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Home advantage in matches of the top Polish men's handball league in the seasons before, during and after the COVID-19 pandemic

Paweł Krawczyk[1], Maksymilian Smoliński[2], Jan Labiński[2], Mateusz Szczerba[2]

[1] Division of Physical Education and Sport, Medical University of Warsaw, Warsaw, Poland; [2] Faculty of Medicine, Medical University of Warsaw, Warsaw, Poland

Abstract

Study aim: The aim of the study was to determine whether there are differences in performance analysis in high-sport handball matches between Pre-COVID-19, during COVID-19, and Post-COVID-19 seasons in the home and away matches.
Material and methods: The study material was obtained from the official match statistics of male PGNiG Superleague Ltd. (493 matches). The study included the 2019/2020 (before), 2020/2021 (during), and the 2021/2022 (after) season. Statistical tests were used: the Mann-Whitney U test and the Kruskal-Wallis test.
Results: The COVID-19 pandemic period affected the reduction of home advantage during handball matches. The venue was a differentiating factor in selected handball team activities in the Pre-COVID-19 season, while there were no differences between home and away matches in the COVID-19 and Post-COVID-19 seasons. The away matches in the Pre-COVID-19 season were characterized by more throws from 9m and lower goals and throws from 6m than in the Post-COVID-19 season, indicating recent trends in handball play.
Conclusion: The home advantage associated with playing home matches in terms of the Pre-COVID-19 season and between seasons occurs mainly in the first round of play. Further studies focusing on performance analysis in handball depending on the outcome of the match (win, lose) and the venue (home, away) should be conducted.

Keywords: Handball – Performance analysis – COVID-19 – Pandemic – Season

Introduction

The COVID-19 pandemic and its associated restrictions forced players and coaching staffs in team games to modify sports training, perform individual home workouts, and change the organization of games by playing matches under a sanitary regime. It also involved the absence of fan participation during matches, which created conditions for a natural home advantage experiment [HA].

Studies on HA have been conducted in basketball. They showed the negative impact of the absence of spectators on home advantage in professional basketball leagues (NBA, Euroleague) [12, 23]. It was found that in games without spectators, free throw efficiency was higher than in other seasons, and that the efficiency of free throws and field goals was at record levels [18, 23]. In European professional basketball leagues, higher HA and HW% [ratio of home matches won to all matches won] occurred in games before the pandemic than during the pandemic. It was also indicated that higher HA occurred in teams with a lower sports level, while higher HW% values were registered in teams with a higher level [1, 23]. A study that included NBA league games played on home, away, and neutral courts showed a higher number of points, percentage efficiency of field throws, rebounds, assists, fouls, and tactical actions in games played on the home court [3]. Previous research indicates that the basis for such results may be the effect of travel (including across time zones), which is reflected in fewer games won, the efficiency of throws, fewer offensive rebounds, and more points scored by the home court team. Resuming NBA games in a restart bubble (without travel) reduces the effects of travel, as reflected in performance analysis [19].

Previous studies on HA in football indicate differences in match results between the season before and during the pandemic. Matches played during the COVID-19 season showed a higher number of home defeats than victories [16, 28]. A decrease in the number of shots and shots on target was also reported in home matches [29]. Analyses

Author's address Paweł Krawczyk, Division of Physical Education and Sport, Medical University of Warsaw, Trojdena 2c Street, 02-109 Warsaw, Poland pawel.krawczyk@wum.edu.pl

of the season played during the pandemic without fans also indicate a decrease in the away team's referee penalties, indicating a reduction in home field advantage [16, 28, 29]. It was also shown that high-intensity running activity and total distance covered increased in matches with empty stands. Differences also exist in tactical aspects of the game. A distance of less than 2 meters between opponents during pandemonium was reduced in football matches [16].

Research on ice hockey in the NHL's professional league showed a drop in HA in games during the COVID-19 pandemic. The authors point to both the lack of fans during the matches and the organization of the games in which matches were played on a neutral field with no movement between host cities as reasons for this. [12].

In handball, analyses indicate that fan participation during matches was seen as the most important factor translating into HA. Fans rated their contribution significantly higher than players and coaches. The lowest contribution to HA was rated by officials in relation to the other groups [9].

Seasons played during the lockdown were also characterized by limitations in training, under normal conditions, and players were forced to train performed at home. Studies indicate a reduction in the intensity, volume of training, and quantity and quality of sleep of handball [11, 20], and basketball [17] players. The period of home training also affected changes in the physiological parameters of the players. A decrease in endurance capacity [5], no difference in maximal oxygen uptake [VO2max] [5], or an increase in it [21], an increase in heart rate [HR] in the shuttle run test in zones 5, 6, 7, and an increase in lactic acid [LA] [7] in handball were demonstrated. In endurance sports, a decrease in VO2max and HR was noticeable [26]. Previous findings also indicate a decrease in power output, mean oxygen uptake, cardiac stroke volume during exercise [14] and a decrease in balance performance [13] in handball players infected with SCoV. There were changes in physiological parameters for both home training and COVID-19 infection, which is extremely important for exercise characteristics in handball [8]. The period during which players trained at home and the changes in exercise parameters created a rationale for modifying training plans and developing special programs for returning to training after a period of isolation with an emphasis on aerobic training, resistance training, speed and explosive strength training, flexibility, prevention of muscle injuries, prevention of tendon injuries and neuromuscular prevention [2].

