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TEAM AND PLAYER PERFORMANCE BEFORE AND DURING CHINESE BASKETBALL ASSOCIATION BUBBLE SEASONS

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Abstract:

To curb the COVID-19 pandemic, from June 2020 onward, the Chinese Basketball Association (CBA) games were played in an isolated zone without spectators, providing a unique opportunity to investigate crowd effects on competitive sports in a natural experiment setting. Our goal was to examine the influence of spectator absence on technical statistics and player performance in basketball by comparing registered game-related technical statistics pre and post-pandemic. A secondary objective was to compare performance between national and international players and to analyze whether players had adapted to the CBA bubble, as determined by player performance. Data were downloaded from CBA's official data website, and Student's T test, ANOVA and forward stepwise regression were applied to analyze team performance and player efficiency. The post-pandemic season results were then compared. We found that team performance, composed of points and a comprehensive set of technical statistics, was similar between designated home and designated away teams in the CBA bubble. More interestingly, while the performance of national players remained unchanged, the performance of international players significantly declined in the CBA bubble and showed no signs of improvement after a full season of adaptation. In conclusion, the results of this study suggest that the absence of spectators had a twofold effect: it nullified the technical statistical differences between designated home and away teams since neither team was able to leverage the benefits of playing in front of a home crowd, and it had a negative impact on the performance of international players.

Keywords: Crowd effect, spectators, basketball, performance analysis, CBA.

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INTRODUCTION

The COVID-19 pandemic crisis has greatly impacted on professional sports around the globe, with the most dramatic change being the absence of spectators during matches. However, this situation provided an opportunity for conducting natural experiments to isolate the effect of crowd support on sport performance. A substantial body of research has examined the effects of spectator absence on home advantage (HA) have been published (1-7); these studies have consistently demonstrated a reduction in HA in games played in the absence of spectators, indicating the crucial involvement of fans on game outcomes. However, there are limitations to these studies. For instance, the away teams still need to travel to host cities and compete in unfamiliar facilities. Therefore, these studies do not exclude the possibility of confounding factors occurring simultaneously during travel.

To prevent the spread of COVID-19, between the 30th of July and the 11th of October 2020, NBA games were restarted in the so-called NBA bubble without the presence of fans. In addition to the empty arenas, the biggest difference between the NBA bubble protocol and the "ghost game" in Europe (7) was that the NBA players were isolated from the outside world and all the matches were played in a neutral arena. This setting provided a natural experiment in which the effects of spectator absence could be examined while minimizing confounding effects related to travel and venue familiarity. Researchers have analyzed data collected from the NBA bubble and found that the absence of fans in the audience led to a reduction in the percentage of home team wins and scores (1, 3, 4) compared to pre-pandemic seasons. However, conclusions from their studies were based on relatively low statistical power since only 176 games were played in the bubble. Furthermore, the home teams were allowed to place logos on the floor and play music in an attempt to recreate the home-court feel. These measures may theoretically arouse home players' territorial perception and increase the saliva testosterone level (8), leading to enhanced athletic performance.

In this study, we aimed to consolidate the findings derived from investigating the effects of empty arenas on team performance by utilizing a stricter natural experiment setting created by the CBA (Chinese Basketball Association) bubble. The CBA bubble was initially introduced in June 2020 and has remained for more than two seasons. This extended period allowed us to examine if players could adapt to empty courts after an adequate period of adaptation. Thus, our second aim was to examine the effects of empty arena on player performance and to investigate whether international players, who are already conditioned to being away from family members, were better acclimated to the CBA bubble.

