition, other studies showed that elevated levels of testosterone do not automatically mandate higher levels of exhibited aggressive behavior (Jones, Bray & Olivier, 2005).

Not only players' and staff behavior is influenced by the presence of supporters in sport events. A study from football (soccer) games - that were played without attendance following safety requirements after hooligan incidents in Sicily - showed that - under normal circumstances - home teams are favored by officials' decisions during matches (Pettersson-Lidbom & Priks, 2010). Similarly, an experimental study investigated the effects of crowd noise on refereeing decisions in football, concluding that referees "viewing the challenges with background crowd noise were more uncertain in their decision making and awarded significantly fewer fouls (15.5%)

against the home team, compared with those watching in silence (Nevill, Balmer & Williams, 2002). It was further found that the crowd size had a direct effect on the number of first yellow cards awarded to the away team in Cup final games (Downward & Jones, 2007) and on referees' overall decisions contributing to the overall size of the home advantage effect (Unkelbach & Memmert, 2010).

Based on previous studies investigating the absence of crowds in professional sports events, we hypothesized that the COVID-19 related "ghost games" in European football have significant effects on athletes, staff and officials. The present study is the first of its kind examining these effects closely on home advantage and coherent sport psychological reactions - by means of analysis of rule-consistent, compliant and fair-play behavior - on a large scale in professional football matches of Europe's Top Elite Leagues.

## Methods

Based on the overall point value of UEFA's country coefficient list ("UEFA. Länder-Koeffizienten", 2020) we chose Europe's Top 15 leagues and excluded countries, in which the respective leagues were suspended after the COVID-19 outbreak. This is because nations beyond rank 15 play a minor role in international football competition due to limited regular starters and a higher number of qualification rounds (up to 5 rounds with first and second leg). This plays a significant role when it comes to qualification for "UEFA Europa League" and especially for the top tier "UEFA Champions League" ("UEFA. UEFA Champions League preliminary round draw," 2020). Additionally, we selected only leagues that were statistically documented in detail on "transfermarkt.de", which is an open and reliable statistics platform and regularly used as a source and forum for football related scientific studies (e.g., Franck & Nüesch, 2012). We analyzed the matches of the particular leagues played after the respective leagues' restarts with no or limited attendance (season 19/20) and compared the acquired data to the respective rounds of season 18/19, which were played with regular attendance of supporters. Because team squads, managers, staff and further performance-related parameters in modern professional football change quickly between seasons, we decided to compare the "ghost games" of season 19/20 only with games from the previous season of 18/19.

**Sample.** "La Liga" (Spain), "Premier League" (England), "1. Bundesliga" (Germany), "Serie A" (Italy), "Premier Liga" (Russia), "Süper Lig" (Turkey), "tipico Bundesliga" (Austria) and "Fortuna Liga" (Czech Republic) were included into the data sample. "Liga NOS" (Portugal), "Premier Liga"

(Ukraine) and “Superligaen” (Denmark) were excluded from the study due to inaccuracies in match statistics documentation regarding specific yellow card bookings. “Ligue 1” (France), “Jupiler Pro League” (Belgium), “Eredivisie” (Netherlands) and the “Scottish Premiership” (Scotland) aborted their seasons and, therefore, could not be included in the study.

This led to a total sample size of 1286 matches, with 645 matches played in season 18/19 (regular attendance) and 641 matches played in season 19/20 (no or strongly limited attendance). The reason for fewer “ghost games” played in season 19/20 than “regular games” in season 18/19 can be found in the Russian “Premier Liga”, where 4 games were cancelled due to COVID-19 cases (FK Orenburg vs. FK Krasnodar [Round 24], FK Orenburg vs. Ural Ekaterinburg [Round 25], FK Tambov vs. FK Sochi [Round 29] and Krylya Sovetov Samara vs. FK Sochi [Round 30]). As mentioned above, Russia was the only country to let a limited number of supporters (10% of stadium capacity) attend football matches during the COVID-19 pandemic. Due to the significant discrepancy in crowd numbers between the two seasons and the high number of large stadiums (11 of 16 stadiums ≥ 30,000 capacity), we decided to include the Russian league into our analysis.

**Data.** The following information was collected from “transfermarkt.de” for each team and match played in the respective leagues: Result (win, loss, draw), points earned (0, 1, 3), goals scored, fouls committed, number of yellow, yellow-red and red cards awarded, reason for booking (criticism, unfair sportsmanship, foul play) and number of spectators.

**Test statistics.** Data were statistically analyzed on round-level, leading to a number of 73 rounds per season ($N$ = 146). Due to ordinal scale of the data, two-sided Mann-Whitney-$U$-tests for independent data and Wilcoxon signed-rank test for dependent data, respectively, were used to investigate potential differences. Effect sizes are reported in Pearson’s $r$, calculated as follows: $r = \frac{z}{\sqrt{N}}$

## Results

**General match results.** Figure 1 illustrates the total numbers and differences of general match statistics of the respective rounds analyzed between season 2018/19 and 2019/20. Additionally, Figure 2 illustrates the season differences in relative numbers. Comparing numbers of wins, draws, points earned and goals scored by home and away teams between seasons 18/19 and 19/20 shows that home teams lost 55 (-17.7%) more games, away teams won 53 (+29.8%) more games (and vice versa for away teams), leading to 2 (-1.3%) fewer draws between “regular

games" of 18/19 and "ghost games" of 19/20. It follows that home teams earned 167 (-15.4%) fewer points and scored 104 (-9.8%) fewer goals and away teams earned 157 (+22.7%) more points and scored 90 (+11.6%) more goals in "ghost games".

We observed significantly fewer home wins ($U$ = 1991, $p$ = .007, $r$ = .222) and more home losses ($U$ = 1913, $p$ = .003, $r$ = .249) between "regular matches" of season 18/19 and "ghost games" of season 19/20.

Furthermore, we observed significantly fewer points earned by the home teams ($U$ = 1923.5, $p$ = .004, $r$ = .241) and more points earned by the away teams ($U$ = 1827, $p$ = .001, $r$ = .272) between "regular matches" of season 18/19 and "ghost games" of season 19/20.