The lockdown period caused changes in the psychological sphere of players as indicated by previous studies. Team games (football, ice hockey, handball) showed worse well-being, criteria for depression were met by 20% of women and 3% of men, and criteria for anxiety by 20% of women and 5% of men. Moderate risk, or problem gambling, was observed in the men's group (10%) [10]. The mental states of players are important because of their impact on training and recovery levels during COVID-19 among handball players [20] and basketball players [17].

The presented review of the literature related to the COVID-19 pandemic and HA indicates a substantive need to address this topic in handball. The analyses and results obtained will allow to determine whether the COVID-19 pandemic and the associated restrictions have translated into the actions of players and entire handball teams at a high sporting level. At the same time, taking up this subject provides opportunities to demonstrate the trends that occur in modern handball with the determination of which parameters are the strongest.

The aim of the study was to determine whether there are differences in performance analysis in high-sport handball matches between Pre-COVID-19, during COVID-19, and Post-COVID-19 seasons in the home and away matches.

Material and methods

Material

The research material was collected based on official match statistics at the highest level of handball competition in Poland, which is organized by PGNiG Superleague Ltd. The data was collected from the official website of PGNiG Superleague Ltd. Written permission was obtained from the owner of the statistics of PGNiG Superleague Ltd. to use them for research purposes. The variables that were included in the study are presented in Table 1.

The material was collected in seasons before the COVID-19 pandemic (Pre-COVID), during the pandemic (COVID-19), and after the pandemic (Post-COVID-19).

The start of the 2019/2020 season (Pre-COVID-19) was on August 30, 2019, and it ended on March 11, 2020. During the games, there were no restrictions related to the COVID-19 pandemic and matches were held with the possibility of full participation of fans.

The 2020/2021 (COVID-19) season began on September 5, 2020, and ended on June 6, 2021. During the season, the games were held under the sanitary regime prescribed by Polish law, and players were tested for COVID-19. From September 5 to October 25, 2020, due to the pandemic condition in Poland, fan participation was limited to 25% of the capacity of the stands. Fans were subject to a sanitary regime: the use of masks covering their mouths and noses, mandatory disinfection, and maintenance of spacing in the stands by Polish law. From October 26 until the end of the games, matches were held without fans.

The post-COVID-19 2021/2022 season began on September 3, 2021, and ended on May 24, 2022. There was no sanitary regime related to the COVID-19 pandemic

Table 1. Used abbreviations and variable names

GSc	Numbers of goals scored
GDef	Number of goals defeated
7mG	Number of 7m goals
7mTh	Number of 7m throws
Th	Number of all throws
AccTh	Number of accurate throws
MissTh	Number of missed throws
9mG	Number of 9m goals
9mTh	Number of 9m throws
6mG	Number of 6m goals (goals scored in throws from 6 meters)
6mTh	Number of 6 m throws (throws made from 6 meters)
FB	Number of fast breaks
FBG	Number of fast break goals
Fouls	Number of fouls
OffFouls	Number of offensive fouls
2 min	Number of 2 min suspensions
RC	Number of red cards
Th%	All throw efficiency [%]
7m%	7m throw efficiency [%]
9m%	9m throw efficiency [%]
6m%	6m throw efficiency [%]
GK%	Goalkepper efficiency [%]
GK7m%	7m goalkeeper eficiency [%]

condition during the games, and matches could be played with the full participation of fans.

Procedures

The process of collecting research material included n = 493 male handball matches at the highest level of handball competition in Poland, in which 14 teams were included. The material was collected for each team. The study included the 2019/2020 playing season before the COVID-19 pandemic (Pre-COVID-19) in which n = 156 matches were analyzed (home n = 156: first round n = 88, second round n = 68; away n = 156: first round n = 88, second round n = 68), the 2020/2021 season during the COVID-19 pandemic (COVID-19) n = 174 matches (home n = 174: first round n = 82, second round n = 92; away n = 174: first round n = 82, second round n = 92) and season 2021/2022 after COVID-19 (Post-COVID-19) n = 163 matches (home n = 163: first round n = 81, second round n = 82; away n = 156: first round n = 81, second round n = 82). Matches ending in a tie in regulation time were not included in the study (Matches that ended in overtime in penalty shot were not taken into account because such regulations only cover the Polish league, and the results obtained could not be generalized to other leagues where such arrangements do not exist. An additional argument is the relatively low number of matches ending in overtime in penalty shot. Including matches ending in overtime in the study would distort the overall results relating to the number of penalty shot, goals from penalty shot, the effectiveness of penalty shot, and the effectiveness of penalty shot defenses, which would not directly result from the teams' actions during the match in regulation time).

The study material was subjected to statistical analysis. The comparative analysis included the place of the game (home, away) in terms of each of the seasons studied (Pre-COVID-19, COVID-19, Post-COVID-19) and comparisons between seasons. The second analysis conducted to compare the collected material included home and away matches in the seasons covered by the study, taking into account the round of play for each season.