MATERIALS AND METHODS

Data preparation and validation

Data were collected from the CBA official website (http://cba.sports.sina.com.cn/). The dataset came from the 2018/2019 season, the 2020/2021 season, and the 2021/2022 season. The 2018/2019 season was the pre-pandemic season and 2020/2021 and 2021/20 22 were the post-pandemic seasons when all games were played in an isolated zone. All matches played during the regular season period were included. There were 460, 504, and 380 games played in seasons 2018/2019, 2020/2021, and 2021/2022, respectively, and the game statistics were registered for both home and away teams. The data registered in 2019/2020 were excluded because the season break in 2020 was prolonged due to the COVID-19 outbreak during which normal training was discontinued. Therefore, we found it inappropriate to include data from the 2019/2020 season in our analysis. Instead, we used data from the 2018/2019 season to serve as the pre-pandemic control data. Data reliability was assessed independently by two associate professors with expertise in basketball coaching and training using a randomly selected subsample of 10 games. The test results were compared with the corresponding data from the

official website. The resulting intraclass correlation coefficients (ICCs) ranged from 0.88 to 0.93 across variables, indicating good reliability.

For team-level analysis, the dataset included field goal percentage (FG%), 3-point field goal percentage (3FG%), free throw percentage (FT%), offensive rebounds (OREB), defensive rebounds (DREB), assists (AST), steals (STL), dunks (DNK), block shots (BLK), turnovers (TO), fouls (FOUL), and points (PTS). For player-level analysis, we ranked the players according to their efficiency calculated from data registered during regular seasons. The player's efficiency was calculated with the following equation: Efficiency = (point + rebound + assist + steal + block) - (field goal attempt - field goal made) - (free throw attempt – free throw made) - turnover. Players were ranked according to their efficiency from the highest to the lowest, and the first 100 players on the ranking were included in the analysis.We then assigned them to a national group and an international group according to their nationalities. The number of national and international players included was 38:62, 57:43 and 67:33 for 2018/2019, 2020/2021 and 2021/2022, respectively.

Statistical Analysis

The results are expressed as mean ± SD. Student's T-test was run to determine significant differences in basketball statistics between home and away teams. ANOVA followed by the LSD or Dunnett T3 (if the equal variance was not satisfied) was run to compare basketball statistics and the performance of national and international players between pre- and post-pandemic seasons. Forward stepwise regression was applied to model the relationship between team PTS and basketball team statistics. The Student's T-test, ANOVA, and forward stepwise regression were performed using SPSS 25. Figures were created with GraphPad Prism 9. The significance level was set at $p < 0.05$. According to the central limit theorem, when the sample size is > 30, the sampling distribution approximates the standard normal distribution and is considered normal (8). The significance level was set at $p < 0.05$.

RESULTS

The existence of home advantage in games played during the pre-pandemic season

A comparison of basketball technical statistics registered for home and away teams in seasons 2018/19, 2020/21, and 2021/22, respectively, is presented in Table 1. In the pre-pandemic season, 2018/19, 460 games were played in a home-away balanced schedule between 20 teams. The home advantage was detected for most of the technical statistics, including FG%, rebounds (both offensive and defensive rebounds), AST, STL, DNK, BLK, and, most importantly, PTS. However, when the games were played without the presence of spectators during the post-pandemic seasons (2020/21 and 2021/22), most of the technical statistics between designated home and designated away teams did not differ. Only the FG% for designated home teams was significantly higher in season 2020/21.

Key basketball team statistics predictive of points pre-and post-pandemic

Because basketball technical statistics can be used as an indirect reflection of a game plan (9), we wanted to know whether the presence of a crowd would affect game statistics. Since the differences between designated home and designated away teams were negligible in 2020/21 and 2021/22 (Table 1), this part was performed without separating game statistics recorded for home and away games. The mean differences of twelve technical statistics between 2018/2019, 2020/21, and 2021/22 are shown in Table 2. In general, most of the basketball statistics registered in 2018/19 differed significantly from those registered in 2020/21 or 2021/22; fewer technical statistics registered in 2020/21 and 2021/22 differed. This suggests the game style was different when games were played in CBA bubble.

