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A LONGITUDINAL INVESTIGATION OF CROWD DENSITY AND THE HOME COURT PHENOMENON IN THE WOMEN'S NATIONAL BASKETBALL ASSOCIATION

Orton, Spencer;
Maggio, Paul;
DeBeliso, Mark[i]
Southern Utah University,
Department of Kinesiology
and Outdoor Recreation,
Cedar City, UT,
USA

Abstract:
The home team advantage has been extensively documented and studied in many team sports, especially men's basketball leagues. In contrast, research that has examined the home court advantage in women's basketball leagues could not be found. Therefore, this study was designed to answer the following questions: (1) is the home court advantage present in the woman's national basketball association (WNBA)? (2) is there a relationship between crowd density and referee bias in favor of the home team in the national woman's basketball league? (3) is there a relationship between crowd density and home team performance in the woman's national basketball league? The study at hand employed a longitudinal study approach to examine 5 regular seasons (2015-2019) of 10 WNBA teams. Data for fan attendance, sport arena capacity, and box scores were collected from public domains. Statistical calculations and analysis were used to compare chosen box scores between the home team and away team. Similarly, chosen box scores were compared between home games that had a crowd density above 50% and home games that had a crowd density below 50%. The results of this study showed that the home court advantage was present in the woman's national basketball league. In contrast to research studies that examined referee bias in men's basketball leagues, the results of this study are conflicting and inconclusive. However, home games that had crowd density above 50% significantly outperformed home games that had crowed density below 50%, both offensively (p=0.003) and defensively (p=0.002).

Keywords: WNBA, statistics, box scores

[i] Correspondence: email markdebeliso@suu.edu

1. Introduction

The home team advantage is a well-known phenomenon that is visible in many sports and suggests that the home team of any sport receives a performance advantage when they compete at home ground compared to their performance when they compete at away ground, with similar conditions (Koning, 2005, p.422). For many sports, this phenomenon can be simply measured and expressed as a percentage calculated by dividing the number of games a team won at home by all the games the team played in that season (Clarke, 2005). Over the past several years the amount of literature concerning the "*home team advantage*" phenomenon in basketball has gradually increased (Boudreaux et al., 2017; Courneya & Carron, 1992; Dilger & Vischer, 2022; Entine & Small, 2008; Harris & Roebber, 2019; Gobikas et al., 2020; Harville & Smith, 1994; Reese Jr. et al., 2013; van Bommel et al., 2021; and Yi, 2017). At this time there is no definitive reason to explain why the home team performs better at home ground compared to away ground, but there are multiple variables that have been identified as possible factors that may influence the overall performance of the home team when they play at home ground. This is especially true in the case of basketball, which is considered one of the most popular sports worldwide.

Home court advantage has been evident in men's college basketball (van Bommel et al., 2021; Yi, 2017), the Euroleague (Gobikas et al., 2020), and the NBA (Boudreaux et al., 2017; Entine & Small, 2008). Since basketball is a sport that is played indoors, the outside weather has no influence on the player and team performance. Although the weather is not considered to be a factor that affects home team performance in basketball, other factors such as home court familiarity (Pollard, 2002; Yi, 2017), travel distance (Boudreaux et al., 2017; Yi, 2017), fatigue (Ashman et al., 2010; Entine & Small, 2008), psychology (Bray & Widmeyer, 2000; Bray, Jones, & Owen, 2002), style of play (Harris & Roebber, 2019), human bias (Anderson & Pierce, 2009; Sutter & Kocher, 2004; van Bommel et al., 2021), and crowd support (Agnew & Carron, 1994; Gobikas et al., 2020: Harris & Roebber, 2019: Smith, 2003; van Bommel et al., 2021) have all been identified as possible contributing factors to the advantage at home. Each of the mentioned factors has been examined to one degree or another in men's basketball, both at the college level and professional level. In contrast, there is only one research study that could be found, at this time that has examined possible factors that contribute to home court advantage in women's basketball (van Bommel et al., 2021). However, the findings of this study were obtained only by analyzing both men and women college basketball players in all divisions of the NCAA.

Although there is evidence that home court advantage is present in women's basketball at the college level (van Bommel et al., 2021), there is still a need for additional research to examine possible factors that contribute to home team advantage in both the female NCAA and the WNBA. For example, there is ample evidence in men's basketball that crowd size positively influences home team performance at all levels (Agnew & Carron, 1994; Anderson & Pierce, 2009; Boudreaux et al., 2017; Gobikas et al., 2020; van

Bommel et al., 2021; Yi, 2017). In contrast, there is no evidence at this time that suggests that crowd size can influence home team performance in the WNBA. Furthermore, some suggest that referee bias in men's basketball could be impacted by fan attendance size and crowd noise (Anderson & Pierce, 2009; Sutter & Kocher, 2004; van Bommel et al., 2021), but there has been no research to determine if crowd size has any impact on referee bias in the WNBA.