Statistical analysis

Due to the non-parametric nature of the collected data (lack of normality of distribution: Shapiro-Wilk test and lack of homogeneity of variance: Leavene's test), non-parametric tests were used to perform the analyses. Comparisons between two independent groups were made using the Mann-Whitney U test. Comparisons between three or more independent groups were made using the Kruskal-Wallis test. The level of accepted statistical significance was $p < 0.05$. The eta-square (η^2) was used to determine the effect size [ES] (<0.01-no effect, 0.01–0 .059-small effect, 0.06–0.139-intermediate effect, >0.14-large effect) [4]. All statistical analyses were performed using TIBCO Statistica 13.3 and Microsoft Office Excel software.

Results

The results of statistical analyses including performance analysis in the seasons covered by the study, taking into account the venue, are presented in Table 2.

Pre-COVID-19 season differences were shown between home and away matches in the variables included in the study. Higher GSc ($U = 10152.00$; $Z = 2.54$; $p = 0.011$; $\eta^2 = 0.021$), 6mG ($U = 9738.5$; $Z = 3.05$; $p = 0.002$; $\eta^2 = 0.03$), 6mTh ($U = 10358.5$ $Z = 2.27$; $p = 0.023$; $\eta^2 = 0.017$), FBG ($U = 22615.5$; $Z = 2.28$; $p = 0.023$; $\eta^2 = 0.016$) and Th% ($U = 10574$; $Z = 2.00$; $p = 0.045$; $\eta^2 = 0.013$) registered in home matches. The away matches have a higher number of GDefs ($U = 10108$; $Z = –2.59$; $p = 0.01$; $\eta^2 = 0.021$) and OffFouls ($U = 10501$; $Z = –2.14$; $p = 0.033$; $\eta^2 = 0.014$). The effect size of the differences shown is small.

Table 2. General statistics of the three seasons in home and away matches

Variables	Pre-COVID-19		COVID-19		Post-COVID-19		Differences
	M (SD)		M (SD)		M (SD)		
	Home	Away	Home	Away	Home	Away	
	1	2	3	4	5	6	
GSc	28.32 (6.06)	26.61 (5.09)	27.89 (5.45)	27.26 (5.05)	28.37 (5.51)	27.39 (5.21)	1 > 2**
GDef	26.61 (5.09)	28.32 (6.06)	27.26 (5.05)	27.89 (5.45)	27.39 (5.21)	28.37 (5.51)	1 < 2**
7mG	2.88 (1.82)	2.74 (1.51)	3.01 (1.77)	2.87 (1.77)	2.72 (1.62)	2.79 (1.37)	
7mTh	3.97 (2.28)	3.97 (1.81)	4.16 (2.1)	3.8 (1.97)	3.7 (1.95)	3.72 (1.63)	
Th	46.71 (5.16)	45.72 (5.18)	46.09 (5.52)	45.16 (4.99)	45.99 (5.18)	45.43 (5.09)	
AccTh	39.39 (5.54)	38.24 (5.02)	38.78 (5.49)	38.08 (5)	39.33 (5.33)	38.6 (5.17)	
MissTh	7.31 (3.27)	7.48 (3.04)	7.43 (3.02)	7.08 (2.98)	6.67 (3.19)	6.83 (2.98)	
9mG	5.27 (2.57)	5.71 (2.54)	5.45 (2.69)	5.39 (2.62)	5.18 (2.45)	4.94 (2.52)	
9mTh	12.38 (4.6)	13.24 (4.46)	12.09 (4.54)	12.34 (4.16)	11.4 (4.27)	11.62 (4.52)	2 > 5**, 6*
6mG	20.17 (6.11)	18.17 (5.05)	19.43 (5.4)	19.02 (4.7)	20.47 (5.27)	19.67 (4.77)	1 > 2**; 2 < 5***, 6*
6mTh	30.26 (6.44)	28.46 (5.86)	29.83 (5.85)	28.93 (5.14)	30.83 (5.42)	30.02 (5.44)	1 > 2*; 2 < 5*
FB	5.26 (3.54)	4.71 (3.23)	4.61 (2.94)	4.3 (3.08)	4.86 (3.21)	4.45 (2.85)	
FBG	3.95 (3.05)	3.18 (2.58)	3.39 (2.67)	3.17 (2.52)	3.73 (2.75)	3.38 (2.32)	1 > 2*
Fouls	27.17 (7.9)	26.55 (7.72)	27.15 (7.1)	27.36 (7.07)	26.67 (6.59)	26.38 (7.24)	
OffFouls	2.13 (1.57)	2.53 (1.7)	2.11 (1.55)	2.44 (1.69)	2.02 (1.7)	2.07 (1.59)	1 < 2*; 2 > 5*
2 min	4.29 (2.13)	4.28 (1.95)	4.6 (1.86)	4.76 (1.94)	4.27 (1.73)	4.39 (1.79)	
RC	0.25 (0.46)	0.22 (0.48)	0.28 (0.55)	0.29 (0.55)	0.2 (0.4)	0.19 (0.42)	
Th%	60.47 (9.81)	58.24 (9.13)	60.43 (9.54)	60.39 (8.81)	61.64 (8.94)	60.25 (9.49)	1 > 2*; 2 < 5*
7m%	73.37 (24.08)	70.29 (26.94)	72.39 (23.77)	75.19 (24.33)	74.25 (27.64)	76.77 (23.06)	
9m%	43.33 (16.45)	43.28 (14.75)	44.95 (15.22)	43.43 (15.05)	45.82 (16.72)	43.55 (18.72)	
6m%	66.02 (10.98)	63.90 (11.27)	64.93 (10.98)	65.5 (9.41)	66.06 (9.67)	65.33 (9.97)	
GK%	30.53 (8.52)	28.46 (8.68)	28.75 (8.26)	28.15 (9.04)	29.19 (8.85)	28.37 (8.64)	
GK7m%	24.97 (26.55)	20.3 (23.17)	16.19 (21.45)	16.35 (20.68)	17.28 (22.67)	20.8 (26.88)	

Legend: *p < 0.05; **p < 0.01; ***p < 0.001.

