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Performance Profiling in Handball Using Discriminative Variables and its Practical Applications

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Abstract

Performance profiles of teams performance highlight areas of weaknesses and strengths for coaches to inform their decision-making on how to spend their limited training time with athletes. This study used a stepwise discriminative analysis approach comparing one successful team's (TEAM) performances through five consecutive seasons against a) other top four teams (TOP4) and b) teams with a final rank between 5th and eight (LOW) in a semi-professional league. The predictive model created was used to set forth a performance profile for the selected team. A total of 95 matches of the TEAM's matches from the last five seasons are in the analysis. The objective was to create a performance profile with relevant performance indicators selected based on the discriminant analysis results of the selected TEAM and discuss its practical applicability. For matches against other TOP4 teams, the predictive model created consisted of three variables; legal stops, blocked shots and 9 m shots, classifying 72.6% correctly. The LOW ranked teams model had six variables and correctly classified 94.4% of cases (assists, blocked shots, legal stops, the goalkeeper saved shots, 2-minute exclusion, and shot efficiency). The selected variables are presented in Table 4, with medians and a 95% confidence interval of the median as a team performance profile. The profile provides the coaches with two models containing values that can serve as a reference for this team's performance. The profile of this TEAM's performances during the last five seasons generally aligns with the variables associated with success in other studies in female handball.

Keywords: *team performance profile, performance indicators, discriminative analysis, female handball*

Introduction

Team handball (hereafter handball), like other team sports, represents a complex adaptive system of two seven-a-side teams with clear intentions, competing under official rules which act as informational task constraints upon the players' behaviour, limiting the possible movement solutions (Button et al., 2021). The game is physically demanding, intermittently fast, with frequent transitions, duels, and scoring (Kniubaite et al., 2019) for 60 minutes of playtime split into two periods. Changes to the official rules by the game's governing body have facilitated development in this direction. As an example, the need to always identify a goalkeeper specifically was removed in 2016, paving the way for faster goalkeeper substitutions for an extra offensive player. Further adjustments to the restart after conceding a goal have also been made to make the game even faster (IX. Rules of the Game: Indoor Handball, 2022). Within each team, the sport places position-specific physical demands on players (Luteberget & Spencer, 2017; Foretic et al., 2022) as their roles and places on the court differ. A recent systematic review on physical demands in handball reports that wings and backs cover more distance than piv-

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ots. On the other hand, pivots perform the most body contacts during a match. Wing players run more fast breaks, while backs perform more throws than wings and pivots (García-Sánchez et al., 2023). Handball play differs between sexes, as female players cover more distance during matches at a higher relative workload than males, who perform more high-intensity strength-related actions (Michalsik & Aagaard, 2014).

In such a fast and dynamic game, it is valuable to know which variables contribute to success more than others to direct efforts in training. Discriminative analysis of game-related statistics is a standard method in sports performance analysis that allows this discrimination. The method constructs a model able to classify performances based on as few variables as possible and a high percentage of correct classifications. Discriminant function analysis allows the creation of a prediction model of group membership based on a collected data set for two or more groups (O'Donoghue, 2009). Regarding female handball, the method has primarily been used to discriminate between winners and losers in semi-professional (Þorgeirsson et al., 2022a) and international level (de Paula et al., 2020) handball. Other uses include comparisons of handball player's body composition to those of athletes from other ball sports (Mala et al., 2015) and for handball talent identification for example (Fernández-Romero et al., 2016; Naisidou et al., 2017). Being a starter or non-starter is another marker of success where discriminatory analysis was used at the youth club level, analysing anthropometry, physical performance measurements and handball skills tests (Saavedra et al., 2020). The primary purpose of performance analysis is to enhance performance (O'Donoghue, 2009), but engaging in the practice can help coaches to enhance their coaching practices (Martin et al., 2018). It can prove challenging to align research aims with the aims of coaches primarily concerned with their team performances. Performance profiles can be used to present typical characteristics of performers through selected performance indicators associated with success. Regularly, papers are published presenting different profiles of handball players describing anthropometry and position-specific demands (Vila et al., 2012), performance levels (Moss et al., 2015) and technical activity (Michalsik et al., 2015).

Previous work on females has attempted to analyse the discriminative variables between winning and losing at the elite level (Saavedra et al., 2018) and the semi-professional level (Þorgeirsson et al., 2022a, 2022b). One cross-sectional research investigated female handball on the domestic semi-professional level. It highlighted goalkeeper saved shot efficiency and total shot efficiency as discriminating between winning and losing matches, classifying 87% correctly. To our knowledge, no performance profiles for a handball team have been published using game-related statistics. Performance profiles can be an accessible information template from performance analysts to the coaches working with players. There are several known barriers for coaches to engage in performance analysis; time and cost are primary, as well as technical know-how and the integration into practice itself (Martin et al., 2018). Therefore, a model containing the most relevant performance indicators with numbers that can be used as reference values might prove valuable. Until recently, most have focused on the elite level and compared several major championships (Saavedra et al., 2018; de Paula et al., 2020). Therefore, the objective is to create a performance profile of one selected team's performances (TEAM) based on performance indicators from a discriminative analysis. Specifically, by analysing the performance of one successful female team using discriminative analysis of the game-related statistics from five successive seasons (2018/19 - 2022/23).

