

Home-audience advantage in basketball: evidence from a natural experiment in Euro League games during the 2019-2021 Covid-19 era

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Published online: July 31, 2022

(Accepted for publication July 15, 2022)

DOI:10.7752/jpes.2022.07220

Abstract

Introduction: The possible audience effect on basketball game-related statistics in a natural setting has not been itself investigated. The EuroLeague Basketball, began the 2020-21 season with restrictions on audience attendance at the games, depending on national and/or local health guidelines, due to the Covid-19 pandemic. As a consequence, these extreme conditions provided the rare opportunity to explore the possible effect of home-audience advantage (HAA) on the most important basketball game-related statistical indexes of team technical performance (Team Performance Indicators – [TPIs]) during the last two regular seasons (2019-21) with an audience and with no audience in a natural setting. **Material and Methods:** The TPIs (e.g., Points, Rebounds, Fouls) derived from the same 17 teams and 112 games that took place in each season based on predefined inclusion-exclusion criteria and provided by EuroLeague's official site. Home advantage (HA) of the included teams was calculated as the number of home wins expressed in a percentage (%) of the total number of games included for analysis in each season (i.e., N=112). It was assumed that, except of the possible audience effect, the interaction of various factors which could impair HA would be equal in both seasons and all teams; thus, HAA per se would be reflected in the difference of home advantage between the two seasons. **Results:** The home teams won significantly more games with an audience (69) in comparison to away teams (43), whereas with no audience they did not. In the season 2019-20 the HA was 61.60%, 4.46% of which corresponds to HAA. Most TPIs were not affected by the presence or absence of an audience and were not different between home and away teams. However, home teams with an audience committed significantly ($p<0.05$) fewer Turnovers (11.92 ± 1.95) in comparison to home teams without an audience (13.33 ± 1.26). **Discussion:** Our findings confirmed, not only the existence of the HAA, but also the significant interaction of HAA on HA phenomenon and revealed that audience support was a necessary precondition for the HA when the away team was not equally familiar with the stadium as the home team in EuroLeague's regular season. This knowledge of the teams' performance may help teams' personnel, psychologists, and coaches to develop proper game strategies, training and mental practices which may further improve the teams' technical performance. **Conclusions:** Findings supported the notion that HAA has a strong effect on winning frequency and on reducing Turnovers of home teams.

Key words: attendance; behaviour; crowd support; fans; fixed effects; spectators

Introduction

The fan audience seems to have a strong impact on the outcome of an individual or team sporting event and has been usually referred as home-field advantage (Courneya & Carron, 1992; Schwartz & Barsky, 1977). In the modern approach of home advantage (HA) (Richard Pollard, 2008), this well documented phenomenon (Legaz-Arrese et al., 2013; Wallace, 2007), i.e., the increased chances greater than 50% up to ~70% of a team (e.g., basketball) to win a game while playing at home compared to the away team, has been examined in the light of the interaction of various factors, such as crowd support and behavior, game location, travel fatigue involved, training routine disruption, familiarization with the court for the away team, and also the players' critical psychological state and referee bias (Boyko et al., 2007; Bray & Martin, 2003; Carron et al., 2005; J. C. Moore & Brylinsky, 1995; Richard Pollard, 2002; Sors et al., 2019). From now on, in the present article, references to HA will presume home-advantage as a multifaceted phenomenon unless otherwise stated.

Regardless of the different factors that may contribute and explain the HA effect, the HA theory has been proved in a variety of team sports (Agnew & Carron, 1994), like American football (Richard Pollard, 1986), hockey (Courneya & Carron, 1992), and basketball (J. C. Moore & Brylinsky, 1993; R. Pollard & Pollard, 2005; Varca, 1980). Most players also feel that performing in front of their home audience helps them perform better, and this sensation alone may be enough to improve performance (Wallace, 2007). So it is generally acceptable that home teams will win ~60% of all athletic contests (Jamieson, 2010), greater than 65% in basketball (Courneya & Carron, 1992), and the presence of a sympathetic audience may also boost the home

basketball teams' confidence (Greer, 1983; Jurkovic, 1985; Wallace, 2007). Nevertheless, it seems that audience effect on HA has declined over the last decades (R. Pollard & Pollard, 2005; Richard Pollard, 2006) or as the level of competition increases (Pojskić et al., 2011); a very recent study has reported that the key factor in HA is the style of basketball play rather than the home audience (Harris & Roebber, 2019). Despite mixed results, in modern basketball players are required to perform medium-to-high-intensity (~15 sec) or explosive muscle actions of high-to-maximal intensity (2-5 sec) and have excellent technical and tactical skills (Dimitrios I. Bourdas, Zacharakis, Travlos, & Souglis, 2021; E. Zacharakis et al., 2021; E. D. Zacharakis et al., 2020), indicating the need for game-related statistical indexes of team technical performance (Team Performance Indicators – [TPIs]) to be recorded during the game. Generally speaking, the basketball game-related statistical TPIs are valuable data and a key tool for coaches for evaluating a team's performance in comparison to their opponents, for technically training and mentally preparing their team for the upcoming games (Doğan et al., 2016; M. A. Gómez et al., 2008; A. Lorenzo et al., 2010). However, to the best of our knowledge, the possible audience effect on basketball game-related statistics in a natural setting has not been itself investigated. Thus, it is not clear (in our days) if audience support per se will provide an advantage to the home team for winning the game. Moreover, it has not been clarified to what extent audience support per se will impair the most important game-related statistical TPIs in basketball.