A comparative analysis of the three seasons analyzed according to the venue of the match shows that in Pre-COVID-19, there is a higher number of 9mTh in away matches than in Post-COVID-19 ($H(5, N = 986) = 17.93$; $p = 0.003$; $\eta^2 = 0.013$) and effect size is small. The reverse is true for the 6mG number ($H(5, N = 986) = 19.91$; $p = 0.001$; $\eta^2 = 0.015$) and effect size is small. Significantly higher numbers 6mTh ($H(5, N = 986) = 16.58$; $p = 0.005$; $\eta^2 = 0.012$; small effect size) and Th% ($H(5, N = 986) = 12.17$; $p = 0.032$; $\eta^2 = 0.007$; no effect size) in home matches in the Post-COVID-19 season relative to away matches in the Pre-COVID-19 season. Players in away matches of the Pre-COVID-19 season committed more OffFouls than in home matches in the Post-COVID-19 season ($H(5, N = 986) = 14.71$; $p = 0.012$; $\eta^2 = 0.01$) and effect size is small.

The other variables analyzed showed no statistically significant differences.

The results of statistical analyses covering players' actions in matches played at home and away in the three seasons covered by the study, taking into account the game round, are contained in Tables 3a and 3b.

A comparative analysis of home and away matches in the first round indicates that in the Pre-COVID-19 season, there is a higher number of GSc ($U = 2701.5$; $Z = 3.47$; $p = 0.001$; $\eta^2 = 0.068$), AccTh ($U = 3104$; $Z = 2.28$; $p = 0.023$; $\eta^2 = .029$), 6mG ($U = 2829.5$; $Z = 3.09$; $p = 0.002$; $\eta^2 = 0.054$) and FBG ($U = 3015$; $Z = 2.56$; $p = 0.011$; $\eta 2 = 0.037$) in matches played at home, however, the effect size is small. In the same season, away matches registered higher GDef ($U = 2675.5$; $Z = –3.55$; $p = 0.000$; $\eta^2 = 0.068$) in the first round and 9mG ($U = 1754$ $Z = –2.45$; $p = 0.014$;

Table 3a. Handball statistics in first and second round of the seasons in home and away matches

