Home Advantage In the Top Czech Hockey League

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ABSTRACT

Home advantage in sport has long been established as an important factor in determining the outcome of a match. According to this phenomenon, the home team should win more games and score more goals than the away team. Home advantage is a very complex phenomenon that is influenced by many different factors. One possible explanation is that the home crowd supports the home team's performance and also causes the referee to be under pressure and favor the home team. The aim of this paper is to quantify the home advantage in the Czech top hockey league. Using statistical analysis, the number of points scored, goals scored, shots taken, penalties awarded and penalty minutes in the 2019/20 season were compared. A total of 364 matches were analysed. The results showed the existence of a home advantage in the Czech top hockey league in the 2019/20 season. Implications for sport practice and possible directions for future research are discussed.

Keywords: sport; ice hockey; home advantage; spectators; Mann-Whitney test

INTRODUCTION

The phenomenon of home advantage has been studied in sport for many years. The influence of the venue on the outcome of a sporting match is a phenomenon that has been discussed quite frequently in the literature (Bray and Carron, 1993; Koning, 2005; Koning, 2011; Balmer et al., 2005; Balmer, et al., 2003). In most cases, bookmakers place emphasis on the venue of the match (i.e., home or away) when setting odds. According to this phenomenon, athletes or sports teams are expected to perform better at home and achieve better overall results. The home advantage has been studied for more than four decades, yet the exact causes and mode of action are still unknown. According to

most authors (e.g. Pollard, 2006; Pollard, 2008; Carron et al., 2005; Courneya and Carron, 1992), the home advantage is mainly due to the influence of fans, travel, familiarity with the pitch, referee bias, psychological factors and tactics, and a host of other aspects.

The first authors to address the home-field advantage were Schwartz and Barsky (1977), who suggested that home fans exert an encouraging and motivating influence on their players. Schwartz and Barsky (1977) examined the influence of the home environment in various sports, most notably American League baseball, Major League Soccer, and ice hockey. The research revealed a positive influence of the home environment on sport performance. However, the degree of influence of the home environment varied across sports. Balmer et al. (2001) further add that the home advantage differs between team and individual disciplines. The home advantage has been demonstrated in most professional sports. Jamieson (2010) demonstrated the home advantage in 10 different sports, and like Schwartz and Barsky (1977) found that the extent of this advantage varies between sports. He found that the home advantage is highest in football compared to all other sports examined. Schwartz and Barsky (1977) consider the proximity of the fans and their cheering and chanting to be a crucial factor in the emergence of home advantage, which leads the home players to exert more effort and ultimately win the game. Similar to Schwartz and Barsky (1977), other research (Anderson et al., 2012; Smith, 2005; Wolfson et al., 2005) has shown that fans are the main reason for the emergence of home advantage. Furthermore, some studies have examined the dependence of home advantage on crowd size (Nevill et al., 1996), crowd density and intensity (Pollard, 1986; Nevill et al., 2002), or the distance of the sports venue from the crowd (Armatas and Pollard, 2012; Dohmen, 2008; Pollard and Armatas, 2017).

On the other hand, some authors (Courneya and Carron, 1992; Nevill and Holder, 1999) are rather sceptical and suggest that the home advantage has less impact than expected. For example, van de Ven (2011) concluded that audience support is not necessary for the emergence of home advantage (HA). Agnew and Carron (1994) found very little effect of fans and their size on home advantage. Pollard (1986) even found no effect of fans on home-field advantage. Pollard and Pollard (2005) report that home advantage in ice hockey, basketball and football in England has declined over the last two decades. These trends and changes provide some evidence that travel and familiarity with the pitch contribute more to home advantage, but fans in the stands have little influence.

Another frequently cited factor that can cause a home advantage is the influence of fans on the referees. Dosseville et al. (2016) report that referees tend to make more decisions in favour of the home team. This phenomenon has been addressed in many studies (Goumas, 2014; Nevill et al., 2002; Boyko et al., 2007; Nevill and Holder, 1999; Pollard, 1986; Sutter and Kocher, 2004; Garicano et al., 2005). The aforementioned studies have confirmed the assumption that referees tend to make decisions more in favor of the home team and that they are highly susceptible to social influence. The role of referees is very demanding and they unconsciously rely on cues from the crowd to make decisions.