In late 2019, there was an outbreak of a new Coronavirus disease (COVID-19) which threatened humanity in a global scale (D.I. Bourdas & Zacharakis, 2020c, 2021). Under this unprecedented threat, social distancing or self-isolation restrictions were applied by many countries, affecting, among others, people's behavior, life style, physical and sport activities (Bann et al., 2021; D.I. Bourdas & Zacharakis, 2020b, 2020a; Dimitrios I. Bourdas, Zacharakis, Travlos, Souglis, et al., 2021; Brooks et al., 2020). Major athletic events and sport activities, such as Olympics, world or national championships, had to be temporarily postponed or suspended due to fears about the spread of COVID-19; basketball events were not an exception (Dimitrios I. Bourdas, Zacharakis, Travlos, & Souglis, 2021). On March 11, 2020, the National Basketball Association (NBA) announced the suspension of the 2019–20 season and later, in order to protect its players from the COVID-19 infection, created a game isolation zone with the forthcoming games held behind closed doors. On the other side of the Atlantic, the EuroLeague Basketball, the top-tier European professional basketball club competition and the second-highest of any professional basketball league in the world behind the NBA (Wikipedia contributors, 2021), began the 2020–21 season with restrictions on audience attendance at the games, depending on national and/or local health guidelines. Nonetheless, these extreme conditions gave us the rare opportunity to study possible home-audience advantage (HAA) on TPIs in a natural setting.

Therefore, the aim of this study was to investigate the existence of HAA in a sample of games (i.e., as a single whole and not for individual teams) in the regular season of the EuroLeague and to explore the effect of HAA on the most important game-related statistics as suggested (J. Sampaio & Leite, 2013; Yu et al., 2008) and provided by EuroLeague during two regular basketball seasons, 2019–20 with an audience and 2020–21 with no audience due to COVID-19 restrictions. As a result, EuroLeague's teams may benefit from the analysis of HAA on the most important game-related statistical TPIs by adjusting respectively their game tactics and building psychological skills, in order to efficiently improve the team's technical performance (Birrer & Morgan, 2010; Dimitrios I. Bourdas, Zacharakis, Travlos, & Souglis, 2021; E. W. G. Moore & Gearity, 2019). Nevertheless, this article focuses mainly on the scientific evidence for the potential association of HAA and basketball game-related statistics of team performance results rather than on understanding the mechanism(s) responsible for this multifactorial phenomenon.

Materials and Methods (Figure 1)

Teams and games

EuroLeague is a closed inter-club basketball event consisting of 18 European man teams. Under normal conditions, in the seasons 2019–20 and 2020–21, each team with a balanced game schedule should have played 34 games (home and away) of the 306 games in total per regular season, or 68 of the 612 games in total in the last two regular seasons. Nevertheless, in the COVID-19 era, the season 2019–20 was halted after the 28th round due to EuroLeague's decision to terminate the season because of the COVID-19 pandemic; in the season 2020–21 (while audience was not allowed in most European countries) some countries allowed audiences in certain home games. Therefore, to ensure that the TPIs for statistical analysis in the present research derived from the same teams and games that took place in both regular seasons (under two different conditions, i.e., the season 2019–20 with an audience and the season 2020–21 with no audience), the selection of the games eligible for inclusion was based on the following inclusion-exclusion criteria.

- i) Games that did not take place or did not finish successfully in respect of EuroLeague's official regulations, for any reason, in the seasons 2019–20 or 2020–21 and their relevant games (home or away) in both seasons respectively were excluded from the analysis.
- ii) Games in the season 2019–20 should have had audience while in the 2020–21 season should had no audience due to national or local COVID-19 restrictions. So, if a team had no audience in its home games in the season 2019–20 for any reason (i.e., due to punishment or due to local or national restrictions towards the end of the season), its relevant games (home or away) in both seasons were excluded from the

analysis. Similarly, if an audience was allowed in some games in the season 2020-21, both the home games and the relevant away games, as well as the respective games in the season 2019-20, were excluded from the analysis.

- iii) Teams (and therefore the relevant games) should have not been exposed to hypoxia and altitude. However, it has been assumed that arenas' microclimate was similar to each game.