Next, we wanted to identify the key basketball team statistics predictive of PTS pre- and post-pandemic. Table 3 displays the results from forward stepwise regression analysis

modeling the relationships between team PTS and team statistics in seasons with or without the presence of spectators. There are nine variables associated with PTS. Our analysis found that FG%, 3FG%, OREB, and FT% were the top four variables significantly associated with higher PTS in the season 2018/19 when fans were allowed in the arenas. In contrast, in seasons 2020/21 and 2021/22 when games were played inside the CBA bubble, the top four variables predictive of higher PTS were AST, FG%, 3P%, and OREB. This was in accordance with the higher AST number in seasons 2020/21 and 2021/22 (Table 2), suggesting that players passed the ball more often inside CBA bubble. Taken together, these data indicate that the presence of spectators markedly affected game statistics.

Table 1. Comparison of Home Advantage during pre- and post- pandemic seasons

		Mean	SD	P	Mean	SD	P	Mean	SD	P
FG%	**Home**	0.546	0.074	0.030*	0.541	0.077	0.000***	0.520	0.078	0.845
	Away	0.535	0.077		0.523	0.074		0.519	0.078	
3FG%	**Home**	0.359	0.091	0.320	0.354	0.094	0.957	0.352	0.090	0.774
	Away	0.353	0.093		0.354	0.094		0.350	0.093	
FT%	**Home**	0.767	0.104	0.144	0.745	0.102	0.886	0.757	0.101	0.291
	Away	0.757	0.107		0.745	0.098		0.749	0.107	
OREB	**Home**	12.159	4.114	0.039*	11.236	3.652	0.159	11.508	4.040	0.843
	Away	11.609	3.942		11.583	4.161		11.566	4.024	
DREB	**Home**	29.924	5.085	0.001**	29.129	5.266	0.062	28.637	5.551	0.438
	Away	28.833	5.078		28.496	5.483		28.318	5.763	
AST	**Home**	20.883	5.540	0.000***	23.746	5.440	0.092	25.111	5.430	0.694
	Away	18.646	4.848		23.181	5.189		25.266	5.444	
STL	**Home**	8.935	3.287	0.000***	9.512	3.304	0.716	8.550	3.228	0.774
	Away	8.176	3.272		9.435	3.445		8.618	3.338	
DNK	**Home**	2.520	1.990	0.000***	1.778	1.558	0.346	1.645	1.643	0.863
	Away	2.028	1.764		1.687	1.515		1.624	1.723	
BLK	**Home**	3.613	1.994	0.000***	3.510	1.985	0.250	3.674	2.098	0.241
	Away	3.035	1.827		3.367	1.957		3.855	2.171	
TO	**Home**	12.165	3.841	0.000***	14.792	4.201	0.608	15.282	4.438	0.563
	Away	13.196	3.880		14.655	4.272		15.095	4.469	
FOUL	**Home**	23.367	4.547	0.533	24.855	4.981	0.286	22.866	4.790	0.994
	Away	23.557	4.643		25.193	5.041		22.863	4.980	
PTS	**Home**	109.311	14.141	0.000***	105.216	13.846	0.155	100.368	14.652	1.000
	Away	105.235	13.714		104.000	13.314		100.368	14.327	

Comparison of Basketball technical statistics of home and away teams. Field goal percentage (FG%), 3-point field goal percentage (3FG%), free throw percentage (FT%), offensive rebounds (OREB), defensive rebounds (DREB), assists (AST), steals (STL), dunks (DNK), block shots (BLK), turnovers (TO), fouls (FOUL), points (PTS). */**/***P < 0.05/0.01/0.001 compared between home and away teams. Standard deviation (SD).

Table 2. Comparison of technical statistics between pre- and post- pandemic season

	2018/2019		2020/2021		2021/2022		
	Mean	SD	Mean	SD	Mean	SD	p
FG%	0.540	0.076	0.532	0.076	0.519	0.078	*, ###, $$
3FG%	0.356	0.092	0.354	0.094	0.351	0.091	
FT%	0.762	0.105	0.745	0.100	0.753	0.104	***
OREB	11.884	4.036	11.410	3.917	11.537	4.030	**
DREB	29.378	5.108	28.813	5.383	28.478	5.657	##,
AST	19.764	5.322	23.463	5.321	25.188	5.434	***, ###, $$$
STL	8.555	3.299	9.473	3.374	8.584	3.281	***, $$$
DNK	2.274	1.895	1.732	1.537	1.634	1.682	***, ###
BLK	3.324	1.933	3.438	1.972	3.764	2.135	###, $$
TO	12.680	3.893	14.723	4.235	15.188	4.451	***, ###,
FOUL	23.462	4.594	25.024	5.011	22.864	4.883	***, #, $$$
PTS	107.273	14.070	104.608	13.589	100.368	14.481	***, ###, $$$