As such, this study attempted to address the following questions: is the home court advantage present in the WNBA?, is there a relationship between crowd density and referee bias in favor of the home team in the WNBA?, is there a relationship between crowd density and home team performance in the WNBA?

2. Methods

2.1 Participants

This study implemented a longitudinal approach to examine 5 regular WNBA seasons of all 6 eastern conference WNBA teams and 4 western conference WNBA teams from 2015 to 2019. Two of the 6 western conference teams were not consistently part of the league during the aforementioned time frame, only the teams that were consistently apart of the league were included. Furthermore, because of the Covid-19 pandemic, seasons 2020 and 2021 were excluded from this study due to unusually low fan attendance.

2.2 Instruments and Apparatus

Attendance data and the exact location of each game and basketball arena were collected from the following public domain *WNBA Historical Attendance Data - WNBA (acrossthetimeline.com)*. Similarly, box score data were collected from the same public domain, but from a different page: *WNBA Historical Box Score Data – WNBA (https://acrossthetimeline.com/wnba/teams.html#segment=reg&team=Indiana%20Fever)*. The first webpage contained attendance data and the name of the sport arena for each game for each WNBA team, which was used to estimate crowd size and identify the name of the arena for each game. After the name of each arena was identified for each game, Wikipedia was used to identify the total capacity for each basketball arena. Crowd density was then calculated by dividing game attendance by basketball arena capacity for each game. The second webpage contained basic and advanced box scores for each WNBA team which were used to measure performance efficiency and determine if there was referee bias. For this study, data from the advance box scores ORtg (team offensive rating) and DRtg (team defensive rating) were gathered to determine overall team performance, while basic box scores such as PF (personal fouls) and FTA (free throw attempts) were collected to observe possible referee bias towards the home team.

Figure 1: Collegiate athletes aspiring to earn a spot on a WNBA team

(Images courtesy of Southern Utah University Athletics)

2.3 Procedures

This study utilized a three-step approach. The first stage consisted of collecting data for attendance, arena capacity, personal fouls (PF), free throw attempts (FTA), team offensive rating (ORtg), and team defensive rating (DRtg) for each game of each season from 2015 to 2019 for the following WNBA teams: Atlanta Dream, Chicago Sky, Connecticut Sun, Indiana Fever, New York Liberty, Washington Mystics, Los Angeles Sparks, Minnesota Lynx, Phoenix Mercury, and Seattle Storm. The data was then transferred to Microsoft excel to be further organized and analyzed. During the second stage, an initial analysis transpired which utilized statistical calculations for each box score mentioned above to compare these box scores between the home team and visiting team for each game and each season as well as between home games that had a crowd density above 50% and home games that had a crowd density below 50%. The final stage included a discussion and closing analysis that was synthesized from the interpretation of the data and previous research findings concerning home court advantage. As a result of the COVID 19 virus, the fan attendance numbers for the past two seasons were dramatically below

the average attendance of previous seasons. Therefore, data was retrieved from 2015 and 2019.

3. Design and Analysis

The variables assessed in this study were: crowd density, PF, FTA, ORtg, DRtg, for home and visiting WNBA teams (2015-2019). Independent t-tests were used to compare home vs. visiting teams' variables of: PF, FTA, ORtg, DRtg ($\alpha \leq 0.05$). An independent t-test was also used to compare the variables of: PF, FTA, ORtg, DRtg between crowd densities of >50% vs. <50% ($\alpha \leq 0.05$). Data management and statistical analysis with conducted in MS Excel and Stata Statistical software.

4. Results

After gathering box score data and crowd size data for each game from seasons 2015-2019 for each of the chosen WNBA teams, the data was then organized into the following tables. Table 1 provides a summary of descriptive statistics for both home teams and visiting teams for every game of each season.

To determine if the home court phenomenon was present in the WNBA from 2015 to 2019, the summary statistics for both the home teams and the visiting teams were compared and displayed in Table 2.

As exhibited in Table 2, the home team on average significantly received fewer personal foul calls (p=0.000) and was given significantly more free throw attempts (p=0.000) than the visiting team. This could suggest the existence of referee bias, but the significant differences are small. Table 2 also shows that on average the home team significantly scored more points within 100 ball possessions than the visiting team (p=0.000). In contrast, the visiting team on average significantly scored fewer points within 100 ball possessions than the home team (p =0.000). These findings show that on average the home team significantly outperformed the visiting team in both offense and defense efficiency. Now that the home court advantage phenomenon has been found to be present in the WNBA, findings for the hypothesis of this study can be seen in Table 3.

