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Is it time for a more analytical approach? Suboptimal shot selection strategies in handball

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Abstract

Increased use of analytics in sports has shed some light on various suboptimal strategies that have long been considered the norm. While sports such as basketball and baseball have adapted to a changing landscape, handball seems slow to adapt. The aim of this study was to examine i) the prevalence of high- and low-probability shots in semi-professional handball, ii) whether taking high-probability shots was associated with winning and iii) whether there were any differences between the men's and women's leagues. Six seasons in the Icelandic elite division were analyzed using a mixed-effects logistic regression model (1410 games, 879 games in the men's league and 531 games in the women's league). The study found that low-probability shots outnumbered high-probability shots (54.1% to 45.9%) and that high-probability shots were associated with winning (odds ratio of 1.46, compared to odds ratio of 0.73 in the low-probability shots). This was especially pronounced in the women's league (odds ratio of 1.77, compared to an odds ratio of 1.20 in the means league). These findings suggest that some handball teams could enhance their performance by focusing on creating high-probability shots. However, the success of such efforts depends not only on the attacking team's tactics but also on the defensive strategies employed by their opponents, which significantly influence the quality of scoring opportunities. Ultimately, the interplay between offensive and defensive approaches dictates the frequency and feasibility of high-probability shots.

Keywords

Gender, home advantage, tactical decisions, team sport, winning probability

Introduction

Bent "Bengan" Johansson and the "Bengan boys" (i.e., the Swedish men's national team) were a dominant force in world handball during the 90's and 00's, winning 13 medals in international championships. The team had a well-defined tactical approach that is well-known in handball circles and centered around the fact that shots closer to the goal (i.e., breakthroughs, shots from the wings and shots from the pivot) have a higher success rate than shots from a distance (i.e., shots from the backcourt and shots from mid-field).[1] The team therefore prioritized high-probability shots in offense and in turn aimed to pressure the opposing team to take low-probability shots when they defended.

Despite this approach being highly intuitive and backed up by research results,[2–4] there are few indications of it being widely applied, at least explicitly. In fact, there are some indications of the opposite strategy, with the majority of shots in handball games being taken by backcourt players, even though the winning teams tend to take more close-range shots.[2,4–8] This tendency can be highlighted by the fact that 79% of the top 10 scorers (excluding

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penalty shots) at the last seven major men's handball championships (Olympics, European- and World Championship) have been backcourt players (see supplemental file). However, it is interesting that the women's list appears more balanced (67% backcourt players vs. 33% wingers and pivots), indicating that there may be differences between how men and women choose to execute their offenses.

While the abovementioned studies offer some valuable preliminary information on shooting strategies, their scope was limited, and they did not explicitly test the relationship between shooting strategies and game success. For most of the studies, the fact that shot selection or efficiency from various positions seemed to be associated with winning was a post hoc revelation or explanation and not the explicit aim of the study. These previous studies also used small sample sizes[3,4] or were limited to either men's or women's handball.[2,3,9] These limitations were highlighted and criticized by Prieto et al.,[10] who recommended an increased focus on more long-term studies with an added emphasis on national leagues, particularly women's leagues, in their systematic review of the handball literature.

These seemingly suboptimal shooting strategies beg the question, "Why would teams make the counterintuitive tactical decision to take more low-probability shots than high-probability shots?" Some might argue that they are just easier to come by. Still, others may argue that there are hidden risks involved in pursuing more optimal opportunities (e.g., increased probability of turnovers or passive plays). Parallels can be drawn to the sport of basketball, where shot selection has changed radically in recent years as teams make more calculated decisions regarding risks and returns because of advances in sports analytics.[11,12] The long two-point shot used to be a highly prevalent shot in basketball but is no longer seen as a desirable option. Instead, teams are prioritizing two-point shots closer to the basket, which have a higher success rate, and three-point shots, which have a lower success rate than long two-point shots but yield greater rewards. No team encapsulates this new landscape more than the 2017/2018 Houston Rockets, which became the first team to attempt more three-point shots than two-point shots during the season.[13]