Post hoc comparison of Basketball technical statistics registered with or without the presence of spectators. Field goal percentage (FG%), 3-point field goal percentage (3P%), free throw percentage (FT%), offensive rebounds (OREB), defensive rebounds (DREB), assists (AST), steals (STL), dunks (DNK), block shots (BLK), turnovers (TO), fouls (FOUL), points (PTS). */**/*** P < 0.05/0.01/0.001 for 2018/19 vs 2020/21; #/##/### P < 0.05/0.01/0.001 for 2018/19 vs 2021/22; $$/$$$ P < 0.01/0.001 for 2020/21 vs 2021/22. Standard deviation (SD).

Table 3. Forward stepwise regression analysis of variables predictive of points

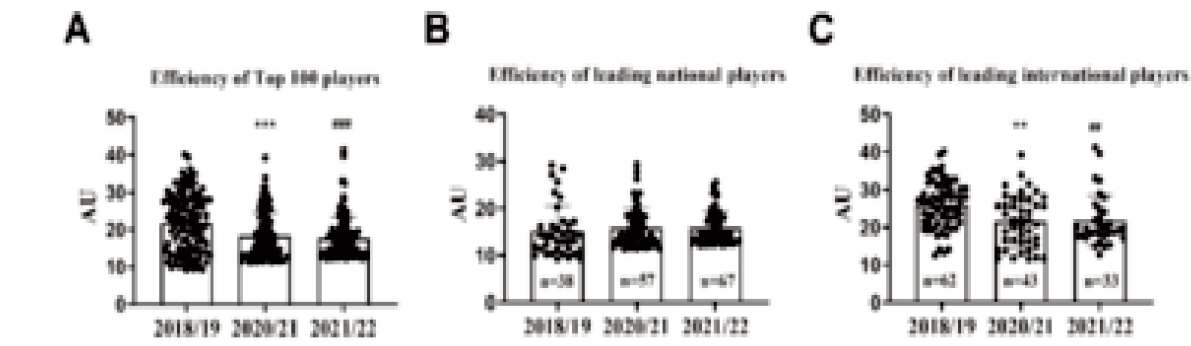
2018/19			2020/21			2021/22		
Constant = -22.879			Constant = -27.530			Constant = -20.792		
Variables	β	P	Variables	β	P	Variables	β	P
FG%	101.511	0.000	AST	0.295	0.000	AST	0.362	0.000
3FG%	79.986	0.000	FG%	93.486	0.000	FG%	90.971	0.000
OREB	1.153	0.000	3FG%	69.584	0.000	3FG%	64.703	0.000
FT%	23.917	0.000	OREB	1.042	0.000	OREB	1.026	0.000
TO	-0.725	0.000	FT%	26.350	0.000	TO	-0.727	0.000
FOUL	0.407	0.000	FOUL	0.555	0.000	FT%	22.584	0.000
DREB	0.344	0.000	TO	-0.738	0.000	FOUL	0.407	0.000
STL	0.427	0.000	STL	0.650	0.000	DREB	0.383	0.000
DNK	0.330	0.014	DREB	0.352	0.000	STL	0.473	0.000

Feedforward stepwise regression model. Dependent Variable: pointsField goal percentage (FG%), 3-point field goal percentage (3FG%), free throw percentage (FT%), offensive rebounds (OREB), defensive rebounds (DREB), assists (AST), steals (STL), dunks (DNK), block shots (BLK), turnovers (TO), fouls (FOUL).