Variables	Round	Pre-COVID-19		COVID-19		Post-COVID-19		Differences
		M (SD)		M (SD)		M (SD)		
		Home	Away	Home	Away	Home	Away	
		1	2	3	4	5	6	
GSc	First	28.76 (5.63)	25.94 (4.96)	27.43 (5.61)	27.63 (5.09)	27.85 (5.17)	27.47 (5.06)	1 > 2***
	Second	27.75 (6.56)	27.47 (5.14)	28.29 (5.29)	26.93 (5.02)	28.88 (5.82)	27.32 (5.38)	
GDef	First	25.9 (4.97)	28.76 (5.63)	27.63 (5.09)	27.43 (5.61)	27.47 (5.06)	27.85 (5.17)	1 < 2***
	Second	27.47 (5.14)	27.75 (6.56)	26.93 (5.02)	28.29 (5.29)	27.32 (5.38)	28.88 (5.82)	
7mG	First	2.93 (1.84)	2.67 (1.48)	2.91 (1.6)	2.95 (2.01)	2.78 (1.57)	**3.09 (1.54)**	
	Second	2.82 (1.81)	2.82 (1.54)	4.21 (2.14)	2.79 (1.52)	2.66 (1.68)	**2.49 (1.23)**	
7mTh	First	4 (2.23)	4.08 (1.91)	4.1 (2.08)	3.85 (2.14)	3.91 (1.89)	**4.05 (1.65)**	
	Second	3.93 (2.35)	3.84 (1.66)	4.21 (2.14)	3.75 (1.82)	3.49 (1.99)	**3.4 (1.56)**	
Th	First	46.91 (4.9)	45.42 (4.99)	45.74 (5.34)	45 (5.11)	46.35 (4.95)	45.37 (5.18)	
	Second	46.44 (5.51)	46.1 (5.44)	46.4 (5.68)	45.3 (4.9)	45.65 (5.41)	45.49 (5.03)	
AccTh	First	39.78 (5.03)	37.81 (4.9)	38.29 (5.32)	38.2 (5.08)	39.48 (5.08)	38.6 (5.2)	1 > 2*
	Second	38.88 (6.14)	38.79 (5.15)	39.21 (5.63)	37.98 (4.95)	39.17 (5.6)	38.6 (5.18)	
MissTh	First	7.11 (2.98)	7.61 (2.81)	7.45 (2.97)	6.8 (3.16)	6.86 (3.02)	6.77 (3.12)	
	Second	7.56 (3.62)	7.31 (3.32)	7.41 (3.08)	7.33 (2.82)	6.48 (3.36)	6.89 (2.85)	
9mG	First	5.4 (2.65)	**5.39 (2.58)**	5.33 (2.82)	5.51 (2.7)	5.23 (2.3)	5.14 (2.5)	
	Second	5.1 (2.47)	**6.12 (2.45)**	5.57 (2.59)	5.27 (2.56)	5.12 (2.6)	4.74 (2.53)	1 < 2*; 2 > 6**
9mTh	First	12.15 (4.49)	12.69 (4.16)	12.07 (4.38)	12.59 (4.13)	11.52 (4.42)	11.98 (4.02)	
	Second	12.68 (4.76)	13.94 (4.76)	12.1 (4.7)	12.13 (4.19)	11.29 (4.15)	11.27 (4.96)	2 > 5*, 6**
6mG	First	20.43 (5.65)	17.89 (4.99)	19.18 (5.12)	19.18 (4.51)	19.84 (5.02)	19.25 (4.69)	1 > 2**
	Second	19.82 (6.69)	18.53 (5.13)	19.64 (5.65)	18.87 (4.87)	21.1 (5.46)	20.09 (4.83)	2 < 5*
6mTh	First	30.59 (6.36)	28.59 (5.86)	29.5 (5.56)	28.51 (4.99)	30.86 (5.37)	29.26 (4.8)	
	Second	29.82 (6.57)	28.29 (5.9)	30.12 (6.12)	29.29 (5.27)	30.8 (5.5)	30.78 (5.94)	
FB	First	**5.95 (3.65)**	5.02 (3.31)	4.2 (2.53)	4.02 (3.17)	4.84 (3.52)	4.31 (2.74)	1 > 3*, 4**, 6*
	Second	**4.37 (3.2)**	4.29 (3.11)	4.99 (3.22)	4.54 (3.01)	4.88 (2.9)	4.59 (2.97)	
FBG	First	**4.38 (3.09)**	3.27 (2.57)	3.02 (2.31)	3.07 (2.68)	3.63 (2.92)	3.36 (2.15)	1 > 2*; 1 > 3*, 4*
	Second	**3.4 (2.92)**	3.06 (2.6)	3.72 (2.93)	3.26 (2.37)	3.83 (2.59)	3.4 (2.49)	

Legend: *p < 0.05; **p < 0.01; ***p < 0.001; **bold** = differences between first and second round.

$\eta^2 = 0.043$) in the second round, and the effect size of these comparisons is small. Otherwise, there were no significant differences in the comparison of home and away matches within each of the seasons analyzed.

A comparison of the results obtained between game seasons shows higher FB values in the first round in home games of the Pre-COVID-19 season with respect to COVID-19 (home and away) ($H(5, N = 502) = 19.23$; $p = 0.002$; $\eta^2 = 0.029$; small effect size). A higher number of FBGs were shown in Pre-COVID-19 home games relative to COVID-19 (home and away) and Post-COVID-19 (away) ($H(5, N = 502) = 14.30$; $p = 0.014$; $\eta^2 = 0.019$), and effect size is small. Second-round away matches showed a higher number of 9mG in Pre-COVID-19 relative to Post-COVID-19 ($H(5, N = 484) = 13.77$; $p = 0.017$; $\eta^2 = 0.018$), and effect size is small. In the second round, the Pre-COVID-19 season's away games showed a significantly higher 9mTh count relative to the Post-COVID-19 (home and away) games ($H(5, N = 484) = 18.04$; $p = 0.003$; $\eta^2 = 0.027$) however, the effect size is small. The second round in Post-COVID-19 showed more 6mG in home matches than away matches in Pre-COVID-19 ($H(5, N = 484) = 11.26$; $p = 0.046$; $\eta^2 = 0.013$) effect size value is small.

Comparisons between the first and second rounds of play indicate higher FB ($U = 4531.5$; $Z = 2.89$; $p = 0.004$;

Tabela 3b. Handball statistics in first and second round of the seasons in home and away matches