Methods

Participants

The team selected (TEAM) for this analysis represents one of the top four (TOP4) teams in the final ranking in all five seasons (2018-2023) in the Icelandic semi-professional league. During this period, the team was under the charge of the same coach. All 95 matches played by the TEAM in the last five seasons of the top semi-professional league in Iceland were included in the analysis (eight-team top league with one lower league). The data set comprises 22 variables describing the efficiency of shots; goalkeeper saves, and the frequency of offensive and defensive-related events. Game-related statistics were obtained from the statistics company HBStatz, the official statistical partner of the Icelandic Handball Federation. The data used is all publicly available online https://hbstatz.is/OlisDeildKvennaLeikir.php. The TEAM had decent success in these five seasons, winning the national championship (2019 and 2023) and the cup competition (2019, 2022), in addition to winning the league twice (2018-2019 and 2022-2023). A more detailed description of the team's performances against other TOP4 and LOW-ranked teams can be viewed in Table 2.

Procedures

During the handball matches, the data was entered by a trained person into an online web-based platform tailored explicitly for handball. The data is then exported into an Excel spreadsheet for computation of efficiency variables by one of the authors (Ó.S.) and subject to a random check by one of the authors (S.Þ.). The information in this research is available online in the public domain; therefore, no informed consent was necessary. The dependent variable in the study was the selected female team compared to a) the other three teams in the top four final league rank and b) LOW ranked teams (5th position and lower). The independent variables was the game-related statistics listed in Table 1. This method has been used with similar studies in the Icelandic handball league (Þorgeirsson et al., 2022a, 2022b).

Statistical analysis

This is structure-oriented comparative research of handball game-related statistics (Pfeiffer & Perl, 2006) using discriminatory analysis to identify variables discriminating between the selected team's performance and different quality opponents. A summary of the team's league performances regarding points earned, goals scored and conceded against TOP4 and LOW ranked teams are in Table 2. Discriminant analysis was performed using the sample-splitting method depending on the final league rank, comparing the TEAM to other TOP4-ranked teams and then separately against other LOW ranked teams (5th to eighth). Wilks's lambda (λ) was used to measure the deviations within each group to the total deviations. The sample included variables that minimized the value of λ, assuming the value of F was great-

Table 1 Definitions of the Game-Related Statistics

Variable	Definition
Shots	Percentage of converted shots relative to the number of shots made.
6 m shots	Percentage of converted shots at 6 m relative to the number of shots made. The shot is from a zone outside the 45° angle from the left and the right.
7 m shots	Percentage of penalties (7 m) converted relative to the number of penalties taken.
9 m shots	Percentage of converted shots at 9 m relative to the number of shots made. The shot is from a backcourt player either (a) over or through the defence, or (b) after a breakthrough but with a defence player in front.
Wing shots	Percentage of converted shots from the wing area relative to the number of shots made. The shot is from a zone within the 45° angle from the left and the right without a defence player in front.
Fast-break shots	Percentage of shots converted in a fast-break situation (rapid switch from defence to attack without the defence organized) relative to the number of shots made in this situation.
Breakthrough shots	Percentage of shots converted in a breakthrough situation relative to the number of shots made in this situation (a) from a backcourt player after breakthrough in the 9 m zone without a defence player in front, (b) from the pivot after a 1:1 situation, (c) from the left or right back after a breakthrough of a 1:1 situation.
Yellow cards	Yellow cards received by each player and/or coaching staff member.
Red cards	Red cards received by each player and/or coaching staff member.
2-min exclusions	Number of 2-minute suspension received by players and/or coaching staff.
Assists	Number of passes from one offensive player to another leading directly to a goal scored.
Technical fouls	Number of turnovers made by the offensive team where the ball is awarded to the defence due to a foul in offence.
Blocked shots	Number of blocked shots by a defender
Legal stops	Number of fouls committed by a team without getting penalized with a 2-minute exclusion or a red card
Steals	Number of turnovers in favour of the defence due to actions of anticipation and snatching the ball.
GK shots	Percentage of shots stopped relative to the number of shots made by the attackers.
GK 6 m shots	Percentage of 6 m shots stopped relative to the number of shots made by the attackers.
GK 7 m shots	Percentage of penalties (7 m) stopped relative to the number of penalties taken by the attackers.
GK 9 m shots	Percentage of 9 m shots stopped relative to the number of shots made by the attackers.
GK wing shots	Percentage of shots stopped in the wing area relative to the number of shots made by the attackers.
GK breakthrough shots	Percentage of shots stopped in breakthrough situations relative to the number of shots made by the attackers.

