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Comparative analysis of win and loss factors in women's handball using international competition records

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Abstract

This study identifies factors affecting match results from major international competitions in women's handball in the last four years. The 12 countries that participated for the 2020 Tokyo Olympics were included in the analysis, and a total of 281 matches from 4 major international competitions were analyzed. To identify factors affecting winning and losing, independent sample t-test and logistic regression analysis were conducted on the variables present in the official records. The findings present several factors that have positive and negative effects on match results. In the analysis of differences in win and loss factors, 6m goals success rate, 9m success rate, FB goals and shooting, AS, BS, and ST had positive effects on winning. Logistic regression analysis had 84.5% accuracy. 6m and Wing goal, 9m success rate, FB shooting, GK Wing save rate, and GK 9m save rate increased the probability of winning.

Key words: women's handball, match record, win and loss factors, independent t-test, logistic regression analysis

Introduction

The development of technology has enabled the measurement of athletes' movements and the analysis of movement data. Technology has also been widely used in the sports industry to improve performance in combination with sports science (Fujii, 2021; Kim, 2012). Recently, technology has been developed for the analysis of game records data, allowing for the quantitative analysis of various events and phenomena observed during games. In addition, game contents and progress can be analyzed in real-time, providing information for the real-time adaptation of tactics and strategies (Kim et al., 2008, Fernandez et al., 2006).

Handball is a representative ball sports game that requires the analysis of the opponent's strategy and tactical information. To collect information on the

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opponent, game records and videos are analyzed (Luteberget, 2018; Kim, 2012). Since the 1996 Barcelona Olympics, all events that occur during matches for all participating teams in international handball competitions have been recorded by professional record keepers from the International Handball Federation (IHF). All results are available on the Federation's website immediately after each game. These records are used as basic data for individual movement and scientific training and are an essential factor for establishing skills and tactics. Analysis methods are continuously being further developed (Taborsky, 2011; Bilge, 2012), and accurate and detailed analyses of opposing teams are more important than ever. Such analyses are considered to be an essential factor for coaches' effective tactics display (Jung, 2006).

The IHF is continuously modifying game rules to enable fast-pace and exciting matches. The pace of transition between offense and defense is greater than that in the past, such as Quick start that leads to an immediate attack after conceding goals. This has increased the demand for high-intensity exercise. Since 2016, empty goal strategy with extra field players participating in attacks instead of goalkeepers also shows the diversity of attack strategies (IHF, 2016, 2019). Sevim and Bilge (2007) and Pokrajac (2010) reported that the new rules on QuickStart have allowed swift attacks in possession of the ball and led to more dynamic and diverse strategies for top-tier teams.

In previous studies conducted in Korea and other countries, Kim (2012) and Kim et al. (2013) found that the success rate of 6m and 9m shots as well as defensive factors such as blocks and steals affect match results. Kim et al. (2011) and Hong and Park (2016) developed an objective model to evaluate players' goals per position. Srhoj et al. (2001) reported that the movement of back position players and goals from swift attack and breakthrough have decisive effects on the final results of matches and that the number of shots from specific locations do not affect the match outcome. Similarly, Bilge (2012) analyzed the results of the World Championships and European Championships and reported that fast swift attack and efficient movement of pivot and back position players affect team standings. In addition, Pfeiffer and Perl (2006) analyzed the tactical structure using an artificial neural network analysis technique and created and applied an optimized attack pattern. However, these studies analyzed one to two competitions before the revision of the game rules. Thus, their findings cannot be generalized, and new studies are needed to analyze the recent international trend of women's handball and evaluate their tactical characteristics.

In this study, we aimed to provide basic data for the establishment of customized tactics and strategies and the development of training programs by assessing changes in the main factors that determine the outcome of handball games using data from recent international competitions in women's handball.

Methods

Analysis target

To analyze global trends in women's handball, a total of 281 games from the 12 countries that participated in the 2020 Tokyo Olympics were analyzed. IHF official data for the 2017 IHF World Women's Handball Championship (66 games), the 2018 European Championship (54 games), the 2019 HF World Women's Handball Championship (96 games), and the 2021 Tokyo Olympics (65 games) were collected. As a result of the game, 169 wins and 112 losses were classified in a total of 281 games and used for analysis. The characteristics of the data from each competition are shown in Table 1.