There is no significant decrease in goals scored by the home teams ($U$ = 2217, $p$ = .079, $r$ = .145) but a significant increase in goals scored by the away teams ($U$ = 2100, $p$ = .027, $r$ = .183) between "regular matches" of season 18/19 and "ghost games" of season 19/20.

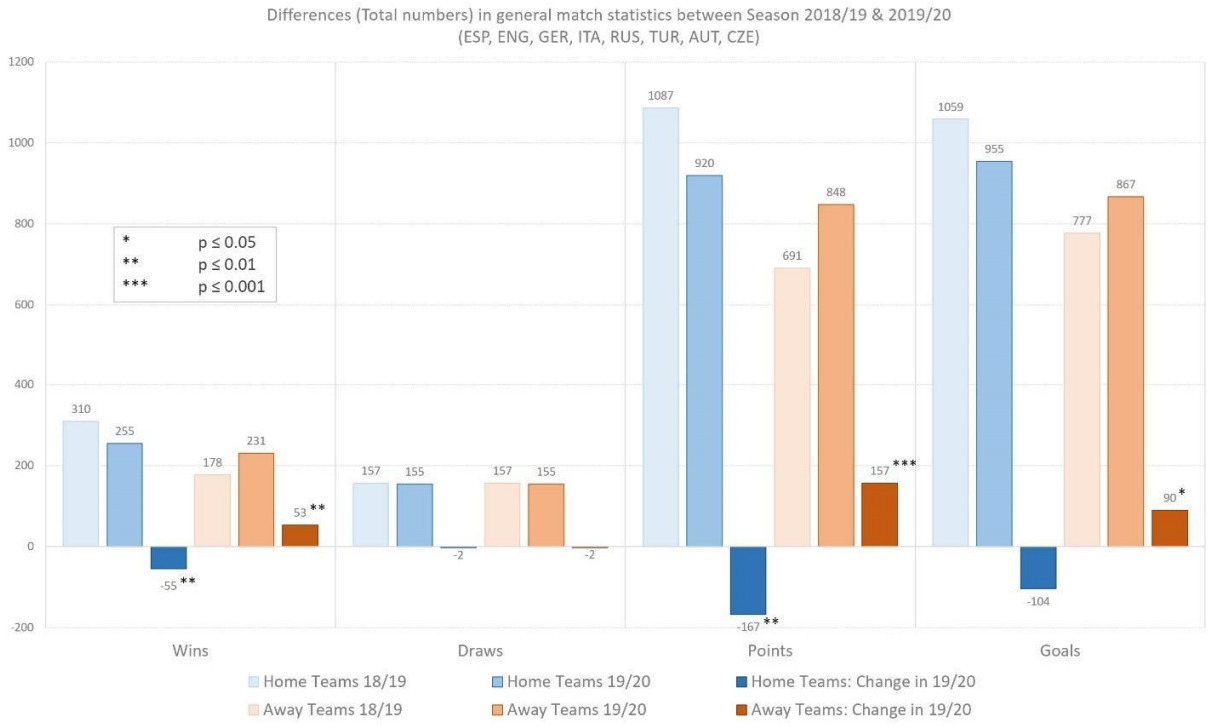


*Figure 1.* Absolute differences in general match statistics

Absolute differences of general match statistics of home and away teams in the highest football (soccer) leagues of Spain, England, Germany, Italy, Russia, Turkey, Austria and Czech Republic. Bar plots are based on aggregated match results statistics of rounds played in the leagues as "ghost games" (no or strongly limited attendance) in season 2019/20 and respective rounds of "regular matches" (regular attendance) in season 2018/19 ($N$ = 146). Data shows that home teams won fewer matches (-55) and away teams won

more matches (+53) during the "ghost games" in season 2019/20. There was just a marginal difference in draws (-2). Accordingly, home teams earned fewer points (-167) and scored fewer goals (-104), whereas away teams earned more points (+157) and scored more goals (+90) in "ghost games". There is a significant difference between seasons for number of wins and losses of home teams (and vice versa for away teams), for number of points earned by home and away teams and for number of goals scored by away teams but not for number of goals scored by home teams.