er than F=3.84 for inclusion. The next step was to combine the variables pairwise. A new variable was added if λ was greater than F. Wilks lambda, canonical correlation, and the percentage of correctly classified matches (the team against oppositions, either TOP4 or LOW ranked teams) was calculated. Table 4 presents the team's performance profile (James et al., 2005). An alpha level threshold of .05 was set for statistical significance. The statistical analysis was performed with the software package IBM SPSS Statistics (Version 27.0; IBM, Armonk, NY, USA).

Results

Table 2 presents the teams league performances with the number of matches, goals scored and conceded on average

Table 2. The Teams League Performance Statistics in Total, Against TOP4 Teams and Lower Ranked Teams

Statistics	Opposition	Season				
		2018-2019	2019-2020	2020-2021	2021-2022	2022-2023
	All					
Number of league matches		21	18	14	21	21
Final league position		1st	2nd	3rd	2nd	2nd
Points earned on average (%)		81	80.5	60.5	71.5	85.5
	TOP4					
Number of league matches		9	8	6	9	9
Points earned on average (%)		61	50	25	55.5	66.5
Goals scored per match (M)		25.22	22.33	22.33	25.67	26.56
Goals conceded per match (M)		21.11	19.3	28.4	25.11	16.21

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Table 2. The Teams League Performance Statistics in Total, Against TOP4 Teams and Lower Ranked Teams

Statistics	Opposition	Season				
		2018-2019	2019-2020	2020-2021	2021-2022	2022-2023
	LOW					
Number of league matches		12	10	8	12	12
Points earned on average (%)		96	100	87.5	91.5	100
Goals scored per match (M)		26.92	29.6	29.63	27.75	31.17
Goals conceded per match (M)		18.83	18.5	20.88	21.17	22.08

Note. M = mean, Seasons 2019-2020 and 2020-2021 fewer matches were played because of COVID19 restrictions

and points earned (%) provided for each of the five seasons, in total and against the TOP4 teams, and LOW ranked teams separately.

Table 3 presents the discriminatory analysis comparing the team selected against its opponents according to the final league rank of TOP4 or LOW ranked teams. It includes Wilks's lambda, the canonical correlation and the predictive model's percentage of correctly classified cases.

Table 3 Discriminative Analysis of the TEAMs Performance against TOP4 and LOW ranked teams separately.

Model´s statistics	Period 2018-2023	
	Against TOP4 (n = 76)	Against LOW (n = 94)
Correctly classified (%)	70.2	94.4
Wilks lambda	0.702	0.250
Canonical correlation	0.546	0.866
Selected variables	Legal stops	Assists
in order of importance	Blocked shots	Blocked shots
	9 m shots	Legal stops
		GK saved shots
		2-minute exclusion
		Shots

Note. Seasons 2019-2020 and 2020-2021 fewer matches were played because of COVID19 restrictions; a GK = Goalkeeper

Against other TOP4 teams, the models correctly classified 70.2% of TOP4 teams with three selected variables and 94.4% against the LOW-ranked team's performances using six variables. The TOP4 model included legal stops, blocked shots and 9 m shot efficiency. The model for performances against LOW ranked teams contained assists, blocked shots, legal stops, GK saved shots, 2-minute exclusions and total shot efficiency.

Table 4. The performance profile of the TEAM according to the opponent's quality based on league performances from the last five seasons.

Predictive models	Team		TOP4		LOW	
	Median	CI	Median	CI	Median	CI
TOP4						
Legal stops (#)	19	17-22	13	11-16		
Blocked shots (#)	4	3-6	2	1-3		
9 m shots (%)	42	37-50	36	28-38		
LOWER						
Assists (#)	12	11-13			5	4-6
Blocked shots (#)	4	3-5			1	1
Legal stops (#)	23	21-24			14	13-15
GK saved shots. (%)	40	39-44			27	24-30
2 min exclusion (#)	1	1-2			2	2-3
Shots (%)	61	57-63			43	39-46

Note. # = frequency of events, CI = 95% Confidence interval of the median

Table 4 presents the performance profile of the selected team using the selected variables as performance indicators presenting the median and the 95% confidence interval of the median.