Table 3 provides a comparison of statistical findings of the chosen variables for home games that reported a crowd density above 50% versus home games that reported a crowd density below 50%. Crowd density was calculated by dividing the total fan attendance by the arena's capacity for each game. The groups were then formed by assigning games that had a crowd density above 50% (375) to the "Above 50%" group and assigning games that had a crowd density below 50% (474) to the "Below 50%" group. Variable averages for each group were then compared. It was found that on average the "Above 50%" group received significantly fewer personal fouls when compared to the "Below 50%" group (p=0.001). The difference is small, but this does suggest that the home team significantly received fewer personal foul calls when crowd density was above 50% than when the crowd density was below 50%. In contrast, when

the crowd density was above 50% the home team received fewer free throw attempts than when the crowd density was below 50%, however, the difference was insignificant (p=0.075). Together, these findings suggest that as crowd density increases the average box scores used to determine referee bias (PF, FTA) are conflicting and inconclusive. On the contrary, the advance box scores (ORtg, DRtg) did show significant differences between groups. The home games that displayed above 50% crowd density significantly outperformed the home games that displayed below 50% density in both offense efficiency (p=0.003) and defense efficiency (p=0.002). This suggests that when crowd density is above 50% the home team performs significantly better offensively and defensively compared to when the crowd density is below 50%.

Table 1: Descriptive Statistics for Seasons 2015-2019

Variables	N	M	SD	Minimum	Maximum
PF	849	17.996	4.142	8	42
FTA	849	19.320	7.147	3	44
ORtg	849	104.240	13.282	62.08	148.72
DRtg	849	99.642	13.039	64.17	141.45
PF_vis	849	18.857	4.348	7	35
FTA_vis	849	18.143	6.756	3	51
ORtg_vis	849	99.642	13.039	64.17	141.45
DRtg_vis	849	104.240	13.282	62.08	148.72

N = Sample Size. M = Mean. SD = Standard Deviation. PF = Personal Fouls (home teams).
FTA = Free Throw Attempts (home teams). ORtg = Team Offense Rating (home teams)
DRtg = Team Defense Rating (home teams). PF_vis = Personal Fouls (visiting teams)
FTA_vis = Free Throw Attempts (visiting teams). ORtg_vis = Team Offense Rating (visiting teams)
DRtg_vis = Team Defense Rating (visiting teams).

Table 2: Home Teams vs Opposing Teams

Variable	Home	Visitor	Difference	p-value	t-stat
PF	17.996	18.857	-0.861	0.000	-4.92
FTA	19.320	18.143	1.176	0.000	3.97
ORtg	104.240	99.642	4.598	0.000	7.75
DRtg	99.642	104.240	-4.598	0.000	-7.75
N	849	849			

PF = Personal Fouls. FTA = Free Throw Attempts. ORtg = Team Offense Rating.
DRtg = Team Defense Rating. N = Sample Size.

Table 3: Home Crowd Density Above 50% vs Below 50%

Variable	Above 50%	Below 50%	Difference	p-value	t-stat
PF	17.466	18.415	-0.948	0.001	-3.33
FTA	18.829	19.708	-0.879	0.075	-1.78
ORtg	105.785	103.018	2.766	0.003	3.03
DRtg	98.051	100.901	-2.850	0.002	-3.18
N	375	474			

PF = Personal Fouls. FTA = Free Throw Attempts. ORtg = Team Offense Rating.
DRtg = Team Defense Rating. N = Sample Size.

5. Discussion

As mentioned in the introduction, there is a lot of evidence that suggests that the home team has an advantage over the visiting team in men's basketball (Boudreaux et al., 2017; Courneya & Carron, 1992; Dilger & Vischer, 2022; Entine & Small, 2008; Harris & Roebber, 2019; Gobikas et al., 2020; Harville & Smith, 1994; Reese Jr. et al., 2013; van Bommel et al., 2021; and Yi, 2017). Likewise, the findings from this study suggest that the same is true for women's basketball at the professional level. On average the home team significantly received fewer personal fouls (-0.861; $p = 0.000$) and more free throw attempts (1.177; $p = 0.000$) than the visiting team, which suggests a slight possibility that there was a referee bias. This would fit the definition of referee bias as described by Anderson and Pierce (2009) however, the differences in both the number of personal fouls and the number of free throw attempts between home teams and visiting teams were very small in magnitude. The findings from this study also support the notion that the home court advantage phenomenon is an efficiency-enhancing phenomenon (Yi, 2017) because the home teams on average were significantly more efficient offensively (4.598; $p = 0.000$) and defensively (-4.598; $p = 0.000$) when compared to the visiting teams. In other words, within 100 ball possessions, the home teams scored an average of 4.598 points more than visiting teams under the same conditions. This finding aligns with Harville and Smith (1994) who estimated that the home team receives an advantage of 4.68 ± 0.28 points for just playing at home. Also, the home team allowed an average of 4.598 fewer points within 100 ball possessions of the visiting team.