It seems that sports analytics are putting long held beliefs about the merits and drawbacks of certain playing styles or strategies in various sports to the test, and many of them don't seem to hold water. Baseball teams are refraining from previously popular tactics such as stealing bases and manufacturing runs.[14] In contrast, American football teams are more likely to take risks by going for it on fourth downs and attempting two-point conversions.[15] In soccer, the introduction of expected goals (xG) as a measure of performance has sparked debates on relative efficiency and individual contributions to chance creation that have revolutionized match evaluation.[16,17] Seeing as there are indications that handball teams may not be opting for the most efficacious shooting strategies available, we wanted to kick-start a data-driven discussion on shot selection and the possible tactical implications of prioritizing differently. The aim of this study was to examine i) the prevalence of high- and low-probability shots in semi-professional handball, ii) whether taking high-probability shots was associated with winning and iii) whether there were any differences between the men's and women's leagues.

Materials and methods

Data and procedure

Every shot during the six seasons from 2018 to 2024 in the semi-professional elite divisions in Iceland has been registered by the sports analytics company HBStatz (www.hbstaz.is), the official statistics partner of the Icelandic Handball Association. A total of 133,447 shots were recorded in the 1410 games (879 games in the men's league and 531 games in the women's league) that took place in the period between 2018–2024. Seeing as each game yields two rows of data (home and away team), the dataset consists of 2820 rows. The data was gathered in situ by designated representatives from the home teams, who had received training from HBStatz before using the system, a process that has previously been found to be reliable and effective.[18]

While most of the actions in the HBStatz software are straightforward, objectively countable entities, the main variable of interest in this study requires some subjective interpretations of the proceedings (i.e., determining which shots belong in any given category). However, to reduce discrepancies and minimize the risk of missing or misregistering any actions, the compilers meet once a year to synchronize their methodology. Further efforts to ensure the validity of the collected data can be seen in previous studies using data from HBStatz.[19,20]

The variables of interest in this study were the number of 6-meter shots (wing shots, pivot shots, breakthroughs from backcourt position; i.e., a catch all term for all shots from within the 9-meter line), 9-meter shots (backcourt shots; i.e., all shots from or beyond the 9-meter line), total number of shots (6-meter shots, 9-meter shots, penalty shots, and fast breaks), game outcome (whether the team won, lost, or tied the game), team quality (the average point tally the team accrued across the studied period), and gender (whether the game was played in the men's or the women's league). Using the shot variables, we computed a categorical variable that categorized whether the team had taken more, less or an equal number of 6-meter shots compared to 9-meter shots. Additionally, a continuous variable was calculated which indicated the proportion of shots taken from 6-meters.

Statistical analysis

We employed a mixed-effects logistic regression model to analyze the binary match outcome (win/loss). The model was formulated as follows:

$$logit(p_{ij}) = \beta_0 + \beta_1 x_{p,ij} + \beta_2 x_{g,i} + \beta_3 x_{p,ij} x_{g,i} + \beta_4 x_{h,ij} + u_{0i} + u_{1i} x_{q,i} + v_j$$

where p_{ij} represents the probability of team i winning match j, and $logit(p_{ij}) = \log\left(\frac{p_{ij}}{1-p_{ij}}\right)$. The fixed effects included $x_{p,ij}$ (percentage of 6-meter shots, centered), $x_{g,i}$ (gender, coded as1 for men and 0 for women), $x_{h,ij}$ (home advantage, coded as 1 for home and 0 for away). The model incorporated an interaction term between shot percentage and gender ($x_{p,ij}x_{g,i}$) to test whether the effect of 6-meter shot percentage on winning probability differs between men's and women's teams. Random effects for team u_{0i} modeling differences in each team's baseline winning odds and u_{1i} capturing how strongly team quality $x_{q,i}$ influences those odds—and the match-level random effect (v_j) addresses the statistical dependency created when each match appears twice in the dataset—once from each team's perspective.