A literature review revealed that there is an extensive literature on home advanteage in individual and team sports. However, most attention was paid to football. According to Pollard (2008) and Jamieson (2010), the home advantage is highest in football compared to all other sports. Other

sports have not received as much attention in the literature. E.g. rugby (Morton, 2006), ice hockey (Agnew and Carron, 1994; Dennis and Carron, 1999; Pollard and Pollard, 2005), basketball (Moore and Brylinsky, 1995; Watson and Krantz, 2003). A major limitation of the above research is that it has not yet been possible to examine matches without home spectators over very long periods of time. The only exception is the period 2020 and 2021 as a result of the Covid-19 disease pandemic. For this reason, spectator presence has been cited as the main factor responsible for the emergence of the home advantage phenomenon (Pollard and Pollard, 2005). However, the available analyses are not consistent regarding the effect of spectators on home advantage. A possible reason for the divergent results may be that research has not accounted for a number of other important factors. This factor may be the playing style of the team, which probably determines its chances of scoring goals and thus the probability of winning. Another factor may be the difficulty of the match schedule in terms of the opponents it faces. The quality of the opponents a team faces is an indicator of its probability of winning (Peeters and van Ours, 2020). More experienced teams may rely less on the support of their spectators than their less experienced opponents. It is also evident from the above that most of the literature focuses primarily on the field of football. Hockey competitions do not receive as much attention in the available literature. Czech hockey in general and the Czech top hockey league in particular do not receive any attention in the literature. The aim of this research is to find out whether there is a home advantage in the Czech hockey league. The presented research uses statistical methods to investigate the differences between the values of selected sports statistics in home and away matches. Empirically, the statistical methods are applied to the Czech top hockey competition (i.e. Tipsport Extraliga) in the 2019/20 season.

METHODS AND DATA

Data

The subject of the analysis was the Czech top hockey league called Tipsport Extraliga. The research focused only on matches in the regular season. Play-off matches were excluded from the research. Tipsport Extraliga was examined based on sports data from the 2019/20 season. 14 teams participated in the Tipsport Extraliga in the 2019/20 season. Namely: Sparta Praha (SPA), Kometa Brno (KOM), Bílí Tygři Liberec (LIB), Mladá Boleslav (MLB), Dynamo Pardubice (PCE), Mountfield Hradec Králové (MHK), Verva Litvínov (LIT), Vítkovice Ridera (VIT), Oceláři Třinec (TRI), Rytíři Kladno (KLA), Škoda Plzeň (PLZ), Olomouc (OLO), Berani Zlín (ZLN) and Energie Karlovy Vary (KVA). The Tipsport Extraliga was played in a four-round system. Each team played 52 games (26 at home and 26 on the opponent's field). This league structure allows an unbiased method for quantifying home games throughout the season. 364 matches were played during the 52 rounds. Tipsport Extraliga managed to play the entire regular season (i.e. 52 rounds) with spectators in the 2019/20 season. It was also the season with the highest average spectator attendance since the 1992/93 season, according to BPA statistics (BPA sport marketing a.s., 2023). The average attendance was 80,142 spectators. The play-offs were cancelled for the 2019/20 season due to the outbreak of the Covid-19 disease pandemic. For this reason, the play-offs are also not included in the research presented.

The data on individual hockey matches was obtained from data on the website of the top hockey competition Tipsport Extraliga, in the database on the Hokej.cz website operated by (BPA sport marketing a.s., 2023; eSports.cz, s.r.o., 2023) and on the Livesport.cz website. This data includes the number of points scored per game (3 points for a win, 2 points for a win in overtime, 1 point for a loss in overtime and 0 points for a loss), the number of goals scored, the number of shots on target, the number of penalties and the number of penalty minutes awarded.