Analysis variables

A total of 43 variables including 18 shooting variables, 2 offense variables, 2 defense variables, 3 penalty variables, and 18 goalkeeping variables were

Table 1. Data from each competition

	Nation	2017 WC	2018 EC	2019 WC	2020 OL	Result
1	**Netherlands**	7	8	10	4	22 W 7 L
2	**Norway**	7	7	10	8	25 W 7 L
3	**Russia**	6	8	10	7	23 W 8 L
4	**Montenegro**	5	6	9	6	15 W 11L
5	**Brazil**	4	0	6	4	6 W 8 L
6	**Sweden**	7	6	8	6	17 W 10 L
7	**Spain**	4	6	9	5	12 W 12 L
8	**Angola**	5	0	7	4	5 W 11 L
9	**Japan**	4	0	8	5	6 W 11 L
10	**France**	7	7	6	6	21 W 5 L
11	**Korea**	5	0	6	5	7 W 9 L
12	**Hungary**	5	6	7	5	10 W 13 L
	Total	66	54	96	65	

WC: World women's handball championship, EC: European women's handball championship
OL: Olympic, W: win, L: Loss

analyzed.

Shooting variables of Goal, number of shots and success rates included shots from 6m, wing, 9m, and 7m positions. FastBreaks (FB) indicates swift attacks from counterattacks, and Break Through s(BT) indicates shots after breakthroughs. Offense variables included assists (AS) and turnover (TO), which indicates giving away the possession of the ball to the opponent. Defense variables included steals (ST) and blocked shots (BS). Penalty variables were yellow card (YC), 2-minute suspension (2min), and red card (RC). Goalkeeping (GK) variables were number of saves (SV) per shooting location, number of shots allowed (SH), and the save rate compared to the total number of shots (%).

Data analysis

To identify factors that affect match outcomes and present differences between winning and losing matches, the collected data were analyzed per country using Excel 2016 (Microsoft, USA).

A t-test was conducted to assess the differences in the variables between winning and losing matches, and logistic regression analysis was performed to analyze the factors that determine wins and losses. In logistic regression analysis, β is the logistic regression coefficient of statistically selected independent variables, and SE is the standard error considering the number of samples. Wald value is calculated by dividing β by SE to verify the significance of the logistic regression coefficient and allows the verification of the χ^2 distribution. Exp(B) was odds ratio. Exp(B) equal to 1, greater than 1, and less than 1 indicated invalid, positive, and negative effects, respectively (Kim et al., 2008). A p value of >.05 was considered statistically significant, and all data were analyzed using SPSS 23.0 (IBM, Chicago, IL, USA). Feedforward selection that allows the program to automatically select and analyze statistically significant variables was conducted for the logistic regression analysis.

Table 2. Results of analysis of difference between winning and losing factors related to shooting

Variables		Result	Mean	SD	t	p
6m	Goal	Win	7.54	3.55	3.522	.000
		Loss	6.10	3.08		
	Shooting	Win	11.11	5.07	1.563	.119
		Loss	10.14	5.12		
	Success rate	Win	70.17	17.30	3.198	.002
		Loss	63.16	18.97		
Wing	Goal	Win	5.56	3.07	1.903	.058
		Loss	4.86	2.99		
	Shooting	Win	8.83	4.16	.024	.981
		Loss	8.82	4.76		
	Success rate	Win	62.69	22.13	-.018	.986
		Loss	62.82	91.99		
9m	Goal	Win	5.49	3.05	1.731	.084
		Loss	4.87	2.75		
	Shooting	Win	12.20	5.52	-2.730	.007
		Loss	14.06	5.71		
	Success rate	Win	46.05	17.91	4.721	.000
		Loss	35.73	17.97		
7m	Goal	Win	3.30	1.94	-1.299	.195
		Lose	3.61	2.00		
	Shooting	Win	4.21	2.34	-2.323	.021
		Loss	4.88	2.42		
	Success rate	Win	77.54	24.33	.622	.534
		Loss	75.73	23.13		
FB	Goal	Win	5.13	3.65	9.224	.000
		Loss	2.13	1.73		
	Shooting	Win	6.56	4.35	9.282	.000
		Loss	2.93	2.15		
	Success rate	Win	75.44	24.30	1.913	.057
		Loss	68.34	33.92		
BT	Goal	Win	3.33	2.52	1.088	.278
		Loss	3.01	2.29		
	Shooting	Win	4.12	2.97	-.143	.887
		Loss	4.17	2.93		
	Success rate	Win	74.86	30.93	1.800	.073
		Loss	67.99	31.75		