Procedure

For TPIs data extraction of the last two regular seasons (i.e., 2019-20 and 2020-21), we used the official site of EuroLeague for game-related statistics (<https://www.euroleague.net/competition/teams>), which is considered valid and reliable (M. Á. Gómez et al., 2018). Consequently, the following TPIs were extracted and analysed: Wins, Score, Point Difference (Home team – Away team), 2 & 3-Point Field Goals Made, 2 & 3-Point Field Goals Attempts, 2 & 3-Point Field Success Rate, Free Throws Made, Free Throws Attempts, Free Throws Success Rate, Offensive Rebounds, Defensive Rebounds, Total Rebounds, Assists, Steals, Turnovers, Blocks in Favor, Blocks Against, Fouls Committed, Fouls Received, Technical Foul and Performance Index Rating [PIR: (Points made + Rebounds + Assists + Steals + Blocks + Fouls Drawn) - (Missed Field Goals + Missed Free Throws + Turnovers + Shots Rejected + Fouls Committed)]. Home advantage of the included teams was calculated as the number of home wins expressed in a percentage (%) of the total number of games included for analysis in each season (i.e., N= 112). It was assumed that, except of the possible audience effect, the interaction of various factors (e.g., players' turnover between seasons, game's location, scheduling of games, travel fatigue involved, training routine disruption, familiarization with the court for the away team, referee bias) which might impair HA would be equal in both seasons and all teams; thus, HAA per se would be reflected in the difference of HA between the two seasons.

Statistical analysis

Statistical analyses were performed using SPSS for windows v23, (IBM Corp., Armonk, NY, USA) and statistical significance was set at $p \leq 0.05$ *a priori*. In order to determine if there is a relation between the game's outcome (win vs lost) and the game's season (2019-20 vs 2020-21), Chi-squared (χ^2) tests were performed (Beasley & Schumacher, 1995). One-way repeated measures analyses of variances (ANOVAs) were used to locate differences in TPIs among home and away teams with and without an audience. Unless otherwise noted, qualitative variables (e.g., wins) are presented as frequency, relative frequency (%) and [95 % confidence interval (CI)], while quantitative data are reported as mean \pm standard deviation (SD) and [95 % CI].

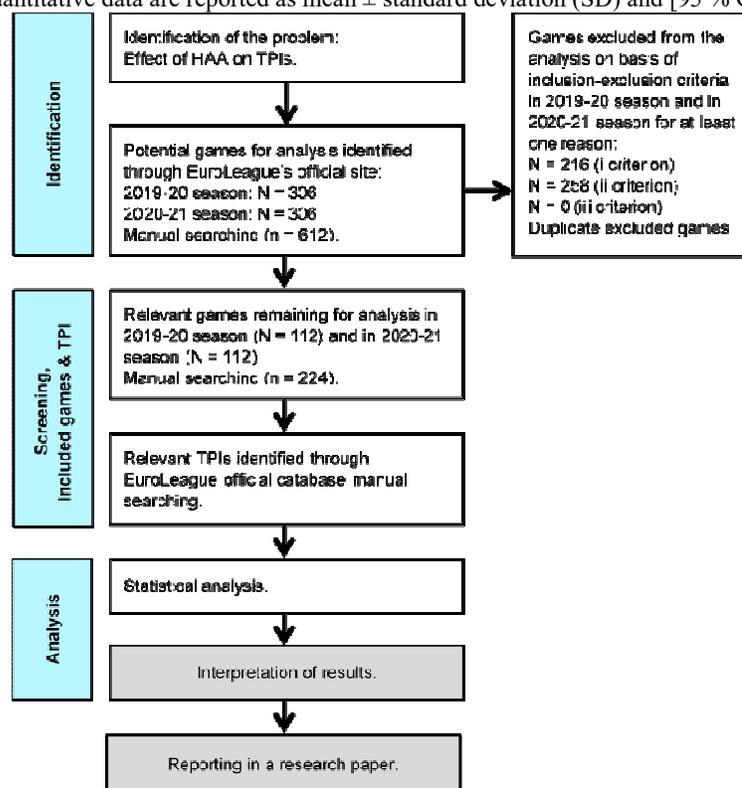


Figure 1. Flowchart of the research design (i, ii and iii criteria are explained in the text). Abbreviations: *HAA*, home-audience advantage; *TPIs*, game-related statistical indexes of team technical performance.

Results

In the season 2019-20, three teams had no audience in their home games (due to punishment) and the last 6 rounds of the season (i.e., 54 overall games) canceled (due to EuroLeague's decision to cancel the rest of

the season because of the COVID-19 outbreak); thus, their relevant games (home and away) in both seasons were excluded from our analysis. In the season 2020-21, nine (9) countries (i.e., 12 teams in total) were allowed an audience in some games; similarly, these relevant games (home and away) from the season 2020-21, as well as the respective games from the season 2019-20 were excluded from the analysis (Figure 1). Therefore, removing the excluded games, 112 games from the season 2019-20 and 112 games from the season 2020-21, derived from 17 teams (representative mix of top, intermediate, and bottom teams included across both seasons), were finally included in the current analysis.