CBA bubble impaired the performance of international players but not national players

We classified the top 100 players according to whether they were foreign nationals and compared their performance, as determined by efficiency, across three seasons (Figure 1). In general, players' performance decreased to the same extent in 2020/21 and 2021/22, respectively (Figure 1 A). Surprisingly, the performance of leading national players was not impaired regardless of whether spectators were present (Figure 1 B). In contrast, the efficiency of international players was highest in 2018/19 (Figure 1 C) and declined significantly in the first post-pandemic season (2018/19 vs. 2020/21). Their performance was not restored despite a full season of adaptation (2020/21 vs. 2021/22). One may argue that this impairment was due to the age effect. For that, we compared the performance of international players who played both seasons 2017/18 and 2018/19, and we found that their performances were similar (data not shown). Together, these data support the finding that the international players' performance was impaired during the bubble season.

Fig.1



Prolonged period of CBA bubble decreased game efficiency of international players. (A)Mean efficiency of top 100 players.(B) Mean efficiency of national players among the top 100 (C) Mean efficiency of international players among the top 100. For (A), ***P<0.01 versus 2018/2019; ###P<0.01 versus 2018/2019. For (C), **P<0.01 versus 2018/2019; ##P<0.01 versus 2018/2019. Data are expressed as mean ± SD. AU, arbitrary unit.

Discussion

In this study, we aimed to examine the impact of a prolonged, no-spectator CBA Bubble (due to COVID-19 restrictions) on a comprehensive set of basketball technical statistics. At the player level, we also analyzed the impact of prolonged isolation on individual players' performance and examined whether adaptation occurred after a full season of living and competing in the bubble by comparing players' game efficiency across three seasons. Our main findings were as follows: home teams were superior on points and on a comprehensive set of technical statistics compared with away teams during the pre-pandemic season. However, these advantages disappeared in the post-pandemic seasons, 2020/21 and 2021/22, respectively. Second, we found that the CBA bubble impaired only international players' performance, as indicated by lower efficiency. Furthermore, international players' efficiency did not restore when their performance in 2020/21 was compared to in 2021/22, suggesting that adaption to the unique physical environment did not occur.

The effects of empty arenas on HA and the related implications for athletic performance have been popular research topics within the

field of exercise psychology in the post-pandemic era. Alonso and co-authors (7) examined the effects of empty courts on HA in five major European basketball leagues pre- and post- the Covid 19 pandemic and found that there was a slight reduction in the home winning percentage, though it remained above 50%. Consistent findings were reported with data collected from other continents (1, 3), sports disciplines (3, 10), and at different competitive levels (5, 11, 12). Taken together with our findings, these studies support the notion that spectator presence influences athletic performance and match outcomes across sports and geographical settings. Interestingly, the magnitude of the influence of empty courts on home advantage appears to be related to the competitive level of the teams in soccer (13). One plausible explanation for this is that low competitive level teams may be accustomed to low occupancy rates in soccer stadiums. Hence, we speculate that the decrease in the number of spectators to zero at the CBA bubble may have been less dramatic for the lowest-ranked teams, which were already accustomed to playing in front of sparser crowds. It is worth mentioning that the Covid-19 restriction protocol may have changed how home and away teams prepared for matches and how they spent the nights leading up to the matches. That is, during normal seasons, home teams get to meet family members and friends for psychological support (14, 15), which significantly reduces home team players' pre-game anxiety (15), resulting in better mental health before the matches. In contrast, away teams travel to other cities/countries and prepare for matches in unfamiliar facilities unaccompanied by family or friends. Indeed, numerous studies have documented and confirmed the crucial role of psychological factors substantially affecting players' performance (16). Thus, by utilizing the CBA bubble setup, the psychological factors together with factors related to traveling, venue familiarity and cultural differences were equalized in our study since all players were isolated in the CBA bubble. Finally, we also compared the average number of fouls for both the home and away teams over three seasons to exclude the potential influence of referee bias on interpretation of the data. Overall, the CBA bubble provides a natural experimental setup for isolating crowd effects on basketball performance.