Variables	Round	Pre-COVID-19		COVID-19		Post-COVID-19		Differences
		M (SD)		M (SD)		M (SD)		
		Home	Away	Home	Away	Home	Away	
		1	2	3	4	5	6	
Fouls	First	27.51 (8.39)	25.83 (7.26)	27.77 (7.89)	27.27 (6.31)	**28.38 (7.05)**	26.74 (7.15)	
	Second	26.74 (7.26)	27.49 (8.24)	26.6 (6.31)	27.45 (7.71)	**24.98 (5.66)**	26.02 (7.34)	
OffFouls	First	2.1 (1.62)	2.32 (1.65)	2.28 (1.55)	2.72 (1.81)	2.05 (1.82)	2 (1.43)	
	Second	2.16 (1.52)	2.81 (1.73)	1.97 (1.54)	2.2 (1.54)	2 (1.59)	2.15 (1.74)	1 < 2*; 2 > 3*, 5*
2 min	First	4.38 (2.11)	4.42 (1.9)	4.78 (1.98)	4.9 (2.09)	**4.56 (1.75)**	**4.77 (1.76)**	
	Second	4.19 (2.16)	4.09 (2.01)	4.45 (1.76)	4.63 (1.8)	**3.99 (1.67)**	**4.02 (1.74)**	
RC	First	0.26 (0.49)	0.18 (0.47)	0.27 (0.59)	0.3 (0.58)	0.22 (0.42)	0.23 (0.45)	
	Second	0.24 (0.43)	0.28 (0.48)	0.29 (0.52)	0.28 (0.52)	0.17 (0.38)	0.15 (0.39)	
Th%	First	61.28 (9.69)	57.15 (9.02)	59.88 (9.78)	61.43 (8.65)	60.14 (8.87)	60.51 (9.25)	1 > 2**; 2 < 4*
	Second	59.43 (9.93)	59.66 (9.13)	60.91 (9.34)	59.47 (8.89)	63.13 (8.81)	59.99 (9.77)	
7m%	First	73.71 (24.49)	67.45 (27.46)	72.28 (25.14)	75.12 (25.4)	72.37 (29.01)	76.48 (21.28)	
	Second	72.94 (23.73)	74.05 (25.96)	72.49 (22.62)	75.24 (23.48)	76.22 (26.16)	77.06 (24.83)	
9m%	First	45.11 (17.21)	42.23 (14.78)	43.1 (14.78)	43.63 (15.74)	45.85 (14.91)	44.22 (20.21)	
	Second	41.01 (15.22)	44.63 (14.7)	46.61 (15.49)	43.24 (14.48)	45.78 (18.43)	42.88 (17.21)	
6m%	First	66.42 (10.73)	62.69 (11.87)	65.04 (11.78)	67.2 (8.63)	**64.05 (10.13)**	65.32 (10.23)	1 > 2*
	Second	65.5 (11.36)	65.47 (10.31)	64.84 (10.28)	63.99 (9.86)	**68.05 (8.81)**	65.34 (9.77)	
GK%	First	31.49 (8.8)	27.94 (8.77)	27.98 (8.14)	28.62 (9.71)	28.83 (8.99)	**30.16 (8.72)**	1 > 2*
	Second	29.29 (8.04)	29.13 (8.58)	29.45 (8.35)	27.73 (8.44)	29.55 (8.75)	**26.6 (8.22)**	5 > 6*
GK7m%	First	26.46 (27.32)	20.65 (24.83)	**11.54 (18.38)**	**12.13 (17.67)**	14.86 (19.38)	21.8 (27.72)	1 > 3**, 4*
	Second	23.02 (25.58)	19.85 (20.99)	**20.33 (23.18)**	**20.15 (22.49)**	19.7 (25.44)	19.75 (26.11)	

Legend: *p < 0.05; **p < 0.01; ***p < 0.001; **bold** = differences between first and second round.

η^2 = 0.053) and FBG (U = 4688; Z = 2.34; p = 0.019; η^2 = 0.035) in the first round of home matches in the Pre-COVID-19 season, an effect size is small. In the Pre-COVID-19 season's away matches, higher values of 9mG were recorded in the second round (U = 5891; Z = –1.99; p = 0.047; η^2 = 0.025; small effect size). In the Post-COVID-19 season, there are significantly higher numbers of 7mG (U = 5919.5 Z = 2.74; p = 0.006; η^2 = 0.044) and 7mTh (U = 6011; Z = 2.41; p = 0.016; η^2 = 0.034) in away matches in the first round, but the effect size of the analyses performed is small.

No statistically significant results were found in the other variables analyzed.

The data presented in Table 3b for the Pre-COVID-19 season in the first round show higher values of Th% (U = 6894; Z = 2.65; p = 0.008; η^2 = 0.04), 6m% (U = 7094.5; Z = 2.05; p = 0.04; η^2 = 0.024) and GK% (U = 6958.5; Z = 2.45; p = 0.014; η^2 = 0.034) in matches at home, however, the effect size is small. In the second round of the Pre-COVID-19 season, significantly higher OffFouls occur in matches played away (U = 5167; Z = –2.27; p = 0.023; η^2 = 0.036), while in Post-COVID-19, higher GK% values (U = 6139; Z = 2.06; p = 0.039; η^2 = 0.026) occur in home matches. The effect size of the differences shown is small.

The results presented in the first round indicate a higher efficiency in Th% throwing (H(5, N = 502) = 11.45; p = 0.043; η^2 = 0.013) in away games during the COVID-19 season relative to Pre-COVID-19, however, the effect size is small. In the first round, a higher efficiency of goalkeepers in 7 meters throw GK7% (H(5, N = 494) = 22.25; p = 0.001; η^2 = 0.035) occurs in home matches in the Pre-COVID-19 season than in the COVID-19 season (home and away), however, the effect size of these comparisons is small. In the second round, a significantly higher number of OffFouls (H(5, N = 484) = 12.59; p = 0.027; η^2 = 0.016) were recorded in away matches in the Pre-COVID-19 season relative to home matches in the other seasons, and the effect size is small.