EuroLeague’s TPIs in home and away games with and without an audience are presented in Table 1. Chi-square (χ^2) analysis showed no statistical significance association among home and away win games with and without an audience; that is, both home win and away win games were equally observed season 2019-20 versus season 2020-21 ($\chi^2(1) = 0.463, p = 0.496$). However, one sample chi-square test could not demonstrate that home win and away win games were equally observed in 2019-20 season and not equally in 2020-21 season ($\chi^2(1) = 6.036, p = 0.014$ and $\chi^2(1) = 2.286, p = 0.131$, respectively). Home advantage was 61.60% and 57.14% in seasons 2019-20 and 2020-21 respectively, so HAA was 4.46% in the season 2019-20 (Figure 2). The results of the one-way ANOVA with repeated measures on Mean Scores for games with an audience home and away and with no audience home and away showed no statistical significance ($F(3, 48) = 2.74, p = 0.053$). The findings of the Point Difference between home and visitor teams for home and away games with and without an audience indicated statistical significance ($F(3, 48) = 16.26, p < 0.001$). Bonferroni post hoc analysis revealed that home teams with an audience ($M = 4.60 \pm 5.60$) and without an audience ($M = 3.27 \pm 4.56$) achieved a higher point difference than away teams with an audience ($M = -3.60 \pm 6.89$) and without an audience ($M = -2.93 \pm 5.77$), respectively. The rest of the paired comparisons did not reach statistical significance ($p > 0.05$).

The 2-Point Field Goals and the 2-Point Field Attempts repeated measures analyses did not reach statistical significance ($F(3, 48) = 2.30, p = 0.089$; $F(3, 48) = 1.29, p = 0.289$, respectively). The repeated measures analysis of the 2-Point Field Goals Success Rate showed statistical significance ($F(3, 48) = 3.44, p = 0.024$); however, Bonferroni post hoc analysis did not reach statistical significance for any of the paired comparisons ($p > 0.05$). The 3-Point Goals, the 3-Point Attempts, and the 3-Point Goals Success Rate repeated measures analyses did not reach statistical significance ($F(3, 48) = 1.17, p = 0.336$; $F(3, 48) = 1.12, p = 0.349$; $F(3, 48) = 2.33, p = 0.087$, respectively). Similarly, Free Throws Points Made, Free Throws Attempts, and Free Throws Success Rate did not yield statistical significance ($F(3, 48) = 0.469, p = 0.705$; $F(3, 48) = 0.785, p = 0.508$; $F(3, 48) = 2.16, p = 0.105$, respectively).

The results of the one way repeated measures ANOVA for Offensive Rebounds, Defensive Rebounds, and Total Rebounds did not reach statistical significance ($F(3, 48) = 1.17, p = 0.330$; $F(3, 48) = 0.442, p = 0.724$; $F(3, 48) = 1.67, p = 0.186$, respectively). The results of the Assists showed statistical significance ($F(3, 48) = 3.50, p = 0.022$) and Bonferroni post hoc analysis revealed that home teams without an audience had significantly more Assists ($M = 18.70 \pm 2.39$) than away teams with an audience ($M = 16.44 \pm 2.53$) and without an audience ($M = 17.02 \pm 1.91$). The rest of the paired comparisons did not reach statistical significance ($p > 0.05$). Steals did not reach statistical significance ($F(3, 48) = 2.26, p = 0.093$). Turnovers showed statistical significance ($F(3, 48) = 6.91, p = 0.001$) and Bonferroni post hoc analysis revealed that home teams with an audience had significantly less Turnovers ($M = 11.92 \pm 1.95$) than home and away teams without an audience ($M = 13.33 \pm 1.26$; $M = 13.99 \pm 1.45$, respectively). The rest of the paired comparisons did not reach statistical significance ($p > 0.05$).

Blocks in Favor and Blocks Against did not differentiate as a function of home and away teams with and without an audience ($F(3, 48) = 0.853, p = 0.472$; $F(3, 48) = 0.635, p = 0.596$, respectively). Fouls Committed, Fouls Received and Technical Fouls did not reach statistical significance ($F(3, 48) = 1.02, p = 0.393$; $F(3, 48) = 1.52, p = 0.928$; $F(3, 48) = 0.577, p = 0.633$, respectively). PIR showed statistical significance ($F(3, 48) = 7.37, p < 0.001$) and Bonferroni post hoc analysis revealed that (i) home teams with audience ($M = 92.01 \pm 10.19$) had significantly higher values than away teams with and without an audience ($M = 81.98 \pm 13.53$; $M = 84.51 \pm 7.87$, respectively) and (ii) home teams without an audience ($M = 91.97 \pm 6.94$) than away teams without an audience. The rest of the paired comparisons did not reach statistical significance ($p > 0.05$).