Statistical Analysis

Shapiro-Wilk test and two-sample Mann-Whitney U test and two-sample t-test were used to evaluate the obtained data. The Shapiro-Wilk test was used to test the normality of the sports data examined. The Shapiro-Wilk test is the preferred test of normality due to its good performance compared to a number of alternative tests (Shapiro et al., 1968). The Shapiro-Wilk test is used to test the hypothesis that a random sample of size n (X_1, X_2, ... X_n) comes from a normal distribution with unspecified parameters μ and σ^2, $N(\mu, \sigma^2)$. The null hypothesis H_0 states that the data sample belongs to a normal distribution. The alternative hypothesis H_1 states that the data sample does not belong to a normal distribution. The test statistic to assess the normality of the data is the W statistic, which according to (Budíková et al., 2010) is given by (1). The test statistic W reaches the value of 1 if the data shows a perfect fit to the normal distribution. If the value of the test statistic W is statistically significantly less than 1, the null hypothesis of a fit to the normal distribution can be rejected and the alternative hypothesis accepted.

$$W = \frac{b^2}{S^2} = \frac{\left(\sum_{i=1}^{k} a_{n-i+1}(y_{n-i+1} - y_i)\right)^2}{\sum_{i=1}^{n}(y_i - \bar{y})^2} \quad (1)$$

In the present research, the non-parametric two-sample Wilcoxon test was also applied to the sports data; in some publications (Nachar, 2008) it is also called the Mann Whitney U test. The non-parametric two-sample test is used when the assumption of normality of the data is not met. The Mann Whitney U test is a non-parametric analogue of the test of the identity of the means of two independent random sets (X_1, X_2, ... X_m) and (Y_1, Y_2, ... Y_n) with different numbers of elements. The null hypothesis H_0 states that the data samples have identical means (medians). The alternative hypothesis H_1 states that the data samples do not have identical means (medians). The null hypothesis H_0 can be written as $\mu_1 = \mu_2$. The alternative hypothesis H_1 can be written as $\mu_1 \neq \mu_2$. The test assumes that (X_1, X_2, … X_n) is a random selection from some continuous distribution and (Y_1, Y_2, ... Y_n) is an independent random selection from the same continuous distribution that is shifted by a constant δ with respect to the former. Thus, the random variables (X_1, X_2, ... X_m) and (Y_1 - δ, ... Y_n - δ) have the same distribution. The test statistic for the Mann Whitney U test is denoted U and is the smaller of U_1 and U_2, defined below (2). In relation (2), R_1 is the sum of the ranks for group 1 and R_2 sum of the ranks for group 2.

$$U_1 = n_1 n_2 + \frac{n_1(n_1+1)}{2} - R_1$$
$$U_2 = n_1 n_2 + \frac{n_2(n_2+1)}{2} - R_2 \quad (2)$$

The second test used was a t-test for two samples. This is a basic test for comparing the means of two independent samples. This test belongs to parametric tests. The null hypothesis H_0 states that the data samples have identical means. The alternative hypothesis H_1 states that the data samples do not have identical means. The null hypothesis H_0 can be written as $\mu_1 = \mu_2$. The alternative hypothesis H_1 can be written as $\mu_1 \neq \mu_2$. The test statistic (3) below is used to test these hypotheses in the case of small sample size (< 30).

$$t = \frac{\overline{X_1} - \overline{X_2}}{S_p\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}} \sim t(n_1 + n_2 - 2) \quad (3)$$

The Shapiro-Wilk test and subsequently the Mann Whitney U and t-test, which served as the basis for the outcomes reported in this research, were conducted at the 5% significance level. All analyses were conducted using SPSS statistical software (IBM, 2023).

RESEARCH RESULTS

This part of the paper is devoted to the results of empirical research in which, in addition to descriptive statistics, the above tests of means were used. The subject of the research was individual matches of the highest Czech hockey competition Tipsport Extraliga in the 2019/20 season.

Descriptive statistics

Table 1 shows descriptive statistics for all 364 games regardless of team. It is well known that home advantage is substantial in professional hockey. Table 1 shows that in all of the games reviewed in the 2019/20 season, 47.53% ended with a home win, 12.64% with a home win in overtime, 9.34% with an away win in overtime, and 30.49% with an away win. This pattern was also reflected in the average difference in points, goals and shots between the home and away teams. On average, hockey teams scored more points in home games than away games. The difference was 0.544 points per game; the median was one point. Home teams scored more goals on average than away teams. The difference in the sample studied was 0.588 goals per game and had a median value of one. Teams also averaged more shots on target and off goal at home than during away matches. The difference in the sample studied averaged 3.368 shots on target and 2.431 shots off target per game and had a median value of equal to four and three shots, respectively. Table 1 also shows the statistics for penalties. On average, there were 3.984 penalties per game at home, which is 0.723

fewer penalties than in away games. On average, all teams playing at home in the analysed sample were given approximately 1.173 fewer penalty minutes than in away games. Fewer penalties for the team playing at home provides better opportunities to score goals, which is also reflected in the statistics described above.