The hypothesis for this study proposed that crowd density could directly influence referee bias and home team performance in women's basketball. Since multiple studies suggest that crowd density has the largest influence on home court advantage in men's basketball (Boudreaux et al., 2017; Gobikas et al., 2020; Yi, 2017) it was reasonable to assume that the same would be true for women's basketball. While comparing home games with crowd density above 50% to home games with crowd density below 50% mixed results were revealed. The home games that reported crowd density above 50% significantly received fewer personal fouls on average than the home games that reported crowd density below 50% (-0.948; $p = 0.001$) which agrees with van Bommel and colleagues (2021) who propose that large crowds are related to referee bias. However, the home games with crowd density above 50% were given fewer free throw attempts on average when compared to home games with crowd density below 50% (-0.879; $p = 0.075$). This finding was not significant but does point in the opposite direction that implies less referee bias as crowd density increases in women's basketball. Together these findings are inconclusive about the relationship between crowd size and referee bias. Due to technology advancements and the style of play that these women used, it is likely that referee bias was minimized over the years (Harris & Roebber, 2019). It is also likely that in the WNBA referees are more cautious about calling fouls when there is a crowd density above 50%. In either case, the magnitude of the difference between crowd density above 50% and crowd density below 50% as it relates to referee bias in the WNBA is small. One

reason why referee bias might be more prevalent in men's basketball compared to women's basketball is that fan attendance at men's basketball games is usually greater than fan attendance at women's basketball games (Reese et al., 2013) which translates into larger differences in crowd density.

In regard to crowd density and performance efficiency, the findings from this study do support previous literature which suggests that the chance of home team victory increases as crowd density increases (Agnew & Carron, 1994; Gobikas et al., 2020; Smith, 2003; van Bommel et al., 2021). As reported in table 3, home games with crowd density above 50% significantly performed more efficiently in offense ($p = 0.003$) and defense (0.002) when compared to home games with crowd density below 50%. Again, the magnitude of the difference is small, but scoring an average of 2.766 more points while playing offense and preventing the visiting team from scoring an average of 2.850 points while playing defense accumulates to be around 5 points in difference. Furthermore, adding 4.598 points for playing at home to 2.766 points for playing at a home game with crowd density above 50%, plus points not allowed to the visiting team because of defense efficiency, and the total difference is points between the home team and visiting team is much larger. Whether the larger crowd density enhanced home team performance, inhibited visiting team performance, or a mixture of both is still unclear, but home games with crowd density above 50% did show a significant increase in efficiency when compared to home games with crowd density below 50%.

Within the parameters of this study, it is concluded, that the home court phenomenon does appear to be present in the WNBA. The magnitude of the 6th woman effect in the WNBA compared to the magnitude of the 6th man effect in the NBA is still unknown. Like men's basketball, larger crowd density does appear to enhance performance efficiency for the home team in women's basketball. However, the relationship between crowd size and referee bias remains unclear in the WNBA. Future research should consider analyzing and comparing performance variables for NBA games and WNBA games that have similar crowd density values.

Conflict of Interest Statement

The authors declare no conflicts of interest.

About the Authors

Spencer Orton, MSc earned his Masters of Science degree at Southern Utah University. He is currently a Physical Education Specialist for Granite School District in Utah, USA. His research interests include physical education pedagogy, and sport in society.

Paul Maggio, MSc CSCS earned his Masters of Science degree at Utah State University. He is currently a Lecturer in the Kinesiology and Outdoor Recreation Department at Southern Utah University. The courses Paul instructs include Physical Education and Olympic Style lifting for sport performance. His research interests include physical education pedagogy, coaching leadership, and sport performance development.

Mark DeBeliso, PhD FACSM earned his Doctoral degree from Oregon State University. He is currently a Professor and Graduate Program Director at Southern Utah University. His research interests include: orthopaedic biomechanics, mechanics and metabolics of sport movements and work tasks, strength training for all walks of life, and masters athletes. orcid.org/0000-0001-6479-7918

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