Table 1. EuroLeague’s game-related statistical indexes of team technical performance (TPIs) in home and away with (N = 112 games) and without an audience (N = 112 games) derived from 17 teams.

TPI	Home Teams With Audience (2019-20 season)	Away Teams With Audience (2019-20 season)	Home Teams No Audience (2020-21 season)	Away Teams No Audience (2020-21 season)
^a Wins	69 (61.60%)† [0.53 – 0.71]	43 (38.39%) [0.29 – 0.47]	64 (57.14%) [0.48 – 0.66]	48 (42.86%) [0.34 – 0.52]
^b Score	81.16 ± 7.14 [77.49 – 84.83]	77.05 ± 6.90 [73.04 – 80.08]	81.15 ± 3.37 [79.42 – 82.88]	77.99 ± 4.22 [75.39 – 80.38]
^b Point Difference	4.60 ± 5.60† [1.72 – 7.48]	-3.60 ± 6.89 [-7.14 – -0.06]	3.27 ± 4.56† [0.93 – 5.61]	-2.93 ± 5.77 [-5.90 – 0.04]
^b 2-Point Field Goals Made	19.87 ± 2.15 [18.77 – 20.98]	18.43 ± 1.89 [17.46 – 19.40]	19.62 ± 1.95 [18.62 – 20.62]	19.75 ± 1.71 [18.87 – 20.63]

^b 2- Point Field Attempts	36.93 ± 3.55 [35.10 – 38.75]	35.67 ± 2.79 [34.23 – 37.10]	37.04 ± 3.46 [35.26 – 38.81]	36.02 ± 2.35 [34.81 – 37.23]
^b 2-Point Field Success Rate (%)	53.91 ± 3.94 [51.88 – 55.94]	51.69 ± 3.93 [49.67 – 53.72]	53.05 ± 3.53 [51.23 – 54.86]	54.84 ± 3.44 [53.07 – 46.61]
^b 3-Point Goals Made	9.10 ± 1.83 [8.16 – 10.04]	8.93 ± 1.84 [7.98 – 9.88]	9.46 ± 1.39 [8.75 – 10.18]	8.49 ± 1.33 [7.80 – 9.17]
^b 3-Point Attempts	24.69 ± 3.15 [23.07 – 26.31]	24.75 ± 4.32 [22.54 – 26.97]	23.64 ± 2.85 [22.18 – 25.11]	23.52 ± 2.91 [22.02 – 25.01]
^b 3-Point Success Rate (%)	37.04 ± 6.01 [33.95 – 40.12]	37.04 ± 6.01 [33.95 – 40.12]	40.22 ± 5.08 [37.61 – 42.83]	36.20 ± 4.81 [33.73 – 38.67]
^b Free Throws Point Made	14.13 ± 2.80 [12.68 – 15.56]	13.40 ± 2.38 [12.17 – 14.62]	13.52 ± 2.47 [12.25 – 14.79]	13.05 ± 2.11 [11.61 – 14.50]
^b Free Throws Attempts	18.10 ± 3.58 [16.26 – 19.94]	17.37 ± 2.65 [16.00 – 18.73]	16.62 ± 3.07 [15.05 – 18.20]	16.61 ± 3.37 [14.88 – 18.34]
^b Free Throws Success Rate (%)	78.41 ± 5.97 [75.34 – 81.47]	77.11 ± 6.22 [73.91 – 80.31]	81.59 ± 5.27 [78.88 – 84.30]	78.58 ± 5.39 [75.81 – 81.35]
^b Offensive Rebounds	9.95 ± 1.65 [9.10 – 10.80]	10.29 ± 2.43 [9.04 – 11.54]	9.68 ± 1.69 [8.81 – 10.55]	9.18 ± 1.32 [8.50 – 9.87]
^b Defensive Rebounds	23.76 ± 2.17 [22.65 – 24.88]	23.25 ± 2.95 [21.74 – 24.77]	23.21 ± 1.97 [22.20 – 24.22]	22.99 ± 2.22 [21.85 – 24.13]
^b Total Rebounds	33.71 ± 2.40 [32.48 – 34.95]	33.54 ± 2.55 [32.23 – 34.85]	32.89 ± 2.61 [31.54 – 34.23]	32.19 ± 2.46 [30.92 – 33.44]
^b Assists	17.81 ± 2.36 [16.90 – 19.03]	16.44 ± 2.53 [15.14 – 17.75]	18.70 ± 2.39* [17.47 – 19.93]	17.02 ± 1.91 [16.04 – 18.01]
^b Steals	7.03 ± 1.48 [6.27 – 7.70]	6.19 ± 1.11 [5.62 – 6.75]	7.07 ± 1.19 [6.46 – 7.69]	6.53 ± 1.11 [5.96 – 7.10]
^b Turnovers	11.92 ± 1.95‡ [10.91 – 12.92]	13.61 ± 1.44 [12.87 – 14.35]	13.33 ± 1.26 [12.68 – 13.98]	13.99 ± 1.45 [13.25 – 14.74]
^b Blocks in Favor	2.71 ± 0.77 [2.32 – 3.11]	2.43 ± 1.04 [1.90 – 2.97]	2.38 ± 1.10 [1.82 – 2.95]	2.35 ± 0.74 [1.97 – 2.73]
^b Blocks Against	2.64 ± 1.36 [1.94 – 3.34]	2.48 ± 0.88 [2.03 – 2.93]	2.43 ± 0.63 [2.10 – 2.75]	2.16 ± 0.84 [1.73 – 2.60]
Fouls Committed	19.66 ± 2.80 [18.22 – 21.10]	20.67 ± 2.37 [19.46 – 21.89]	19.77 ± 2.01 [18.74 – 20.81]	20.59 ± 1.90 [19.62 – 21.57]
^b Fouls Received	20.42 ± 2.11 [19.33 – 21.50]	20.13 ± 1.99 [19.10 – 21.15]	20.00 ± 1.65 [19.15 – 20.85]	20.05 ± 1.30 [19.38 – 20.72]
^b PIR	92.01 ± 10.19# [86.77 – 97.24]	81.98 ± 13.53 [75.02 – 88.94]	91.97 ± 6.94† [88.40 – 95.54]	84.51 ± 7.87 [80.47 – 88.56]
^b Technical Fouls	0.08 ± 0.10 [0.03 – 0.13]	0.089 ± 0.10 [0.04 – 0.14]	0.119 ± 0.15 [0.04 – 0.19]	0.134 ± 0.20 [0.03 – 0.24]