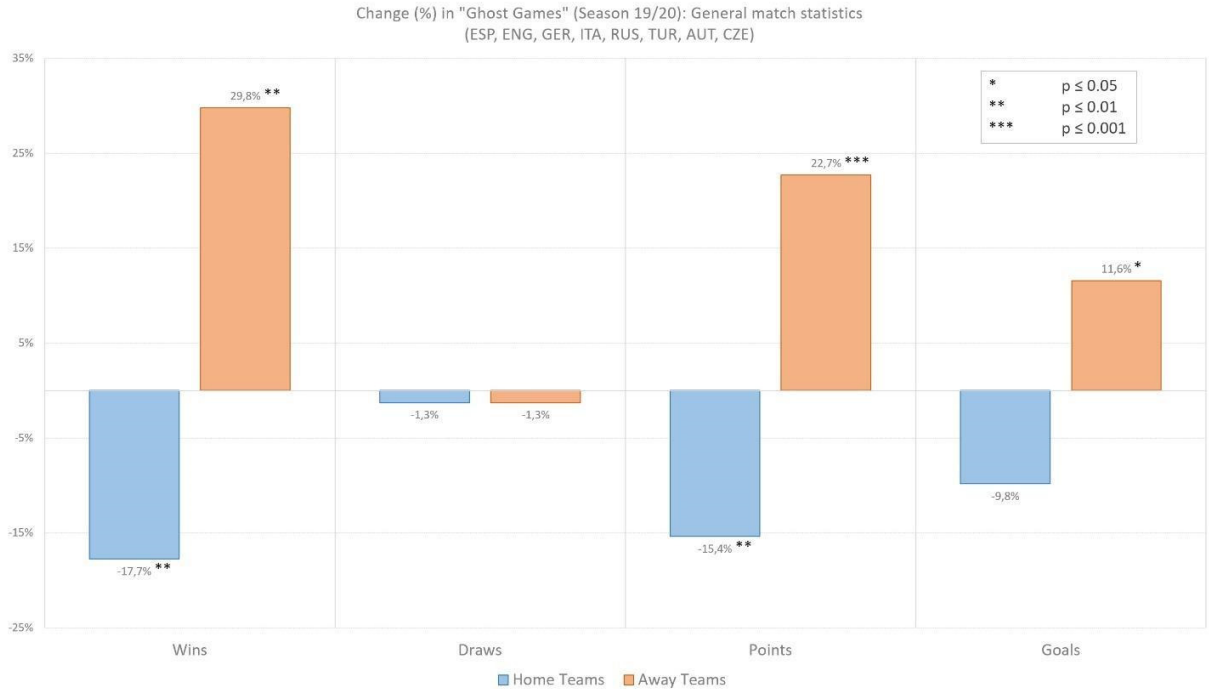


*Figure 2.* Relative changes in general match statistics

Relative changes in "ghost games" (season 2019/20) of general match statistics of home and away teams in the highest football (soccer) leagues of Spain, England, Germany, Italy, Russia, Turkey, Austria and Czech Republic. Bar plots are based on aggregated match results statistics of rounds played in the leagues as "ghost games" (no or strongly limited attendance) in season 2019/20 and respective rounds of "regular matches" (regular attendance) in season 2018/19 ($N$ = 146). Data shows that home teams won fewer matches (-17.7%) and away teams won more matches (+29.8%) during the "ghost games" in season 2019/20. There was just a small difference in draws (-1.3%). Accordingly home teams earned fewer points (-15.4%) and scored fewer goals (-9.8%), whereas away teams earned more points (+22.7%) and scored more goals (+11.6%) in "ghost games". There is a significant difference between seasons for number of wins and losses of home teams (and vice versa for away teams), for number of points earned by home and

away teams and for number of goals scored by away teams but not for number of goals scored by home teams.

**Home advantage and points per game.** Figure 3 illustrates the relative change in team performance when playing at home between seasons of 2018/19 (regular attendance) and 2019/20 ("ghost games"). In order to analyze the "home advantage" as the difference between home wins, home losses and draws within one season, results show that in the season 2018/19, home teams won 48.1%, lost 27.6% and drawed in 24.3% of all analyzed games with regular attendance. This difference between the number of home wins compared to home losses is statistically significant. Therefore in the season 2018/19 with regular attendance, home teams won significantly more often in home games ($z$ = -5.376 , $p$ = .000, $r$ = .445). In contrast, in the season 2019/20, home teams won 39.8%, lost 36.0% and drawed 24.2% of all analyzed "ghost games". This difference between the number of home wins compared to home losses is not significant. Therefore in the season 2019/20 with "ghost games", home teams did not win significantly more often in home games ($z$ = -1.264, $p$ = .206, $r$ = .105). It should be noted that we decided against excluding draws as in other studies on home advantage (e.g. Jamieson, 2010). If calculated without draws (i.e., taking into consideration only the games that resulted in a win or loss), the home advantage increases to 63.5% in season 2018/19 (which is in line with the findings of the meta-analysis by Jamieson, 2010) and 52.5% in season 2019/20.

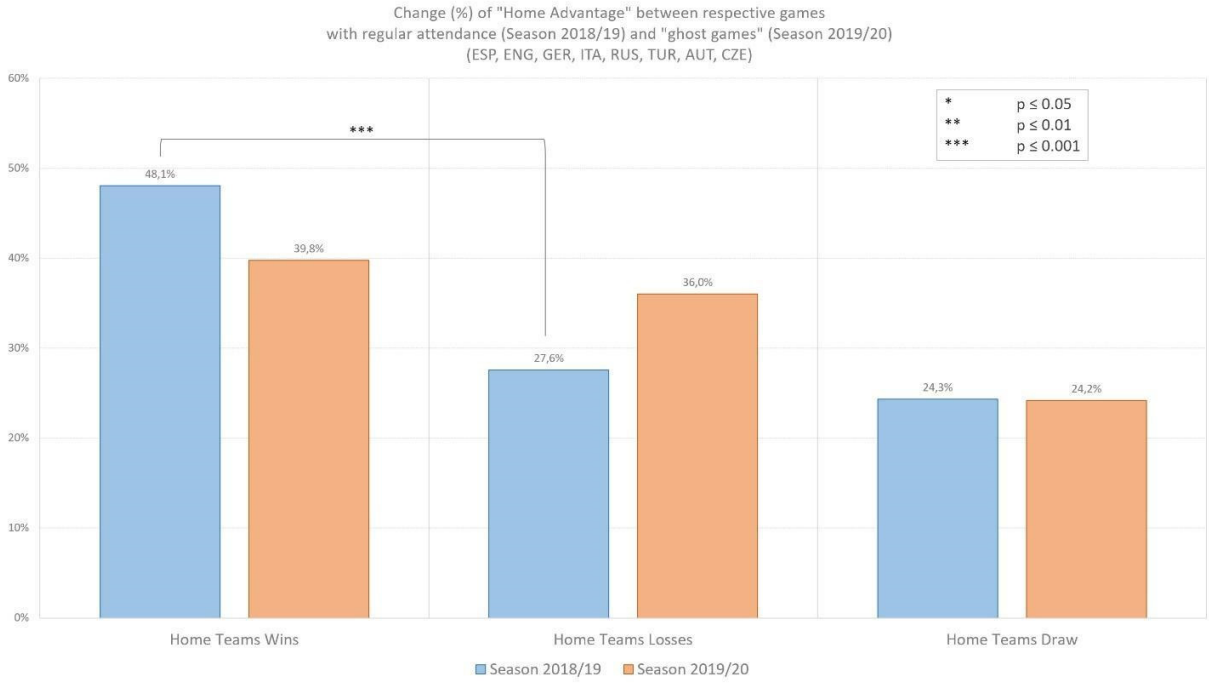

*Figure 3.* Relative changes of "Home Advantage"

Relative changes in "home advantage" between games with regular attendance (season 2018/19) and "ghost games" (season 2019/20) in the highest football (soccer) leagues of Spain, England, Germany, Italy, Russia, Turkey, Austria and Czech Republic. Bar plots are based on aggregated match results statistics of rounds played in the leagues as "ghost games" (no or strongly limited attendance) in season 2019/20 and respective rounds of "regular matches" (regular attendance) in season 2018/19 ($N$ = 146). Results show that home teams win significantly more often in matches with regular attendance ("home advantage"). In "ghost games" this effect vanishes and the difference between the number of wins and losses is not significantly different.