In recent decades the globalization process has facilitated professional athletes crossing borders to start athletic careers in host countries. Ryba and co-authors (17) proposed that there are three main phases for the relocation and adaptation of athletes. Among them, the second phase, termed the acute cultural adaptation stage, is characterized by athletes' feelings of loneliness. Accompanying family members will certainly alleviate feelings of loneliness during the integration process in the host countries. However, transnational relocation and adaptation of foreign players in the CBA normally take place without the presence of family members. Hence, it is reasonable to assume that international players in the CBA may have already been conditioned to live without accompany of family members, thus translating to better performance inside the CBA bubble. Unexpectedly, we found that the efficiency of international but not national players decreased substantially in comparison to the period before the pandemic. The mechanisms underlying the decline in international players' performance were not directly assessed in the present study. One possible explanation is that international players may have experienced greater uncertainty during the pandemic because of language barriers and limited access to timely and comprehensive information about the rapidly evolving situation(18). Such uncertainty may have increased feelings of insecurity and anxiety. Previous studies have shown that these negative psychological states can undermine motivation and performance (19, 20). In fact, how to maintain immigrant workers' performance became a universal issue during the pandemic crisis (21-23). Proposed approaches (24) that can be adopted by CBA to enhance international players' performance include improvement in the information sharing

strategy between CBA and the international players and cognitions and rewards for players with superior performance. Another possible explanation is that international players may have been exposed to additional stressors and challenges compared with national players (25, 26), which could have further affected their performance. However, the relative contributions of these factors to the observed decline in performance remain unclear and warrant further investigation.

The study has some limitations such that the findings must be interpreted with caution. For instance, some players and coaches were not able to participate in all the matches due to travel restrictions imposed by the pandemic. Therefore, the members of the squads were not steady. It should be noted that foreign players often play an important role in game tactics and strategy and some teams would have to continue the season without foreign players involved. This would inevitably affect the game statistics. Second, players' performance is related to many factors, including age. The current analysis of players' efficiency did not control for the influence of age. Next, the data obtained from publicly available sources has limitations related to data reliability. The detailed procedures of how the data was registered were not disclosed. Thus, these data may have suffered from human errors or observer bias, which occurs when recorders' expectations, opinions, or prejudices influence what they perceive or record. Moreover, the regression model used in the current study did not adjust for changes in team performance while adjusting for the quality of opponents. An alternative approach is to use the Negative Binomial regression model, as proposed by Higgs and Stavness (27). The negative binomial regression model is a valuable and flexible tool for modeling count data, especially when overdispersion is present(28). However, the model may have convergence issues if there are highly correlated predictors(29, 30). As in our current study, we used basketball statistics as predictors, some of which are correlated. Therefore, we decided to use the forward stepwise regression model. Finally, the season length and schedule were different in the post-pandemic seasons. Specifically, the season was divided into three periods to allow players to recover from stressors received during isolation. However, we are not clear on how this would affect technical statistics and the players' performance.

Conclusion

The introduction of the CBA bubble substantially altered team-level technical statistics and player performance. Home advantage, which was evident during the pre-pandemic season, disappeared when games were played without spectators in the bubble. Notably, international players showed lower game efficiency during the bubble seasons, whereas the performance of national players remained relatively stable. However, given the limitations related to data availability, changes in competition schedules, and potential confounding factors, these findings should be interpreted cautiously. Further research is needed to identify the mechanisms underlying the differential responses of national and international players to the bubble environment.

Author contributions

RJZ, ZHS and ZCL collected the data. HZS, RJZ and ZCL analyzed and visualized the data. ZHS and ZCL conceived the study. ZCL drafted the manuscript with input from all the authors. All the authors read and proved the final version of the manuscript.

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Declaration of competing interests

The authors declare no conflict of interest.

Declaration of Generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the author(s) used ChatGPT (version 5.5) to improve the readability and clarity of the manuscript. All data analysis and interpretation were conducted independently by the author(s) without the use of artificial intelligence. After using this tool, the author(s) carefully reviewed and edited the content as needed and take full

responsibility for the content of the publication.

Data sharing statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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