Results

Verification of differences in win and loss factors

Among the 18 shooting variables, a total of 7 variables showed significant differences: 6m goal (t= 3.522, p= .000), 6m success rate (t= 3.198, p=. 002), 9m shooting (t= -2.730, p= .007), 9m success rate (t= 4.721, p= .000), 7m shooting (t= -2.323, p= .021), FB goal (t= 9.224, p= .000), and FB shooting (t= 9.282, p= .000) (Table 2).

Among the seven variables related to offense, defense, and penalties, AS (t= 7.264, p= .000), TO (t= -4.770, p= .000), BS (t= 5.501, p= .000), and ST (t= 4.886, p= .000) showed significant differences (Table 3).

Among the 18 variables related to goalkeeping, 11 variables showed significant differences: 6m save (t= 2.610, p= .010), 6m save rate (t= 3.921, p= .000), Wing save (t= 3.836, p= .000), Wing save rate (t= 5.233, p= .000), 9m save (t= 4.852, p= .000), 9m save rate (t= 4.449, p= .000), 7m save (t= 2.374, p= .018), FB save (t= -2.322, p= .021), FB shooting (t= -7.038, p= .000), BT shooting (t= -2.177, p= .030), and BT save rate (t= 2.061, p= .040).

Table 3. Results of analysis of difference between winning and losing factors related to offense, defense, and penalties

Variables	Result	Mean	SD	t	p
AS	Win	16.24	5.43	7.264	.000
	Loss	12.15	3.96		
TO	Win	11.43	3.34	-4.770	.000
	Loss	13.45	3.67		
BS	Win	2.82	2.25	5.501	.000
	Loss	1.58	1.52		
ST	Win	3.95	2.11	4.886	.000
	Loss	2.76	1.80		
YC	Win	1.53	1.08	-.158	.875
	Loss	1.55	1.11		
RC	Win	0.08	0.27	-.869	.385
	Loss	0.11	0.31		
2min	Win	3.62	1.86	1.436	.152
	Loss	3.33	1.52		

Table 4. Results of analysis of difference between winning and losing factors related to GK

Variables	Result	Mean	SD	t	p
6m Save	Win	2.92	2.10	2.610	.010
	Loss	2.29	1.85		
6m Shooting	Win	8.92	4.32	-1.791	.074
	Loss	9.91	4.82		
6m Save Rates	Win	30.99	17.28	3.921	.000
	Loss	23.06	15.52		
Wing Save	Win	2.56	1.85	3.836	.000
	Loss	1.76	1.50		
Wing Shooting	Win	6.70	3.73	-.424	.672
	Loss	6.88	3.37		
Wing Save Rates	Win	40.17	23.93	5.233	.000
	Loss	25.63	20.88		
9m Save	Win	4.91	2.71	4.852	.000
	Loss	3.56	1.93		
9m Shooting	Win	9.91	4.40	1.005	.316
	Loss	9.38	4.22		
9m Save Rates	Win	49.55	19.82	4.449	.000
	Loss	38.91	19.35		
7m Save	Win	0.76	0.92	2.374	.018
	Loss	0.54	0.68		
7m Shooting	Win	3.97	2.16	-.172	.864
	Loss	4.02	2.42		
7m Save Rates	Win	17.30	21.07	1.437	.152
	Loss	13.73	19.29		
FB Save	Win	0.52	0.76	-2.322	.021
	Loss	0.75	0.89		
FB Shooting	Win	2.46	1.79	-7.038	.000
	Loss	4.63	2.91		
FB Save Rates	Win	18.27	28.10	.579	.563
	Loss	16.54	21.76		
BT Save	Win	0.66	0.91	1.248	.213
	Loss	0.53	0.77		
BT Shooting	Win	3.23	2.67	-2.177	.030
	Loss	3.97	2.98		
BT Save Rates	Win	16.57	24.12	2.061	.040
	Loss	11.35	18.20		