Another important factor when it comes to home advantage is the mean number of points earned per game (see Figure 4). Therefore, we calculated the mean number of points earned by home and away teams based on the number of rounds played in season 2018/19 ($N$ = 645) and in season 2019/20 ($N$ = 641). Results show that home teams earned on average 1.69 points in games with regular attendance in season 2018/19 and 1.44 points in "ghost games" in season 2019/20, resulting in a mean decrease of 0.25 points per game. In contrast, away teams earned on average 1.07 points in games with regular attendance in season 2018/19 and 1.32 points in "ghost games" in season 2019/20, resulting in a mean increase of 0.25 points per game. Therefore, the home advantage in the 2018/19 season (with supporters) can be quantified with a difference of 0.61 points per game, whereas in the 2019/20 season (without supporters) it corresponds to a difference of only 0.11 points per game between home and away teams.

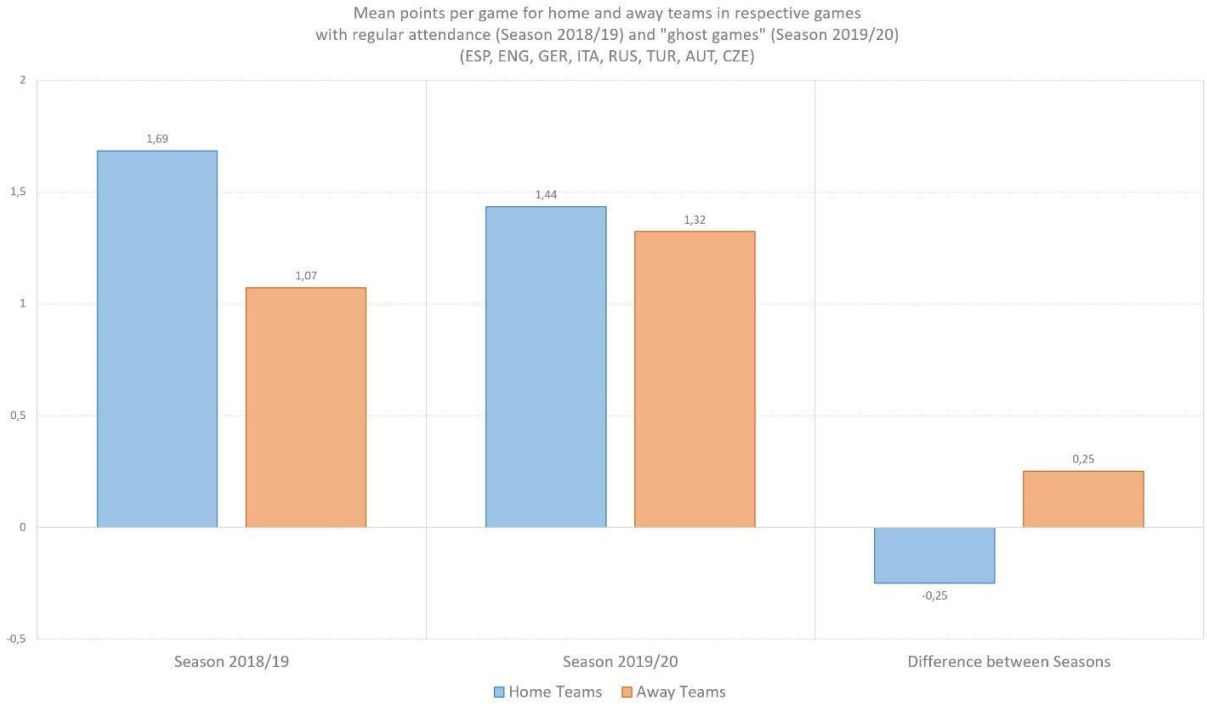


*Figure 4.* Mean points per game

Mean points earned by home and away teams in respective games with regular attendance in season 2018/19 and "ghost games" in season 2019/20 in the top football (soccer) leagues of Spain, England, Germany, Italy, Russia, Turkey, Austria and Czech Republic. Bar plots are based on aggregated match results statistics of rounds played in the leagues as "ghost games" (no or strongly limited attendance) in season 2019/20 and respective rounds of "regular matches" (regular attendance) in season 2018/19 ($N = 146$). Results show that home teams gain 0.25 fewer points when playing without supporters, while away teams tend to gain 0.25 more points when competing in "ghost games".

**Fouls and total yellow cards.** Aggregation of all committed fouls from all analyzed matches of the 8 included leagues and comparison between the two seasons of 2018/19 ("regular games") and 2019/20 ("ghost games") shows that both home (+296 fouls / +3.7%) and away (+75 fouls / +0.9%) teams committed more fouls in "ghost games". There is a significant increase in total fouls committed by home teams ($U$ =2143, $p$ = .041, $r$ = .169) and no significant difference in total fouls committed by away teams ($U$ = 2365, $p$ = .240, $r$ = .097) between "regular matches" of season 18/19 and "ghost games" of season 19/20.

In addition, in "ghost games" the total number of yellow cards awarded to the home teams increased (+148 yellow cards / +11.7%), whereas it decreased for the away teams (-77 yellow cards / -5.5%) (see Figure 5). There is no significant difference in the total yellow cards awarded

to home teams ($U$ = 2170, $p$ = .053, $r$ = .160) and the total yellow cards awarded to away teams ($U$ = 2409.5, $p$ = .317, $r$ = .083) between “regular matches” of season 18/19 and “ghost games” of season 19/20.