Table 1. Summary statistics over hockey matches, 2019/20

	Mean	St. Dev.	Min.	Median	Max.
number of points (home)	1.772	1.320	0	2	3
number of goals (home)	3.168	1.847	0	3	9
number of shots on target (home)	31.984	6.963	12	32	55
number of shots off target (home)	13.019	4.341	2	13	28
number of penalties (home)	3.984	2.000	0	4	13
number of penalty minutes (home)	9.755	7.912	0	8	51
number of points (away)	1.228	1.320	0	1	3
number of goals (away)	2.580	1.664	0	2	8
number of shots on target (away)	28.615	6.671	12	28	55
number of shots off target (away)	10.588	3.935	2	10	23
number of penalties (away)	4.706	2.043	1	4	15
number of penalty minutes (away)	10.929	7.393	2	10	59
points difference	0.544	0	0	1	0
goal difference	0.588	0.184	0	1	1
shots on target difference	3.368	0.292	0	4	0
shots of target difference	2.431	0.406	0	3	5
difference of penalties	-0.723	-0.043	-1	0	-2
penalty minutes difference	-1.173	0.519	-2	-2	-8
number of home wins			173 (47.53%)		
number of home wins in overtime			46 (12.64%)		
number of away wins in overtime			34 (9.34%)		
number of away wins			111 (30.49%)		

All hockey teams scored on average more points in home games than away games, see Table 2. The biggest average difference of 1.385 points was recorded by HC Škoda Plzeň in the 2019/20 season. Almost one point average difference was for the team HC Rytíři Kladno. Thus, in terms of average points scored, the 2019/20 season saw a difference between whether a team played at home or away. On the other hand, the smallest average difference of 0.038 points was captured by HC Olomouc. Furthermore, a difference of 0.077 points was recorded for HC Dynamo Pardubice. In terms of the number of points scored, there was almost no difference between whether these teams played at home or away. In terms of the number of goals scored, each team scored more goals on average at home, with the exception of HC Olomouc. The largest average difference of 1.385 goals scored was found for HC Škoda Plzeň. BK Mladá Boleslav scored more than one goal on average at home in the 2019/20 season. On the other hand, only HC Olomouc scored 0.423 more goals on average in away games. All teams took more shots on target and shots off target during home games. The difference within each team was the biggest for Mountfield HK (5.731 more shots on target during home games). The smallest difference in the number of shots on target

in home and away matches in the 2019/20 season was recorded by HC Sparta Praha (only 0.231). The differences in the number of shots off target were not significant for individual teams, with the exception of HC Vítkovice Ridera, HC Škoda Plzeň and HC Verva Litvínov. These teams took on average three or more shots off target during home games than during away games.

Table 2 also shows the statistics for penalties for each team. On average, all teams except HC Dynamo Pardubice were awarded fewer penalties in home games. The biggest difference was observed for HC Energie Karlovy Vary and HC Rytíři Kladno. These teams were awarded an average of 1.308 (KVA) and 1.269 (KLA) fewer penalties during home games. The opposite was true for HC Dynamo Pardubice, who were awarded an average of 0.346 more penalties in home games. In terms of the number of penalty minutes awarded, the results are different. HC Berani Zlín, HC Bílí Tygři Liberec, HC Dynamo Pardubice and BK Mladá Boleslav were awarded more penalty minutes on average during home games. The other teams were awarded fewer penalty minutes during home games. The biggest difference was observed for HC Olomouc (3.577 fewer penalty minutes on average during home games).

Table 2. Average difference of selected statistics for each team, 2019/20

	points difference	**goal difference**	**shots on target difference**	**shots of target difference**	**difference of penalties**	**penalty minutes difference**
ZLN	0.231	0.346	2.962	1.962	-0.423	0.962
LIB	0.769	0.423	3.077	0.577	-0.231	0.731
PCE	0.077	0.423	4.308	2.231	0.346	1.423
KVA	0.269	0.385	5.346	1.808	-1.308	-0.346
KOM	0.808	0.423	0.269	1.462	-1.192	-3.154
MLB	0.846	1.038	3.538	0.731	-0.423	1.038
MHK	0.154	0.615	5.731	2.615	-0.769	-0.615
TRI	0.500	0.962	2.000	1.615	-1.000	-3.308
OLO	0.038	-0.423	2.115	1.692	-0.923	-3.577
KLA	0.923	0.615	3.962	0.846	-1.269	-2.462
SPA	0.615	0.846	0.231	1.769	-1.000	-2.808
PLZ	1.385	1.385	4.385	5.000	-0.077	-0.885
LIT	0.654	0.885	4.692	3.538	-1.077	-2.269
VIT	0.346	0.308	4.538	8.192	-0.769	-1.154