Table 5. Logistic regression analysis results for winning or losing factors

Variables	β	SE	Wald	df	p	Exp(B)
6m Goal	.336	.073	21.177	1	.000	1.399
Wing Goal	.562	.130	18.605	1	.000	1.754
Wing Shooting	-.274	.085	10.478	1	.001	0.760
9m Success rate	.046	.011	16.068	1	.000	1.047
FB Shooting	.485	.087	31.118	1	.000	1.624
GK 6m Shooting	-.212	.049	18.551	1	.000	0.809
GK Wing Save rate	.044	.010	20.963	1	.000	1.045
GK 9m Save rate	.036	.011	10.867	1	.001	1.036
GK FB Save	-.404	.092	19.443	1	.000	0.668

β: logistic regression coefficient, S.E.: standard error, Wald: X^2 distribution verification statistics,
p: p-value, Exp(B) = 1: invalid, Exp(B) > 1 positive effect, 0 < Exp(B) < 1: negative effect

Table 6. Logistic regression analysis results for the factors of winning or losing each competition from 2017 to 2021

	Variables	β	SE	Wald	df	p	Exp(B)
2017	FB Goal	1.257	0.386	10.609	1	0.001	3.516
	GK Wing Save	1.295	0.530	5.980	1	0.014	3.652
	GK FB Shooting	-0.719	0.297	5.860	1	0.015	0.487
							X^2 =59.051, df=3, p= .000
2018	9m Shooting	0.443	0.173	6.568	1	0.010	1.557
	AS	0.580	0.205	7.980	1	0.005	1.785
	ST	1.223	0.576	4.517	1	0.034	3.398
	GK Wing Save Rates	0.097	0.041	5.631	1	0.018	1.102
	GK FB Shooting	-1.121	0.384	8.514	1	0.004	0.326
							X^2 =47.976, df=4, p= .000
2019	6m Shooting	0.274	0.123	4.980	1	0.026	1.316
	9m Success Rate	0.170	0.051	11.003	1	0.001	1.186
	FB Goal	0.867	0.333	6.784	1	0.009	2.379
	AS	0.486	0.196	6.139	1	0.013	1.626
	TO	-0.560	0.215	6.751	1	0.009	0.571
	GK 6m Shooting	-0.441	0.175	6.342	1	0.012	0.644
	GK Wing Save Rates	0.098	0.032	9.305	1	0.002	1.103
	GK 9m Save Rates	0.046	0.021	4.615	1	0.032	1.047
	GK 7m Save	2.331	0.953	5.983	1	0.014	10.289
							X^2 =84.286, df=9, p= .000
2020	6m Goal	0.515	0.173	8.800	1	0.003	1.673
	FB Shooting	0.576	0.199	8.370	1	0.004	1.779
	AS	0.303	0.111	7.423	1	0.006	1.354
	GK BT Save Rates	0.054	0.023	5.389	1	0.020	1.055
							X^2 =42.393, df=4, p= .000

β: logistic regression coefficient, S.E.: standard error, Wald: X^2 distribution verification statistics, p: p-value, Exp(B) = 1: invalid, Exp(B) > 1 positive effect, 0 < Exp(B) < 1: negative effect

Logistic regression analysis of win and loss factors

The logistic regression analysis of independent variables predicting wins and losses had statistical significance and an accuracy of χ^2=197.441, p<.000. The logistic regression model correctly predicted 78% of wins and 88.7% of losses with an overall accuracy of 84.5%.

Among the 43 independent variables, 6m goal (β= 0.336, Wald= 21.177, p= .000), Wing goal (β= 0.562, Wald= 18.605, p= .000), Wing shooting (β= -0.274, Wald= 10.478, p= .001), 9m success rate (β= 0.046, Wald= 16.068, p= .000), FB shooting (β= 0.485, Wald= 31.118, p= .000), GK 6m shooting (β= -0.212, Wald= 18.551, p= .000), GK Wing save rate (β= 0.044, Wald= 20.963, p= .000), GK 9m save rate (β= 0.036, Wald= 10.867, p= .001), and GK FB save (β= -0.404, Wald= 19.443, p= .000) affected wins and losses.