Discussion

This research explored the discriminant variables for one top four TEAM against two groups of opponents according to final league rank in a semi-professional league. The objective was to create a performance profile of a female handball team and discuss how the information obtained with this method could inform the practices of handball coaches in semi-professional leagues. These results highlight how different sets of variables emerge as discriminant depending on the quality of the opponents. Therefore, presenting the medians and 95% confidence intervals of the medians of the relevant performance indicators holds the potential to be a valuable reference for coaches in match preparation, during and post-match analysis.

Offensively, only 9 m shot efficiency was included in the model against the TOP4 teams. The 9 m shot had already been highlighted in previous work on the 2012 Olympics (Milanović et al., 2018) and again during the final minutes in balanced matches at this level for males and females as characteristic of successful performances (Þorgeirsson et al., 2022b). The selected TEAM has this characteristic in common with other successful teams. Total shot efficiency, which had been identified as discriminant in previous work on semi-professional league (Þorgeirsson et al., 2022a) and also international level (Saavedra et al., 2018), was only found to be discriminant in the LOW model. Furthermore, in the LOW model, assists also emerged as discriminant, in accordance with a study on the elite level for unbalanced and very unbalanced matches (de Paula et al., 2020). Perhaps this tendency of successful teams creating more assists has more to do with matches being unbalanced rather than the performance level, even though the exact definition of what counts as an assist in handball can be seen as vague.

Defensively, the first two variables named in the TOP4 model are blocked shots and legal stops. While legal stops physically stop the offense and interrupt the offensive build-up, blocked shots may lead to a quick turnover creating chances for a fast break. So does stealing the ball, which was not found to be discriminating for the TEAM, even though it is important in recent research for balanced matches on the female elite level, just as the blocked shots (de Paula et al., 2020). Interestingly, legal stops were not a deciding factor in this female league, even though it was for the male league (Laxdal & Ivarsson, 2023). Actively seeking legal stops in the female league may not yield better results, but this TEAM's defense style can be considered an aggressive characteristic. However, this aggressive but still legal style (only 1-2 2-minute exclusions per match) may have the desired effect on the opponents. However, that is very difficult or even impossible to observe using statistics. In addition to blocked shots and legal stops found in the TOP4, the LOW model also identified the goalkeeper's total shot saved efficiency and 2-minute exclusions were included. The goalkeeper's efficiency was expected as it aligns with a previous study comparing male and female handball across a single season(Þorgeirsson et al., 2022a). Finally, five out of nine variables in the two models are defense-related signals key TEAM characteristics (blocked shots and legal stops in both models).

This study's limitations include i) the outcome-based nature of this data does not provide insight into the process and action leading to the events. ii) the results represent only one TEAM's performance, and their profiles may vary. iii) The variables used for shots and goalkeeper saves are entered as efficiency values; therefore, the weighted importance of each cannot be assumed from this analysis. iv) The models produced discriminate only between the team's performance and the opponents without regard to the outcome of the games. v) Goalkeepers fastbreak shot save could not be included in the analysis because of too many missing data points.

Potential directions for research in this field are to get qualitative feedback from coaches on performance profiles like the one produced here to improve its structure. Furthermore, to perform an advanced analysis of the processes behind statistics using dynamic process-oriented data. It could also be interesting to explore if key actions for defense could be presented in a performance profile for different teams to compare.

Practical implications

The selected variables used as performance indicators for the TEAM are actions performed under match conditions (constraints). In preparation for matches, the different profiles of the opponents of different qualities can shape the tactical preparation for each match. To effectively train these actions, creating a representative training environment is important. We, therefore, recommend that coaches manipulate task constraints for the desired actions. This could include constraining the starting players (more quality) during training against their teammates (less quality) in preparation for matches. These constraints could target the player's defensive actions specifically and force the players to explore different solutions and find new successful ways to block shots and perform legal fouls. Since stealing the ball has been related to success in female handball, the coach could create specific incentives in training to steal the ball to add that variable to their defensive profile. This might direct coaches to play more full court (as opposed to half) in match preparation to enable representative decision-making by players. This approach could prepare the team for competition against a quality opponent by developing problem-solving abilities in a representative context. Changing the game's rules (task constraint) even a little bit can significantly impact the player's emergent movement and team synergies (Araújo et al., 2022). These recommendations align with those made by authors of similar research on elite-level female handball, emphasising representative task design for learning (de Paula et al., 2020). In matches, the performance profile can serve as reference values for the TEAM's performance and post-match evaluation.

Conclusions

Performance profiles can provide a statistic-based knowledge of the TEAM's performances. Should coaches decide to engage, they can use the model to reflect and inform their coaching practice and philosophy. The defensive profile of the team analysed was a key characteristic. In match preparation, targeting the preferred actions specifically using task constraints in representative handball training (e.g., rules, space, and time constraints) is recommended.

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Conflict of Interest
The authors declare that there is no conflict of interest.

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