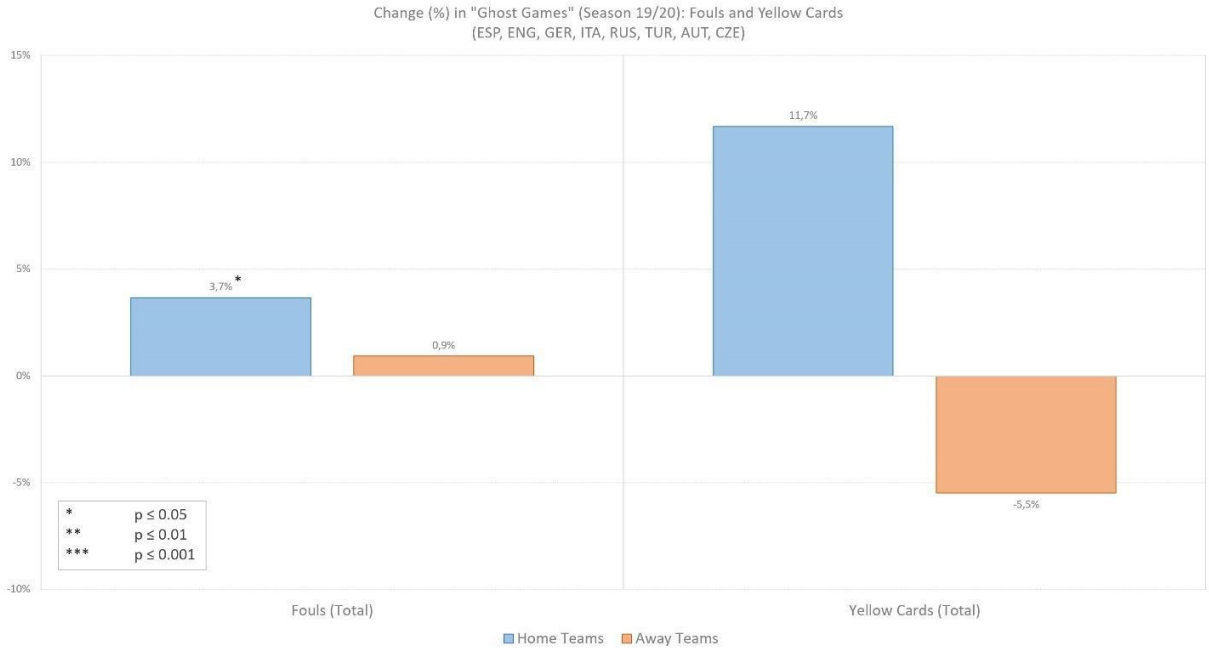


*Figure 5.* Relative change in fouls and yellow cards

Relative differences in number of total fouls committed by home and away teams and number of total yellow cards awarded to home and away teams in the top football (soccer) leagues of Spain, England, Germany, Italy, Russia, Turkey, Austria and Czech Republic. Bar plots are based on aggregated match results statistics of rounds played in the leagues as “ghost games” (no or strongly limited attendance) in season 2019/20 and respective rounds of “regular matches” (regular attendance) in season 2018/19 ($N$ = 146). Data shows that both home (+3.7%) and away (+0.9%) teams committed more fouls in “ghost games” in season 2019/20. Only home teams earned more yellow cards in total (+11.7%), while away teams earned fewer yellow cards in total (-5.5%) in “ghost games”. There is a significant difference between seasons for the number of fouls committed by home teams, but not for away teams. For total yellow cards there is no significant difference between seasons for both teams.

**Rule-consistent and fair-play behavior.** Figure 6 illustrates the total numbers and differences of yellow cards awarded for criticism, unfair sportsmanship and foul play of the respective rounds analyzed between season 2018/19 and 2019/20. Figure 7 illustrates these season differences in relative numbers. Comparing absolute and relative numbers of yellow cards awarded for criticism,

unfair sportsmanship and foul play for home and away teams between “regular games” of season 18/19 and “ghost games” of season 19/20 showed the following: yellow cards for criticism (home teams: +41 / away teams: +34) increased by 53.2% for home teams and by 36.6% for away teams. Unfair sportsmanship (home teams: -132 / away teams: -135) decreased by -57.6% for home teams and by -54.2% for away teams. Contrarily, yellow cards awarded for fouls increased strongly for home teams (+238) by 26.2% but only slightly (+28) for away teams (+2.8%).

We observed significantly more yellow cards awarded for criticism for the home teams ($U$ = 2057.5, $p$ = .013, $r$ = .205) and for the away teams ($U$ = 2173, $p$ = .048, $r$ = .164) between “regular matches” of season 18/19 and “ghost games” of season 19/20.

Furthermore, there were significantly fewer yellow cards awarded for unfair sportsmanship for the home teams ($U$ = 1297, $p$ = .000, $r$ = .451) and for the away teams ($U$ = 1513.5, $p$ = .000, $r$ = .380) between “regular matches” of season 18/19 and “ghost games” of season 19/20.

Finally, there was a significant difference in more yellow cards awarded for foul play for the home teams ($U$ = 1712.5, $p$ = .000, $r$ = .309) and no significant difference in yellow cards awarded for foul play for the away teams ($U$ = 2497.5, $p$ = .513, $r$ = .054) between “regular matches” of season 18/19 and “ghost games” of season 19/20.