Table 3 shows the median values of selected statistics for each hockey team. The median values, like the mean values, are more favorable for home games or there is no difference according to the median. In terms of points scored and goals scored, the only exception is the HC Olomouc team, which, according to the median for these statistics, was better in away games.

Table 3. Median of differences in selected statistics for each team, 2019/20

	points difference	goal difference	shots on target difference	shots of target difference	difference of penalties	penalty minutes difference
ZLN	0.5	1	4	1.5	0	0
LIB	1	1	5	0	0	0
PCE	0	0.5	3.5	4	0	0
KVA	1.5	0	4.5	3	-1.5	-2
KOM	2	0	0	1.5	-2	-4
MLB	2	2	2	1	-1	-2
MHK	0.5	0	6.5	3.5	-0.5	-2
TRI	1.5	1.5	4.5	1.5	-1	-2
OLO	-0.5	-0.5	2	2	-1	-2
KLA	1.5	0.5	2	0	-1.5	-3
SPA	0	1	2	2	-1	-2
PLZ	2.5	1,5	3.5	3.5	-1	-2
LIT	1	0.5	5.5	3.5	-1	-3
VIT	1	1	6	8.5	-0.5	-2

Dependency testing

The first objective of the research was to determine if there were statistically significant differences between the selected sports statistics during 182 home games (selection H) and 182 away games (selection A). Since the Shapiro-Wilk test showed that all selected sports statistics did not have a normal distribution, a non-parametric two-sample Mann-Whitney U test was used to test the hypothesis. The Mann-Whitney U test determines whether two samples have the same median. The statistical program SPSS (IBM, 2023) was used for testing. The null hypothesis assumes that there are no significant differences between the values of the sports statistics of the two samples ($\mu\_H=\mu\_A$). The null hypothesis was tested with a significance level of 0.05. One-sided and two-sided tests were conducted to distinguish between the alternative hypothesis. In case of rejection of the null hypothesis, either $\mu\_H\neq\mu\_A$, or $\mu\_H>\mu\_A$ (resp. $\mu\_H<\mu\_A$). Table 4 shows the results of the two-sample Mann-Whitney U test for the selected sport statistics. From the data in Table 4, it can be seen that statistically significant differences were observed for all the selected statistics.

Table 4. Results of Mann-Whitney U test for all matches, 2019/20

	Results			
Compared game statistics	**Difference**	**Test statistic U**	**P-Value**	**H_1**
number of points	**Yes**	80492	**< 0.00001**	$\mu\_H>\mu\_A$
number of goals	**Yes**	78336	**< 0.00001**	$\mu\_H>\mu\_A$
number of shots on target	**Yes**	85316	**< 0.00001**	$\mu\_H>\mu\_A$
number of shots off target	**Yes**	87193	**< 0.00001**	$\mu\_H>\mu\_A$
number of penalties	**Yes**	51442	**< 0.00001**	$\mu\_H<\mu\_A$
number of penalty minutes	**Yes**	53134	**< 0.00001**	$\mu\_H<\mu\_A$

Another objective of the research was to determine whether there are statistically significant differences between selected sports statistics within individual hockey teams. Within each team, 26 home games (selection H) and 26 away games (selection A) were always compared. The null hypothesis assumes that there are no significant differences between the values of the sports statistics of the two selections (μ_H=μ_A). The null hypothesis was tested with a significance level of 0.05. One-sided and two-sided tests were conducted to distinguish between the alternative hypothesis. In case of rejection of the null hypothesis, either μ_H≠μ_A, or μ_H>μ_A (resp. μ_H<μ_A). The first indicator evaluated was the number of points obtained. This sport statistic did not have a normal distribution and the non-parametric Mann-Whitney U test was used to test the hypothesis. From the data in Table 5, it can be seen that only some teams had statistically significant differences. A statistically significant difference in the number of points scored in home and away matches was confirmed for HC Bílí Tygři Liberec, HC Kometa Brno, BK Mladá Boleslav, HC Rytíři Kladno and HC Škoda Plzeň. These teams can thus be said to have scored more points during home matches. For the other teams, there was no evidence that the number of points scored at home was different from the number of points scored in away matches.