^a Data are presented as frequency, relative frequency (%), and [95% CI].

^b Data are presented as mean ± SD, and [95% CI].

* p < 0.05, significant difference of home teams without an audience with away teams with and without an audience.

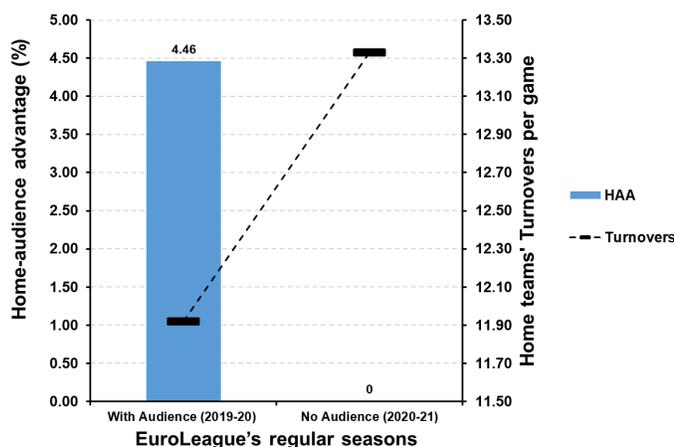
† p < 0.05, significant difference between home and away teams in the same season.

‡ p < 0.05, significant difference between home teams with audience with home and away teams without an audience.

p < 0.05, significant difference between home teams with an audience with away teams with and without an audience.

Abbreviations: *CI*, confidence interval; *PIR*, Performance Index Rating; *SD*, standard deviation.

Figure 2. Depiction of the interaction of home-audience advantage (HAA) with Turnovers committed by the home teams in two consecutive regular seasons of EuroLeague. Data are presented as means.



Discussion

The audience appears to have a significant impact on the outcome of an individual or team athletic event (Courneya & Carron, 1992; Schwartz & Barsky, 1977) and perhaps in a regular basketball season of EuroLeague. Nonetheless, it is not known if crowd support will also impair the basketball game-related TPIs. The purpose of this study was to examine to what extent the possible HAA will impair the most important game-related statistical TPIs during the last two regular basketball seasons (2019-21) in EuroLeague, with respect to presence (season 2019-20) or absence (season 2020-21) of an audience. Although the Point Difference was significant in favor of home teams with or without an audience, it seems that home teams won significantly more games in the presence of an audience compared to away teams. In the season 2019-20, HA was 61.60%, 4.46% of which corresponds to HAA. It was also observed that home teams in the presence of the audience committed significantly fewer Turnovers compared to home teams without an audience, whereas in the absence of the audience they had more Assists in comparison to away teams. Moreover, it was observed that the home teams performed significantly better (as reflected in the PIR) regardless of the presence or absence of an audience.