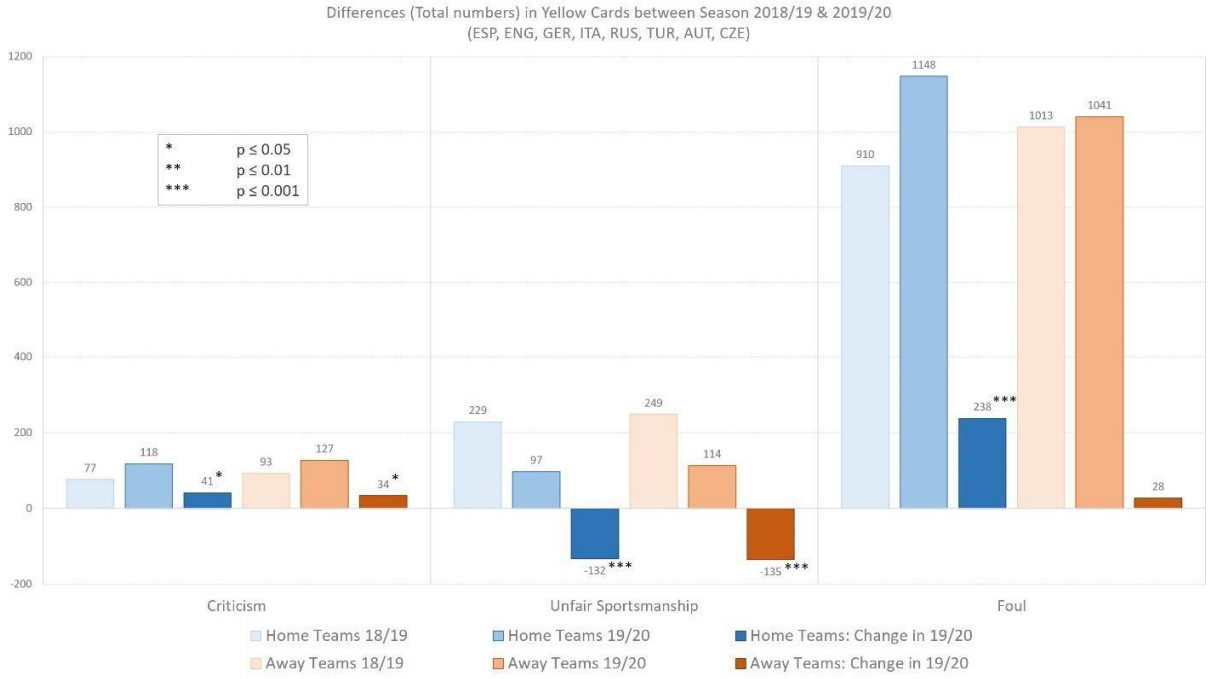


*Figure 6.* Absolute differences in Criticism, Unfair Sportsmanship and Foul Play

Absolute differences of yellow cards (criticism, unfair sportsmanship & foul play) awarded to home and away teams in the top football (soccer) leagues of Spain, England, Germany, Italy, Russia, Turkey, Austria

and Czech Republic. Bar plots are based on aggregated match results statistics of rounds played in the leagues as "ghost games" (no or strongly limited attendance) in season 2019/20 and respective rounds of "regular matches" (regular attendance) in season 2018/19 ($N$ = 146). Data shows that both home (+41) and away (+34) teams earned more yellow cards for criticising officials' decisions during the "ghost games" in season 2019/20. On the contrary, both home (-132) and away (-135) teams earned fewer yellow cards for unfair sportsmanship behavior. Number of cards awarded for fouls strongly increased for home teams (+238) but only slightly for away teams (+28) in "ghost games". There is a significant difference between seasons for the number of yellow cards awarded for criticism for both home and away teams, for unfair sportsmanship for both home and away teams and for committed fouls for home teams but not for away teams.

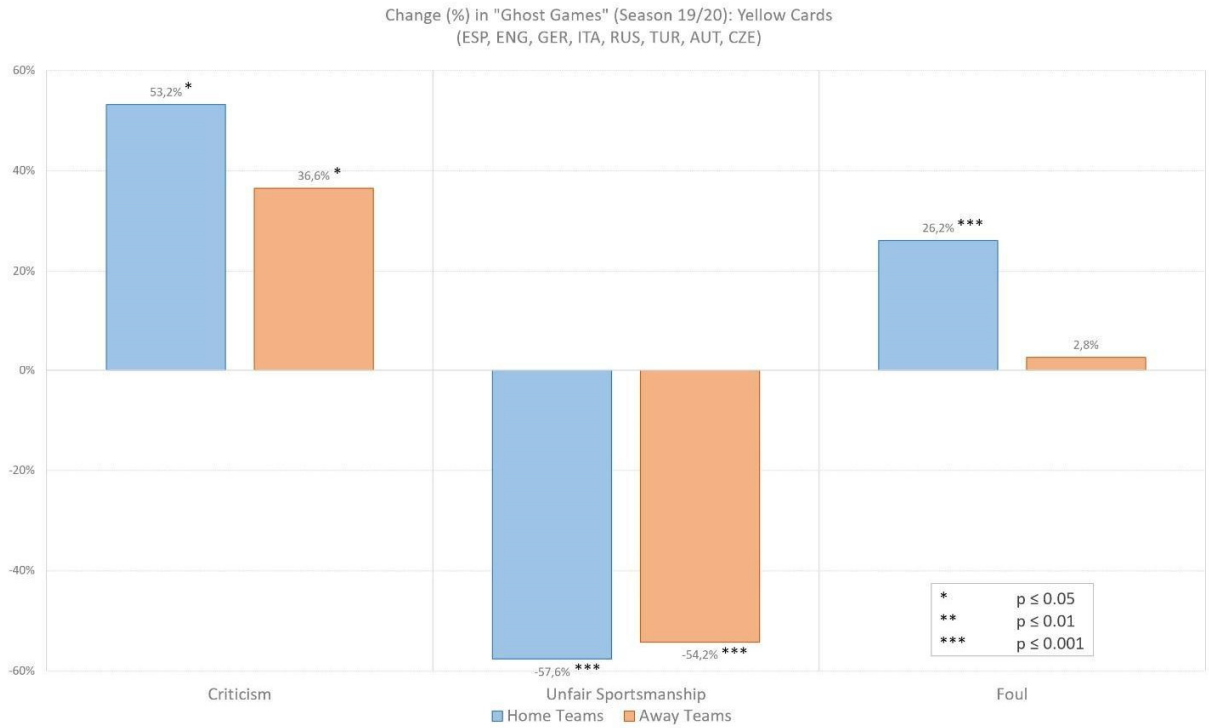


*Figure 7.* Relative changes in Criticism, Unfair Sportsmanship and Foul Play

Relative changes in "ghost games" (season 2019/20) of yellow cards (criticism, unfair sportsmanship & foul play) awarded to home and away teams in the top football (soccer) leagues of Spain, England, Germany, Italy, Russia, Turkey, Austria and Czech Republic. Bar plots are based on aggregated match results statistics of rounds played in the leagues as "ghost games" (no or strongly limited attendance) in season 2019/20 and respective rounds of "regular matches" (regular attendance) in season 2018/19 ($N$ = 146). Data shows that both home (+53.2%) and away (+36.6%) teams earned more yellow cards for criticising officials' decisions during the "ghost games" in season 2019/20. On the contrary, both home (-

57.6%) and away (-54.2%) teams earned fewer yellow cards for unfair sportsmanship behavior. Number of cards awarded for fouls strongly increased for home teams (+26.2%) but only slightly for away teams (+2.8%) in “ghost games”. There is a significant difference between seasons for the number of yellow cards awarded for criticism for both home and away teams, for unfair sportsmanship for both home and away teams and for committed fouls for home teams but not for away teams.