Table 5. Results of two-sample non-parametric Mann-Whitney U test (number of points)

	number of points		
	Diff.	**P-Value**	**H_1**
ZLN	No	0.321	μ_H≠μ_A
LIB	**Yes**	**0.026**	μ_H>μ_A
PCE	No	0.593	μ_H≠μ_A
KVA	No	0.770	μ_H≠μ_A
KOM	**Yes**	**0.027**	μ_H>μ_A
MLB	**Yes**	**0.008**	μ_H>μ_A
MHK	No	0.359	μ_H≠μ_A
TRI	No	0.117	μ_H≠μ_A
OLO	No	0.430	μ_H≠μ_A
KLA	**Yes**	**0.005**	μ_H>μ_A
SPA	No	0.066	μ_H≠μ_A
PLZ	**Yes**	**< 0.001**	μ_H>μ_A
LIT	No	0.070	μ_H≠μ_A
VIT	No	0.142	μ_H≠μ_A

Other indicators were the number of goals, shots on target and shots off target. These sport statistics had different distributions and the parametric t-test and non-parametric Mann-Whitney U test were used to test the hypothesis. From the data in Table 6, it can be seen that only some teams had statistically significant differences. A statistically significant difference in the number of goals scored in home and away matches was confirmed for BK Mladá Boleslav, HC Oceláři Třinec, HC Rytíři Kladno, HC Škoda Plzeň and HC Verva Litvínov. These teams can thus be said to have scored more goals during home matches. More than half of the teams (9 in total) had a statistically significant difference in the number of shots on target during home matches. Seven teams were found to have a statistically significant difference in the number of shots off target during home matches.

Table 6. Results of two-sample non-parametric U test and parametric t-test (goals and shots)

	number of goals				number of shots on target				number of shots off target			
	test	**diff.**	**P-Value**	**H_1**	**test**	**diff.**	**P-Value**	**H_1**	**test**	**diff.**	**P-Value**	**H_1**
ZLN	U	No	0.218	μ_H≠μ_A	t	No	0.111	μ_H≠μ_A	t	**Yes**	**0.039**	μ_H>μ_A
LIB	t	No	0.212	μ_H≠μ_A	t	**Yes**	**0.036**	μ_H>μ_A	U	No	0.323	μ_H≠μ_A
PCE	*U*	No	0.853	μ_H≠μ_A	t	**Yes**	**0.016**	μ_H>μ_A	t	**Yes**	**0.029**	μ_H>μ_A
KVA	U	No	0.368	μ_H≠μ_A	t	**Yes**	**< 0.001**	μ_H>μ_A	U	**Yes**	**0.045**	μ_H>μ_A
KOM	U	No	0.316	μ_H≠μ_A	t	No	0,431	μ_H≠μ_A	t	No	0.073	μ_H≠μ_A
MLB	U	**Yes**	0.007	μ_H>μ_A	t	**Yes**	**0.019**	μ_H>μ_A	t	No	0.230	μ_H≠μ_A
MHK	t	No	0.095	μ_H≠μ_A	U	**Yes**	**0.002**	μ_H>μ_A	*U*	Yes	0.018	μ_H>μ_A
TRI	U	**Yes**	**0.033**	μ_H>μ_A	U	No	0.082	μ_H≠μ_A	t	No	0.055	μ_H≠μ_A
OLO	U	No	0.845	μ_H≠μ_A	U	No	0.085	μ_H≠μ_A	t	No	0.086	μ_H≠μ_A
KLA	U	**Yes**	**0.036**	μ_H>μ_A	U	**Yes**	**0.042**	μ_H>μ_A	t	No	0.194	μ_H≠μ_A
SPA	t	No	0.052	μ_H≠μ_A	U	No	0.456	μ_H≠μ_A	t	No	0.064	μ_H≠μ_A
PLZ	U	**Yes**	**0.003**	μ_H>μ_A	t	**Yes**	**0.016**	μ_H>μ_A	t	**Yes**	**< 0.001**	μ_H>μ_A
LIT	U	**Yes**	**0.044**	μ_H>μ_A	t	**Yes**	**0.003**	μ_H>μ_A	t	**Yes**	**0.004**	μ_H>μ_A
VIT	U	No	0.272	μ_H≠μ_A	t	**Yes**	**0.003**	μ_H>μ_A	t	**Yes**	**< 0.001**	μ_H>μ_A