Although collegiate basketball players seem to have 76% more self-confidence when playing at home (Jurkovic, 1985), the HA effect was confirmed in a number of basketball studies (R. Pollard & Pollard, 2005; Richard Pollard & Gomez, 2007) and it was reported that NBA (seasons 2001-2014) and European teams playing at home in the regular season concisely win ~60% (Richard Pollard & Gomez, 2013; Ribeiro et al., 2016), in recent years it was observed that the effect not only has diminished (e.g., in NBA itself or in comparison to European leagues) (Harris & Roebber, 2019; R. Pollard & Pollard, 2005; Richard Pollard & Gomez, 2007; Ribeiro et al., 2016; Smith, 2003) but tends to disappear where the away team is equally familiar with the court as the home team, even if the home team has the most crowd support (Van de Ven, 2011). In the present study, none of the included teams had a common home court with another one, which means that the away teams did not have the same familiarity with the stadium as the home teams. So, the fact that home teams (regardless of the presence or not of an audience) had the chance to win more games (23.22% with an audience and 14.28% without an audience) compared to away teams, and that the Point Difference and PIR were significant in favor of the home teams with or without an audience, further strengthens the evidence in support of the HA hypothesis in a regular season of EuroLeague independently of audience presence. Indeed, TPI analysis of the included games indicated that the HA in games with an audience (61.60%) was significant and was in line with previously reported values, 60.30% (NBA from 1995-2007) and 60.13% (222 worldwide different league seasons from 2011-2015) (Richard Pollard et al., 2017; Richard Pollard & Gomez, 2007). Additionally, the observation that home teams in the presence of an audience won significantly more games than away teams, whereas without an audience they did not, and also that home teams in the presence of the audience committed significantly fewer Turnovers compared to home teams without an audience, confirmed not only the existence of the HAA (4.46%) in a regular basketball season of EuroLeague, which was in line to HAA (5%) reported in baseball (Carron & Paradis, 2014), but also the significant interaction of HAA (as an important factor) on HA phenomenon and revealed that audience support was a necessary precondition for the HA when the away team was not equally familiar with the stadium as the home team in EuroLeague's regular season.

On the other hand, several TPIs have been utilized in basketball statistics, but only a few have been deemed important to the outcome (Doganc & Ersoz, 2019; J. Sampaio & Leite, 2013; Yu et al., 2008). For instance, in the 2000 European Championship only the rebounds (offensive and defensive), the assists and the 2-point field goals game-related statistics were associated with the game winners (Dezman et al., 2002). Rebounds, 2 & 3-point shooting % and assists were the TPIs with the greatest impact on the outcome of a season among Spanish first-division teams (García et al., 2013; M. Á. Gómez et al., 2008), whereas in another study defensive rebounds, successful 2-point field-goals and successful free-throws had the strongest impact on the outcome (Ibáñez et al., 2009). It also seems that senior teams differed from U-18 teams in that they had more assists and a lower steals % (Jaime Sampaio et al., 2004). It is understood that various TPIs recorded in basketball games do not affect the game's outcome equally. With respect to home and away teams of NLB-Adriatic league, EuroLeague-regular season and EuroLeague-Top 16, the starting five on home teams have more points scored, more assists, and steals, while the starting five on away teams have more turnovers (Pojskić et al., 2011). It seems that offensive instrumental aggressiveness as measured by the shooting efficiency is higher in home teams (Jaime Sampaio et al., 2008), probably due to higher self-confidence, motivation and lower anxiety caused by the audience in contrast to away teams (Thuot et al., 1998) whereas defensive assertiveness as measured by the personal-fouls between home and away adult teams seems not to be always a discriminating factor (Mateus et al., 2021; Jaime Sampaio et al., 2004). On the other side of Atlantic, in the NBA, home teams who make more two point and free-throw shots have larger HA (Harris & Roebber, 2019). Although all these game-related TPIs may be attributed to the offensive and defensive tactics followed by home teams, various observed TPIs in the present study (i.e., 2 & 3 -Point Field Goals Made/Attempts/Success Rate, Free Throws Point Made/Attempts/Success Rate, Offensive/Defensive/Total Rebounds, Steals, Blocks in Favor/Against, Fouls Committed/Received and Technical Fouls) were not affected by the presence or absence of an audience, nor did they differ between home and away teams. In a sense, these findings confirm that the values of most game-related TPIs based on multifactorial variables determine a complicated dynamic system throughout the game which is difficult to regulate in its entirety from the presence or absence of an audience. Nevertheless, there was

an exception: home teams in the presence of an audience committed significantly fewer Turnovers compared to home teams without an audience (Figure 2), whereas in the absence of an audience they had more Assists than away teams. This may be happen because home players under audience pressure are more careful and/or hesitant (e.g., they do not attempt risky passes) and/or away teams play a less aggressive or forceful defence (Pojskić et al., 2011), whereas in the absence of audience pressure they may take more risks and eventually perform more Assists. Even though this is a “risky” speculation, one mistake can result the lost of a game. Therefore, Turnovers and the level of risk taking for a difficult pass or an Assist in the game may be a key factor in HAA, especially the moment when the outcome of a game can be judged by one point; this remains to be clarified.