The changes in important factors determining wins and losses in women's handball international competitions were assessed per year. Among the 43 variables, 3 variables in 2017 (FB goal, GK Wing save, GK FB shooting), 5 variables in 2018 (9m shooting, AS, ST, GK Wing save rates, GK FB shooting), 9 variables in 2019 (6m shooting, 9m success rate, FB goal, AS, TO, GK 6m shooting, GK Wing save rate, GK 9m save rate, GK 7m save), and 4 variables in 2020 (6m goal, FB shooting, AS, GK BT save rate) affected wins and losses.

Discussion

In this study, we observed that the factors determining wins and losses in women's handball matches diversified after 2017. Kim(2012) reported that the 7m and Wing success rate had a low influence on the match results, and Kim (2021) stated that the 6m and 9m success rate had significant effects on the match results. However, in our analysis of international competitions from multiple years rather than single competitions, Wing's goal and FB shooting had the greatest effects on the match results. This may be attributed to the Quick Start system, which has led to faster transitions between offense and defense, the empty goal rule with seven players on field, and diverse tactics using the space in the wing position for penalties. Players in the Wing position travel the longest distance in games, move at the fastest pace during swift attack, and have become an essential part of recent handball team strategies.

Empty goal strategy that adds an extra field player instead of a goalkeeper is used during matches by approximately 88% of all participating teams. In the 2019 IHF Women's Handball World Championship, 11.3% of total offense was executed by the extra player replacing the goalkeeper with an average of 5.3 goals per game. The extra players also accounted for 9.9% of total goals [IHF Education Center].(2021,Oct 31). https://ihfeducation.ihf.info

Kim et al. (2013) reported that a goalkeeper save rate greater than 35.29% and shooting success rate greater than 56.40% were associated with a 91.11% probability of winning. In addition, weighted defense goal's conceded balance index for each position was greater than 12.6% and was associated with a 100% probability of winning. In agreement with these findings, factors related to goalkeeping such as the number of saves and save rate affected wins and losses of matches. In particular, increased FB saves had negative effects on the match results (Exp(B)=0.668). As goalkeepers face one-on-one situations in most contexts except for 9m shooting, many aspects of a goalkeeper's record are closely related to the team's defense. Thus, the enhancement of teamwork in defense such as backcourt transitions that are not reflected in game records would have greater impacts on the match results.

6m and 9m goals (success rate) were also important factors affecting the match results. This indicates that basic offense formation to penetrate the opponent's defense is a basic requirement for winning matches. Consistent with our findings, previous studies also reported that winning teams had a balanced offense

(Rogulj, 2000; Ferrari et al., 2014).

In another study that analyzed factors affecting wins and losses in the Men's European Championship, AS was found to have significant effects on match results (Ferrari et al., 2020). However, although AS was found to be significantly different between the won and lost matches of women's handball in this study (t= 7.264, p= .000), the regression analysis did not show significant differences. This may be due to the distinct characteristics of women's matches, in which offense patterns using FB and BT are mainly used in crowded spaces instead of AS.

Our findings suggest that back and pivot position players who mainly stay in 6m and 9m areas that are important factors for the most basic attack type (offense), GK defense capacity, increased frequency of FB for fast-paced matches, and the role of Wing players have become important factors in recent international competitions for women's handball. In addition, transition into defense and teamwork were factors with significant effects on match results.

Conclusion

In this study, we aimed to analyze the match records of major international competitions for women's handball in the last four years and identified factors affecting match results to provide basic data for the establishment of tactics, strategies, and training programs. The following results were observed.

In the analysis of differences in win and loss factors, 6m goals success rate, 9m success rate, FB goals and shooting, AS, BS, and ST had positive effects on winning. In contrast, 9m and 7m shooting and TO had negative effects. Among the factors related to goalkeeping, 6m wing, and 9m saves and save rate, 7m saves, and BT save rate had positive effects on the match results, while FB saves and shooting and BT shooting had negative effects. Increased attempts of FB during offense regardless of success rate had positive influences on winning and negative effects on match results for goalkeepers regardless of an increased number of saves.

Logistic regression analysis had 84.5% accuracy. 6m and Wing goal, 9m success rate, FB shooting, GK Wing save rate, and GK 9m save rate increased the probability of winning. However, Wing shooting, GK 6m shooting, and GK FB save lowered the probability of winning. Wing players required high success rate and fast transition into defense to prevent FB for goalkeepers for an increased probability of winning matches.

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