The last group of indicators was the number of penalties and penalty minutes awarded. These sport statistics had different distributions and the parametric t-test and the non-parametric Mann-Whitney U test were used to test the hypothesis. It can be seen from the data in Table 7 that only some teams had statistically significant differences. A statistically significant difference in the number of penalties awarded in home and away matches was confirmed for HC Energie Karlovy Vary, HC Kometa Brno, HC Oceláři Třinec, HC Olomouc, HC Rytíři Kladno and HC Verva Litvínov. These teams can thus be said to have received fewer penalties during home games. In terms of the number of penalty minutes awarded, the results are almost identical. Statistically significant differences were found for HC Kometa Brno, HC Oceláři Třinec, HC Olomouc, HC Rytíři Kladno and HC Verva Litvínov. These teams can be said to have been awarded fewer penalty minutes during home games.

Table 7. Results of two-sample non-parametric U test and parametric t-test (penalties)

	number of penalties				number of penalty minutes			
	test	**diff.**	**P-Value**	**H_1**	**test**	**diff.**	**P-Value**	**H_1**
ZLN	U	No	0.136	μ_H≠μ_A	U	No	0.122	μ_H≠μ_A
LIB	U	No	0.276	μ_H≠μ_A	U	No	0.427	μ_H≠μ_A
PCE	U	No	0.750	μ_H≠μ_A	U	No	0.656	μ_H≠μ_A
KVA	t	**Yes**	**0.009**	μ_H<μ_A	U	No	0.208	μ_H≠μ_A
KOM	U	**Yes**	**0.012**	μ_H<μ_A	U	**Yes**	**0.016**	μ_H<μ_A
MLB	*U*	No	0.504	μ_H≠μ_A	U	No	0.198	μ_H≠μ_A
MHK	t	No	0.127	μ_H≠μ_A	U	No	0.287	μ_H≠μ_A
TRI	U	**Yes**	**0.013**	μ_H<μ_A	U	**Yes**	**0.010**	μ_H<μ_A
OLO	t	**Yes**	**0.016**	μ_H<μ_A	U	**Yes**	**0.014**	μ_H<μ_A
KLA	U	**Yes**	**0.008**	μ_H<μ_A	*U*	**Yes**	**0.011**	μ_H<μ_A
SPA	U	No	0.072	μ_H≠μ_A	U	No	0.071	μ_H≠μ_A
PLZ	U	No	0.504	μ_H≠μ_A	U	No	0.370	μ_H≠μ_A
LIT	U	**Yes**	**0.049**	μ_H<μ_A	U	**Yes**	**0.048**	μ_H<μ_A
VIT	U	No	0.067	μ_H≠μ_A	U	No	0.054	μ_H≠μ_A

DISCUSSION

The statistical analysis showed the existence of statistically significant differences between home and away games in the Czech top hockey league and was consistent with similar analyses from hockey leagues in the USA. For example, Agnew and Carron (1994) examined 15 teams over two hockey seasons. A significant home advantage was found when all games were included (58.7%) and when ties were excluded from the analyses (61.6%). Pollard and Pollard (2005) examined the National Hockey League (NHL) from 1917 to 2003. In the first seven seasons, home advantage was very high, reaching 75.0% in 1922/23. As the NHL expanded, the home advantage gradually began to decline. By the 1930s it had stabilised at an average of around 60%, which was maintained until the mid-1970s. Since then, there has been a further decline, which has stabilised at around 55% since the mid-1990s. The present research on the Czech top hockey league has not yet followed the development over such a long period of time. Thus, the results cannot be compared with Pollard and Pollard (2005) and other similar research at this time. The findings from the Czech hockey league are also in line with the findings of Bray (1999) who found an average home winning percentage of 52%. The findings from the Czech hockey league, on the other hand, contradict the findings of Szabó (2022) who found that there is no significant difference in the number of penalties and goals scored in home and away games in the American National Hockey League.