It appears that HAA has a strong impact on winning frequency and on reducing Turnovers of home teams in the presence of an audience. However, there have been reported cases where home audience can negatively affect the home team (R. F. Baumeister, 1984; R. F. Baumeister et al., 1990; Wallace et al., 2005). In key moments of important games, performance pressure naturally rises for both teams; nevertheless, home teams have more reason to feel pressure than their opponents, since home players know that their audience (and perhaps the local social media) expects them to defeat an away team of similar ability. This home-audience disadvantage phenomenon could occur in cases where the home team initially seeks an easy victory but the away team is very close to the score, so while the home team struggles to remain confident, the away team keeps building up their own confidence. However, in the present study, there was no evidence of a negative audience effect on the TPIs of the home teams during the regular season games.

Strength, limitations and suggestions for future research

In this unfortunate situation for humanity (the COVID-19 crisis), where, among other unfavorable effects, there was an increase in psychological problems (Dimitrios I. Bourdas, Zacharakis, Travlos, Souglis, et al., 2021; Brooks et al., 2020; Schinke et al., 2020), life style impaired (Kim, 2020) and physical activity and basketball activities on a local or national level were reduced (D.I. Bourdas & Zacharakis, 2020b, 2020a; Dimitrios I. Bourdas, Zacharakis, Travlos, & Souglis, 2021; Constandt et al., 2020; Maugeri et al., 2020), we have been given a rare opportunity to examine the possible audience impact on the various TPIs recorded in a sample of EuroLeague’s basketball games in a natural setting during this period. As it seems that there is not seasonal differences in match-play demands, seasonal TPIs have normal distribution and therefore assuming that the TPIs variations remained constant across the two seasons (Fanson, 2020; J. Lorenzo et al., 2019; Petway et al., 2020), our current findings highlight not only the existence of the HA but also the impact of the home audience to helping home teams reduce Turnovers and increase their chances of winning. However, our results are not derived from complete league and over time data but only from comparative data of the two last consecutive regular seasons in the basketball EuroLeague, which is also a men’s league. It seems that in some cases females are unaffected or less affected by HA compared to males (Koning, 2011; Krommidas et al., 2019; Richard Pollard et al., 2017). Thus, we do not know if the HAA remains the same (or how much fluctuates) over time and, most importantly, we do not know how players adapt and get used to every new situation over time. Although home teams may benefit from the HAA, we still do not know if the team that plays at home second may have a greater advantage, as is more likely to happen in a two-stage knock-out competition (Legaz-Arrese et al., 2013; Page & Page, 2007) or in play-off games (Jamieson, 2010). We also do not know how our findings may be impaired by a possible differentiation of the capacity or ability of the teams between the two seasons and by the players’ positive COVID-19 cases which may affect the capacity of the teams. Although HAA is a multifactorial phenomenon with many unknown aspects, in the present study we mainly focused on the HAA on TPIs and we did not isolate other relevant individual factors [e.g., function of crowd size-density-noise-proximity versus referee or judging bias and vice versa (Legaz-Arrese et al., 2013)] which may be associated with the existence of HAA, as it has proved quite difficult to isolate and quantify them (Richard Pollard, 2006). In terms of ecological validity, since our results reflect EuroLeague’s conditions from a sample of games in a specific period (2019-2021) in regular seasons only, the findings of this study should be treated with caution and under the prism of the aforementioned limitations. More research is needed to test our hypothesis in different arena sizes, players’ positions, play-off games, and various individual or team sport games, at different levels and for female athletes.

Perspectives and conclusion

It seems that HAA has a strong effect (4.46%) on winning frequency and on reducing Turnovers of home teams in EuroLeague. The determination of HAA with its interaction on the most important game-related statistics increases the knowledge on team performance and may help team personnel and coaches to develop proper training practices and game strategies, while psychological interventions on mood state, cognitive-emotional regulation and psychological skills, provided by sport psychologists, may further improve the teams’ technical performance (Birrer & Morgan, 2010; Dimitrios I. Bourdas, Zacharakis, Travlos, & Souglis, 2021; E. W. G. Moore & Garity, 2019). Thus, pre-game for the better preparation of the teams, coaches and technical teams should take into account individual factors (e.g., players experience, court position, sex), team factors (e.g., game tactics and strategy) and any other possible factors (e.g., travels, referee bias, season period) related to HA (Mateus et al., 2021).

In conclusion, our findings confirm not only the existence of the HAA, but also the significant interaction of the HAA on the HA phenomenon, demonstrating that audience support is a necessary precondition for the HA when the away team is not as familiar with the stadium as the home team during the regular season of the EuroLeague. Though it is recommended our results be used for planning the team strategies, the exact mechanism by which HAA influences team game performance has yet to be determined, and more research is required.

Acknowledgments

No financial support was received for the conduct of this study or the preparation of this manuscript.

Authors declare that they have no conflicts of interest that are directly relevant to the content of this article.

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