Comparisons of the collected study material between rounds of play indicate significantly higher GK7m% scores

in the COVID-19 season in the second round at home (U = 8705; Z = –2.75; p = 0.006; η^2 = 0.038) and away matches (U = 8119; Z = – 2.48; p = 0.013; η^2 = 0.033), effect size of these differences is small. Post-COVID-19, home matches in the first round have higher values for Fouls (U = 5793; Z = 3.09; p = 0.002; η^2 = 0.059), 2 min (U = 6107.5; Z = 2.08; p = 0.038; η^2 = 0.026), while in the second round, a higher efficiency of 6m% was registered (U = 7516; Z = –2.63; p = 0.009; η^2 = 0.042). The effect size of the differences shown is small. In away games of the post-COVID-19 season in the first round there are significantly higher values of 2 min (U = 5925.5; Z = 2.69; p = 0.007; η^2 = 0.043) and GK% (U = 6055; Z = 2.22; p = 0.026; η^2 = 0.03), and the effect size of these comparisons is small.

The other variables analyzed showed no statistically significant differences.

Discussion

Discussing the obtained results of the comparative study of the three seasons, it should be pointed out that 9mTh values were higher in Pre-COVID-19 (away) than in Post-COVID-19. The opposite situation was registered for 6mG, and the difference between Pre-COVID-19 (away) and Post-COVID-19 (home) was shown in 6mTh. The obtained results correspond with recent reports [27], which indicate a trend in the offensive play of teams focusing on finalizing the action with throws from 6 meters. It should also be pointed out that throws made from closer distances show higher efficiency [24, 25, 27]. Such a condition may indicate the implementation of offensive actions, which create the possibility of obtaining the highest sports score within a single match. It should also be pointed out that the differences obtained were recorded mainly in the second round of the season, which may be due to a number of factors. One of them may be the content and training load implemented throughout the season. A second factor could be the players' fatigue from the ongoing season and emerging injuries. A third factor may be the emotional intensity associated with the games, which enter a phase in the second round where each game can determine the sports result (championship, medals, place in the table, and retention or relegation to a lower league). Previous studies in handball indicate the differences between the regular season and the playoff phase, which determines the sports result achieved [15].

The demonstrated differences involving OffFouls between the Pre-COVID-19 and Post-COVID-19 seasons may be due to referee bias against teams playing at home. Previous research indicates that such a phenomenon occurred in pre-COVID seasons in football [16, 28, 29]. The Th% results indicating higher throwing efficiency in the post-COVID-19 season are consistent with data in the literature, which show increasing throwing efficiency over two years [27], as well as the last decade [22].

The results presented show differences between home and away game parameters in the Pre-COVID-19 season, indicating the presence of HA in the pre-pandemic season. The absence of such differences in the COVID-19 season was also shown to indicate a reduction in this effect, which is consistent with results in basketball [1, 3, 12, 18, 19] and football [28, 29]. The absence of such differences in the post-COVID-19 season may indicate that players are adapting to playing home and away matches at similar sporting levels and reducing the impact of supportive fans in their own arena on technical and tactical actions.

The results also indicate a substantive need for further research on performance analysis in handball in home and away matches. The basis of this research should be the determination of the incidence of HA not only in the context of the COVID-19 pandemic but also in the next playing seasons to determine, the latest trends and possible changes in handball.

Demonstrated differences in the Pre-COVID-19 season in the number of GSc and GDef in home and away matches (especially in the first round of the season) indicate the need for further research in the adopted methodology taking into account the venue (home, away) as well as the result (win, lose). The results obtained in this way, in addition to learning about the latest trends in the game, will make it possible to demonstrate the main factors determining victory in a match and learn which actions prove most effective in home and away matches.

Discussing the results obtained, it should be pointed out that differences were shown between the seasons in the first round of play in which the number of FBs and FBGs is higher in home games in the Pre-COVID-19 season than in the entire COVID-19 season. These differences may be due to the difficulties faced by the coaching staff and players during the COVID-19 season, which was related to limited training opportunities and the necessity of training performed by players at home. The ability to run a fast break attack is dependent on the effectiveness of defensive play [6]. Defensive training in handball focuses, in addition to proper motor preparation, on the actions of individual players and, above all, on the interaction of defensive players. The constraints of the COVID-19 pandemic greatly hampered both technical and tactical preparation, which may have been one of the reasons for the differences shown. Previous studies also indicate a tendency for defensive play to become less effective, which could also be one of the reasons for the differences shown [22, 27]. It should also be noted that no differences were shown in the second round of games, which may indicate the adaptation of players to the conditions. The highest results achieved occur in home matches in the Pre-COVID-19

season, which may also indicate, a higher impact of HA on the game, which during defensive play also requires high emotional involvement, which may be the result of social support from their own fans. Similar results (decrease in HA) associated with games without an audience during the COVID-19 pandemic occurred in football [28] and basketball [1, 12, 18, 19].

An analysis of OffFouls indicates that they are more numerous in the second round of play, in away matches in the Pre-COVID-19 season than in home matches in other seasons. Also, the difference between home and away matches in the Pre-COVID-19 season may indicate that referees are biased against away teams, resulting in increased punishment. Studies in football have shown increased penalization of away teams in matches played before the COVID-19 pandemic relative to those during the pandemic [28, 29], which may also be reflected in handball.