The presented empirical research on the Czech hockey environment also found statistically significant differences between home and away environments for some hockey teams. A similar conclusion was reached by Bray (1999), who examined individual NHL teams. Bray (1999) found that the vast majority of NHL teams won 17.3% more games at home than away. Further research is needed to clarify the reasons for the differences within individual teams in the Czech hockey league. A higher home advantage was found for the teams HC Verva Litvínov and HC Rytíři Kladno. A statistically significant difference was found for five of the six selected sport statistics. This is in line with previous studies (Clarke and Norman, 1995; Pollard and Gómez, 2009) that present similar findings for teams from geographically isolated locations or smaller cities. At the same time, these are hockey clubs with a rich hockey history and a strong hockey community in both cities. A higher home advantage in terms of points scored and shooting activity was found for HC Škoda Plzeň. Thus, it can be concluded that HC Škoda Plzeň hockey players have a higher shooting activity on their home court. For the teams HC Karlovy Vary, HC Kometa Brno, BK Mladá Boleslav and HC Oceláři Třinec, statistically significant differences were found for half of the selected sports statistics. For the teams HC Kometa Brno, HC Oceláři Třinec, the main statistically significant differences were in penalties and penalty minutes. The research presented here suggests that the teams in question receive fewer penalties when playing at home. Thus, these findings add to existing scientific evidence supporting the involvement of referees in the home advantage (Scoppa, 2021; Sors et al., 2020) and reinforce the existence of this phenomenon in elite hockey. This phenomenon could manifest itself to a different degree at critical moments such as the playoffs. It would be relevant to assess this in future research. A rather lower home advantage was found for HC Bílí Tygři Liberec, HC Dynamo Pardubice, Mountfield KH, HC Olomouc, HC Ridera Vítkovice and HC Berani Zlín. For these teams, statistically significant differences were

found in only two of the six sports statistics evaluated. A surprising result was achieved by HC Sparta Praha, which did not show a significant difference between home and away matches in any of the statistics. This finding is consistent with research by (Clarke and Norman, 1995; Pollard and Gómez, 2009). Given that capital cities are typically cosmopolitan places, a reduced sense of territorial protection might be expected to play a role in the consistently lower home advantage also found in this research. Empirical research on the Czech hockey league did not find evidence of a home disadvantage for any of the teams evaluated. Which is contrary to the finding of Bray (1999) according to which a small percentage of teams always show a home disadvantage in the regular season.

Other factors that may have influenced each team's home advantage, such as unusual home stadium characteristics, were not considered in this analysis. However, any home advantage found for HC Sparta Praha playing in a large stadium suggests that the capacity of the home stadium could be taken into account in future research on differences between teams. The presented research is limited to Tipsport Extraliga matches, which means that other matches in lower hockey leagues may behave differently. There is an assumption that different results can be expected from lower hockey leagues with lower spectator attendances. The research presented here is limited to the top hockey league in one season and further research needs to be conducted in other seasons and other leagues or countries so that the findings can be generalised to the wider population of ice hockey teams.

CONCLUSION

The aim of this research was to find out whether there is a home advantage in the Czech hockey league. Using parametric and non-parametric two-sample tests, the present research examines the differences between the number of points scored per game, goals scored, shots on and off target, penalties and penalty minutes awarded during home and away matches. The results of the research presented suggest that home and away matches played with spectators differed significantly in the 2019/20 season. The analysis of penalties and penalty minutes also suggests that referees favoured the home team more in matches played with spectators during the 2019/20 season.

The analysis of the individual hockey teams revealed that the home advantage is manifested to different degrees for each team. The home advantage was more pronounced for teams from smaller and traditional hockey cities such as Litvínov and Kladno. Conversely, the home advantage was generally very low in the capital city of Prague. Here, there was no statistically significant difference in any of the statistics examined.

The home field advantage in hockey is one of the less explored areas. According to many authors, the influence of the home environment is much smaller compared to football. Hockey players are isolated from the crowd by boundaries. The pitches also tend to be similar, at least in terms of temperature and ice quality. Hockey is one of the most unpredictable sports, and the outcome can be influenced by chance. Still, there are very many reasons why the home advantage in hockey is important to watch. One of them is the betting odds. The home advantage in hockey is something that every bettor should consider before placing a bet. We must not forget the hockey rules, which give the home team several significant advantages (substitutions, face-offs and shootouts).

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