Due to the findings of significantly increased yellow cards awarded for fouls, we performed an in-depth analysis by collecting data on the relationship between course of play and yellow cards. We found this effect to be independent of the current score (condition), but dependent on the team (home – away). Figure 8 illustrates that, regarding yellow cards for foul play, every condition (winning, losing, drawing) of the home team differs significantly in season 2019/20 from season 2018/19, while there is no significant effect for any condition of the away team.

We observed significantly more yellow cards awarded for fouls for the home teams while leading ($U$ = 2060.5, $p$ = .017, $r$ = .197), but not for the away team while leading ($U$ = 2195, $p$ = .063, $r$ = .154) in “ghost games” of season 19/20.

Furthermore, there is a significant difference in more yellow cards awarded for fouls for the home teams while trailing ($U$ =2100, $p$ = .026, $r$ = .184) but not for the away teams while trailing ($U$ = 2623.5, $p$ = .872, $r$ = .013) in “ghost games” of season 19/20.

Similarly, we observed significantly more yellow cards awarded for fouls in “ghost games” of season 19/20 for the home teams while the score was draw ($U$ = 2034, $p$ = .013, $r$ = .205) but not for for the away teams ($U$ = 2564.5, $p$ = .694, $r$ = .033).

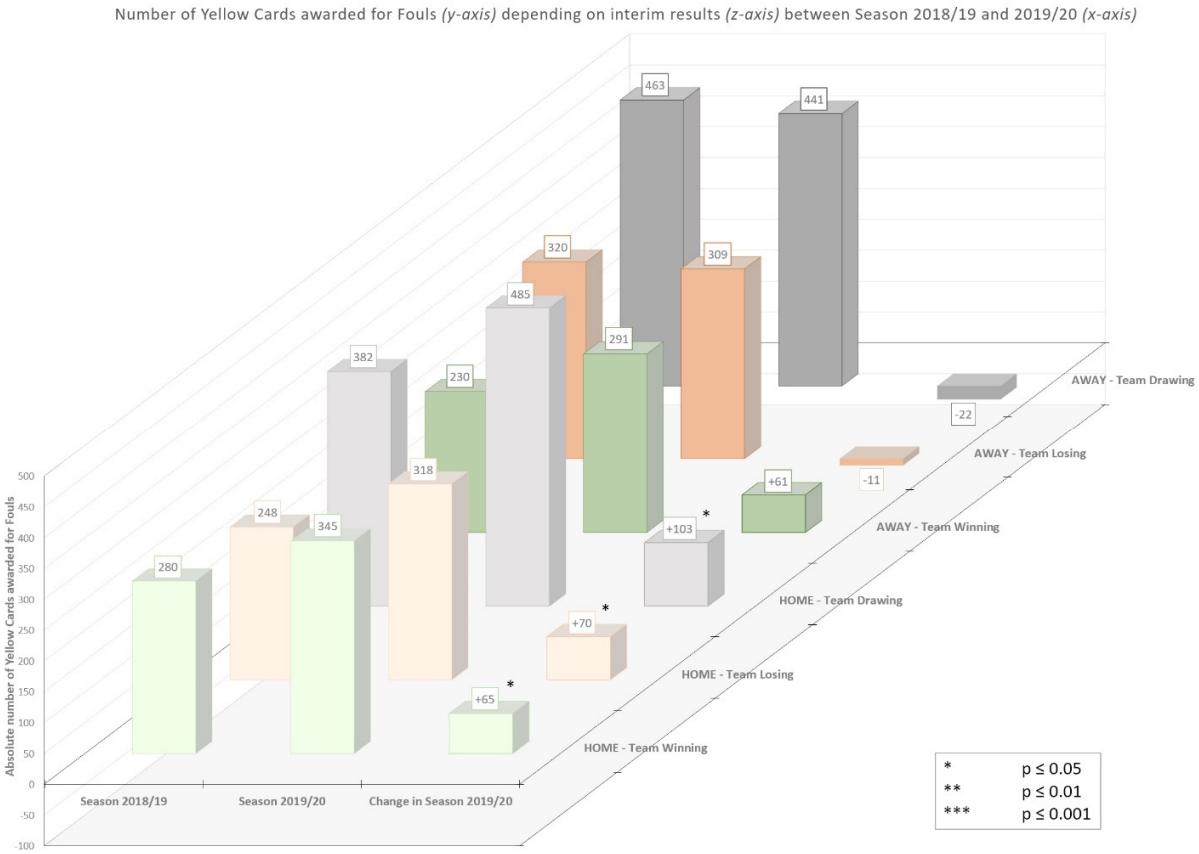


*Figure 8.* Absolute differences in yellow cards for foul play depending on course of game

Absolute differences of yellow cards of home and away teams while winning, losing or drawing in respective games of season 2018/19 (regular attendance) and season 2019/20 (limited attendance). Results indicate that home teams earn significantly more yellow cards for fouls while winning (+65), losing (+70) or drawing (+103) in games without attendance in season 2019/20. In contrast, there is no such significant effect for away teams while winning (+61), losing (-11) or drawing (-22).

## Discussion

The first main finding of our study is that overall, football (soccer) teams of Europe's elite leagues, lose significantly more of their home games and win significantly more of their away games, when there are no supporters in the stadium attending the matches. This means that these "ghost games" have a significant effect on the "home advantage". This finding is supported by data of CIES Football Observatory, who also found an overall decrease in home win percentage in the same time window (from April 2020 to August 2020) by -2.1%. Specifically, CIES found major decrease of home advantage in Austria (-15%), Germany (-.14.1%), Russia (-8.9%), Spain (-

6.1%) but no change in Turkey (0%) and minor increase in Italy (+0.1%), England (+0.8%) and Czech Republic (+1.4%) ("CIES. Football Observatory. What about the home advantage," 2020). There are numerous studies showing that home teams generally win more games when competing at home and performing better when supported positively from the ranks (for a meta-analysis see Jamieson, 2010). Corresponding evidence was also identified in our study in the games with supporters taking place in the 2018/19 season, with a quantified home advantage of 63.5% home-win-rate or a plus of 0.61 points per game for home (1.69 points per game) relative to away (1.07 points per game) teams. Without supporters on matchday, the well documented effect of "home advantage" diminishes to 52.5% home-win-rate or a plus of only 0.11 points per game for home (1.44 points per game) relative to away (1.32 points per game) teams. Interestingly the number of draws appears to be stable and unaffected by "ghost games".