Analysis of the efficiency of play in the three seasons covered by the study showed differences in Th% in the first round of play between away games in the Pre-COVID-19 and COVID-19 seasons. Throwing efficiency was higher in the season played under a sanitary regime and without the participation of fans. The lack of participation of the home team's fans can be cited as the reason for the observed condition, so that the pressure exerted on the players of the away teams was less, which may have promoted higher throwing efficiency. Higher efficiency in matches played during the COVID-19 pandemic without the participation of fans was demonstrated in basketball [18, 19] and football [29]. The results presented here indicate a higher level of GK7m% in home matches in the first round of the Pre-COVID-19 season in relation to all matches of the COVID-19 season. It can therefore be conjectured that supportive fans are one of the factors that can influence the effectiveness of goalkeeper intervention through positive pressure, motivation, and hope for goalkeepers' success. The low percentage of successful interventions during the COVID-19 season may be related to two main factors. The first may be the limited opportunity for team training, which resulted from restrictions on the training process. It can be conjectured that during home training, the main training content was the players' motor skills, as indicated by previous reports [7, 21]. The characteristics of playing in the goalkeeper position require the formation of defensive techniques and tactics during both individual and team training, which was limited during the COVID-19 season. A second factor may be the playing of matches in conditions without fans, which may have distorted the effectiveness of defenses through the players' feelings, which appeared new and unfamiliar. There is a significantly lower level of GK7m% in the first round of games during the COVID-19 season, so it can be presumed that in the second round of games, there was an adaptation of the goalkeepers to the new, previously unseen conditions, which had a positive effect on the higher level of efficiency.

Statistical analyses indicate differences between matches played at home and away mainly in the first round of the Pre-COVID-19 season. In the COVID-19 season, such differences do not occur, while in the Post-COVID-19 season, the only difference is limited to GK% in the second round of games. The observed condition corresponds with the results of other authors indicating a reduction of HA in games played by fans during the pandemic in both basketball [1, 18, 19] and football [28, 29]. In addition, the occurring differences involving only one round of play (mainly the first round) and the demonstrated differences between the first and second rounds of play may indicate additional factors that directly and indirectly affect the characteristics of handball play during the games. It can be assumed that the second round of the competition is characterized by a direct fight for the championship, to stay in the league, and to take the top spot, thus teams show more commitment to the quality of the game. At the same time, it is important to point out the optimization of the training process, during which coaching staffs have the opportunity to eliminate both technical and tactical mistakes from the first round and this can make, which can translate into higher game efficiency. Therefore, this creates a substantive rationale to undertake further research aimed at demonstrating the factors that affect the observed condition, which is also confirmed by other authors addressing this issue in handball [15].

When discussing the obtained results, it is also necessary to point out changes in the rules of the game, which may also affect the obtained results. It is worth mentioning changes including a quick restart after a conceded goal (restart from the center circle instead of from the halfway line), which could have resulted in a greater number of quick attacks. Limiting passive play to four passes (previously six) could also translate into increased defensive effectiveness, a greater number of fouls and a greater number of missed throws. It can also be assumed that increasing the protection of players shooting from wing positions could have resulted in a greater number of goals scored by them and a greater number of penalties and 2-minute suspensions. In order to accurately describe the impact of rule changes on technical and tactical activities in handball, further research should be carried out focusing on this aspect and looking for differences between seasons.

Practical applications

The obtained research results indicate the need for coaching staffs and clubs to take actions aimed at eliminating the home advantage in away matches and strengthening it in home matches. Actions to eliminate the opponents' home advantage include arriving at the match early

enough (1–2 days) in order to eliminate the effects of travel and improve acclimatization in the arena. Conducting training in the opponent's hall the day before the match may also result in a higher level of players' acclimatization to the conditions there. In mental preparation before the match, special actions should be taken, e.g. by a sports psychologist, in order to reduce the influence of the effect of the opposing team's fans and the place of the game, which may reduce the home advantage and the obtained sports result. In the case of home matches, in order to increase the effect of home advantage, promotional activities should be undertaken to increase the number of supporting fans, organized cheering, social support, which may increase social support, the level of motivation, acceptance, hope for success and self-confidence, which may translate into results obtained by the players.

Limitations

The variables included in the analysis refer to selected team activities in aggregate. It should be noted that there is a lack of registration of actions on an individual basis relating to positions in the game. Tactical actions involving the defensive system of play and the offensive system of play were also not recorded. The exclusion of players from the game related to the COVID-19 infection was also not recorded in this study. All the factors that were not recorded would have allowed to expand the area of exploration and a very detailed description of the handball game with a special focus on the COVID-19 pandemic.

Conclusions

The COVID-19 pandemic period affected the reduction of home advantage during handball matches. The venue was a differentiating factor in selected handball team activities in the Pre-COVID-19 season, while there were no differences between home and away matches in the COVID-19 and Post-COVID-19 seasons. The away matches in the Pre-COVID-19 season were characterized by more shots from 9m and lower goals and shots from 6m than in the Post-COVID-19 season, indicating recent trends in handball play. The home advantage associated with playing home matches in terms of the Pre-COVID-19 season and between seasons (pre, during, and after the COVID-19 pandemic) occurs mainly in the first round of play. There is a substantive need for further research to show which factors differentiate teams' actions in the first and second rounds of the season. For scientific understanding, further studies focusing on performance analysis in handball depending on the outcome of the match (win, lose) and the venue (home, away) should be conducted.

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