The model was fitted using a frequentist approach through maximum likelihood estimation with Laplace Approximation, as implemented in the lme4 package in R. Model parameters were estimated by maximizing the integrated likelihood function, and statistical inference was based on Wald tests for fixed effects. The selected mixed-effects logistic regression model was chosen after systematic comparison of several alternative specifications using both Akaike Information Criterion (AIC) and likelihood ratio tests. More complex models incorporating additional interaction terms failed to significantly improve model fit, supporting our decision to adopt this more parsimonious specification. All analyses were conducted using R (version 4.1.0) with the lme4 package (version 1.1-27) for fitting mixed-effects models. Visualizations were created using the ggplot2 package (version 3.3.5).

Results

The teams shot more 9-meter shots than 6-meter shots 57.4% of the time (more 6-meter shots than 9-meter shots = 38.5%, equal amount of 6-meter shots and 9-meter shots = 4.1%). In total, 54.1% of the shots analyzed were 9-meter shots and 45.9% were 6-meter shots. On average 42.6% (SD = 13.1%) of the 9-meter shots were successful, while 66.3% (SD = 12.0%) of the 6-meter shots ended up in the goal (45.2% [SD = 12.5%] vs. 67.4% [SD = 11.5%] for the men's league and 38.4% [SD = 13.0%] vs. 64.4% [SD = 12.6%] for the women's league).

The mixed-effects logistic regression model revealed several significant predictors of winning probability in handball matches. Table 1 presents the estimated coefficients, standard errors, and p-values for all fixed effects in the model.

Table 1. Fixed effects estimates from the mixed-effects logistic regression.

	Estimate	Std. Error	z value	p-value
Intercept	−0.2323	0.1722	−1.349	0.1773
6-meter shot percentage	5.7377	0.9381	6.116	<0.001
Gender	−0.2915	0.2011	−1.449	0.1472
Home advantage	0.3095	0.1097	2.822	0.0048
6-meter shot percentage × Gender	−3.9097	1.2028	−3.251	0.0012

The non-significant intercept (p-value = 0.1773) indicates that for women's teams playing away with average 6-meter shot percentage, the log-odds of winning are slightly negative, corresponding to a probability of approximately 44%. The percentage of 6-meter shots (centered around its mean) was highly significant (p-value < 0.001) with a large positive coefficient (5.7377) for women's teams. Since this variable represents the proportion of shots taken from 6-meter (ranging from 0 to 1), this coefficient indicates the change in log-odds associated with a complete shift from 0% to 100% 6-meter shots. For a more practical interpretation, a 10-percentage point increase in 6-meter shots (a 0.1 change in proportion) would result in a change in log-odds of 0.57377 for women's teams, corresponding to an odds ratio of 1.77. This means that for women's teams, increasing the proportion of 6-meter shots by 10 percentage points increases the odds of winning by approximately 77%. The home advantage effect was significant and positive (p-value = 0.0048), with teams playing at home having 36% higher odds of winning compared to playing away. Gender showed a non-significant effect (p-value = 0.1472), indicating that men's teams do not have statistically different odds of winning compared to women's teams, and this non-significance of gender is particularly meaningful when examined alongside the random effects structure of our model. Most notably, the interaction between 6-meter shot percentage and gender was significant (p-value = 0.0012) with a negative coefficient (−3.9097). This indicates that the positive effect of 6-meter shots is substantially weaker for men's teams than for women's teams. For men's teams, the effect of increasing 6-meter shot percentage is still positive (5.7377–3.9097 = 1.8280), but much less pronounced. A 10-percentage point increase in 6-meter shots above the average results in a log-odds change of 0.18280 for men's teams, translating to an odds ratio of 1.20. This means that for men's teams, the same 10-percentage point increase in 6-meter shots