The second main finding of our study is that home teams are awarded with significantly more yellow cards for committed fouls in "ghost games" than in "regular games" (with supporters present). In contrast, the number of yellow cards for fouls awarded to away teams is unaffected by "ghost games". Conversely, other rule infringements awarded with yellow cards increase (criticism) or decrease (unfair sportsmanship) similarly for both home and away teams (see Figure 6). Therefore, the mere increase of fouls committed by home teams in "ghost games" cannot explain the significant difference in the number of yellow cards for fouls between home and away teams. We further analyzed the course of the games and documented at what point in the matches yellow cards were awarded for fouls. Our initial assumption was that - due to the average worse performance of the home teams in season 19/20 - the increased number of yellow cards was due to trailing in score. Our analyses, however, showed that this was not the case and that, instead, a significant increase in yellow cards could be observed in all three score conditions (winning, losing, drawing). Therefore, we conclude that there are at least three possible - mutually not exclusive - explanations for our observed effects in "ghost games".

1. Due to missing supporters, players experience an unfamiliar reduction of arousal and drive - based on the theories and findings of Allport (1924), Zajonc (1965) and Courneya & Carron (1992) - and therefore have trouble reaching their familiar "top game". The relationship between arousal and sporting performance has been well documented in numerous studies (e.g., Arent & Landers, 2003; Gould & Krane, 1992). In order to compensate for unusually low match performance, players are compelled to play harder and tackle more fiercely.

2. Due to missing supporters, players lack the positive support (home advantage) from the ranks in the task to defend their "territory" in the course of the game. Based on the theories and findings of Neave & Wolfson (2003) and Varca (1982), a home crowd functions as a modulator facilitating the occurrence of "functional aggressive behavior" (rule consistent aggressive behavior) in home teams. With elevated levels of testosterone in home teams compared to away teams, the lack of supporters leads to increased dysfunctional aggressive behavior, which, in turn, results in more fierce tackles and ultimately in more bookings for fouls.
3. Due to missing supporters, referees act - based on the theories and findings of e.g. Nevill, Balmer & Williams (2002), Pettersson-Lidbom & Priks (2010) and Unkelbach & Memmert (2010) - more objectively in their decision making, which leads to consequent booking of both teams after rule infringement. For example, as concluded by Pettersson-Lidbom & Priks (2010) "ghost games" decrease the effect of "social pressure" from the stands and therefore leads to changes in refereeing and officials' behavior.

Based on our findings of the present study and our previously conducted analysis of the (nonverbal) behavior of sport professionals in "ghost games" (Leitner & Richlan, in press), we argue that there are indeed significant differences in the experience of football players when performing in empty stadiums. While in our previous work we found less displayed emotional (nonverbal) behavior of players, staff and officials in "ghost games" during game breaks (i.e., due to foul, ball out of bounds, etc.), our present study indicates that the match itself becomes more fierce and aggressive with supporters missing. Our hypotheses - based on the "arousal & drive theory" and "territory theory" - regarding the underlying psychological effects on players, staff and officials appear comprehensible in the light of significant (behavioral) changes in match results and rule compliance in "ghost games". Although we assume that the COVID-19 pandemic has most likely a general psychological impact on the everyday experience of people worldwide - originating from uncertainty and fear - it is highly unlikely the sole reason for changed on-pitch-behavior of football professionals. Rather, it is more probable that situational factors during competition have a more substantial impact on the experience and performance of professional sports athletes. Because the only matchday related major difference between regular matches in late stages of season 2018/19 and "ghost games" in late stages of season 2019/20 is the missing crowd and its external stimulation, we assume that our documented effects of decreased "home advantage" and increased yellow card booking for fouls for home teams mainly attribute to the missing supporters in the stadium. The absence of spectators probably has a profound influence

on the behavior of players and referees alike, both independently contributing to the effect of the “ghost games” on the “home advantage”.

From interviews with players, staff and officials, we know that, especially at the beginning of the pandemic, matches in this extraordinary context were a particularly challenging and unfamiliar situation for all involved. As the COVID-19 pandemic is expected to accompany professional football in Europe far into 2021 (or even longer), we assume that there will be a point in time when players, staff and officials will have become accustomed to the "novel situation" of "ghost games". Based on our three possible explanations regarding the sport psychological effects we present in this study, we assume that by the end of season 20/21 (or season 21/22), a significant reduction in the effects found in season 19/20 will be observable and return to the level of season 18/19.

**Limitations.** In contrast to other studies, we decided not to analyze the data on league level or include a vast number of different (worldwide) leagues. The reason is the deliberately focused scope of our study, concentrating on both economic and sporting top tier European leagues. As mentioned above, European top 15 leagues are the most important football leagues in the world, with regular attendance in major tournaments such as UEFA Europa League and UEFA Champions League. In our view it is not sensible to mix elite leagues and minor leagues (or second or even third leagues) when investigating complex sport psychological phenomena like home advantage and underlying mechanisms. In our opinion, a more focused and controlled approach is more favorable from an empirical standpoint.

Additionally, one might note that there are various possible approaches regarding the time frames for contrasting match data from different rounds of football played over different seasons in different countries. Because we believe that stretching the time horizon for analysis only creates inaccuracies and biases the final results - as mentioned above - we decided to compare the “ghost games” of season 2019/20 only with games from the previous season of 2018/19. We are fully aware that there are other research groups dealing with this matter differently, but we strongly believe that our approach stands on reasonable empirical grounds, particularly considering the remarkably fast development of elite football.

Although we analyzed match data extensively and in depth, we cannot make decisive statements about the roles of the referees. Previous studies suggest that due to the absence of supporters, referees should be less biased by conformity and social pressure effects. We believe that this is an important research question in the context of the COVID-19 pandemic and the

extraordinary situation that emerged from it, and therefore we plan to investigate this matter in a follow-up study.

**Conclusions.** We conclude that missing supporters ("ghost games") in professional elite football (soccer) leagues to a large extent dissolve the "home advantage" effect. This missing support has also a direct effect on the experience, behavior and performance of home teams. Therefore, home teams tend to compensate with increased aggressive behavior, resulting directly in more fierce tackles and ultimately in significantly more yellow cards awarded for foul play. In addition, the referees might be more consequent in booking after rule infringement particularly for the home teams.

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