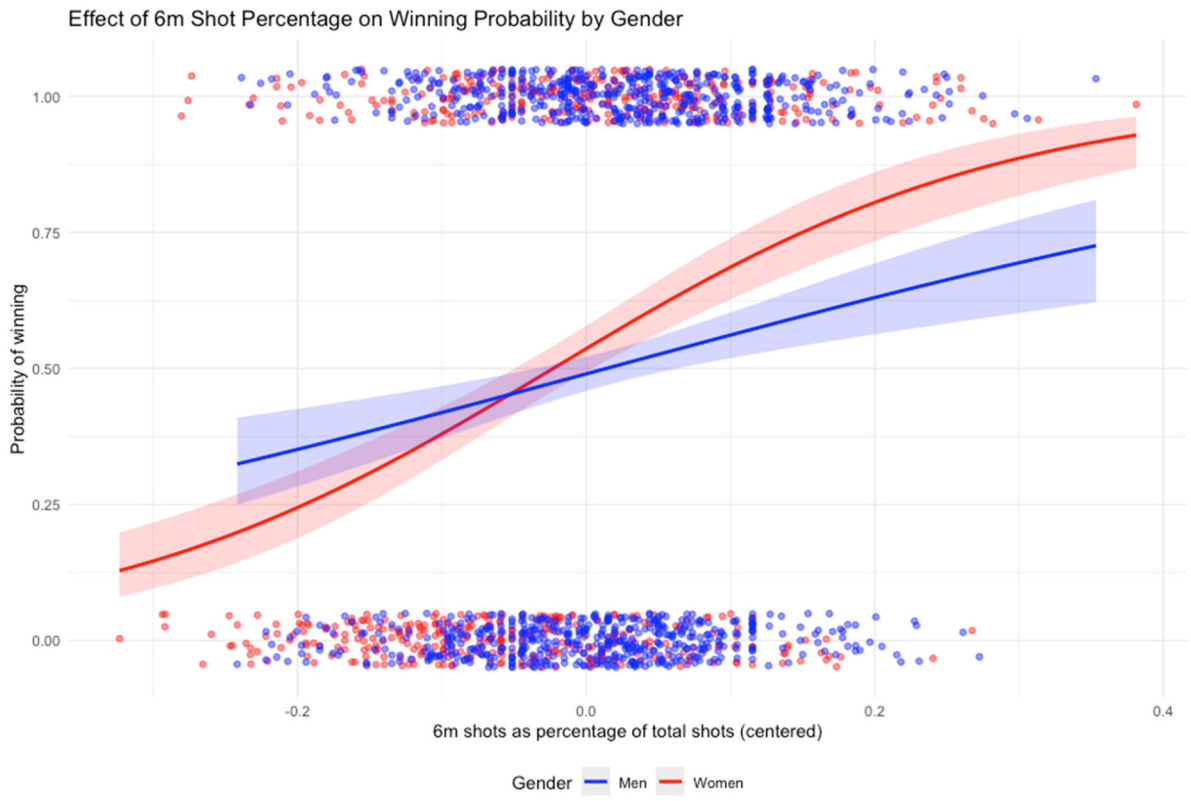

Figure 1. This figure shows how 6-meter shot percentage affects winning probability for women and men. Dots represent actual match outcomes (wins at top, losses at bottom), with color indicating gender.

increases the odds of winning by only 20%, compared to 77% for women's teams.

Figure 1 clearly illustrates the interaction between gender and 6-meter shot percentage. The women's curve shows a notably steeper slope compared to the men's curve, confirming our statistical finding that the effect of 6-meter shot percentage on winning probability is significantly stronger for women's teams than for men's teams. The relatively flat trajectory of the men's line is not a visualization artifact but rather a meaningful representation of our model's significant negative interaction term. In logistic regression, weaker effects naturally appear more linear when transformed to the probability scale, while stronger effects display more pronounced curvature. The dots visible at the top and bottom of the figure represent the actual match outcomes in our dataset, with values of 1 (win, at the top) or 0 (loss, at the bottom) for each team's match. These data points are plotted against the centered 6-meter shot percentage for that specific match, with red dots representing women's matches and blue dots representing men's matches. The vertical jittering of these points is added merely for visual clarity, as binary outcomes would otherwise stack exactly at 0 and 1. The confidence bands surrounding each line provide a visual indication of our statistical certainty about these relationships, with narrower bands indicating greater precision in our estimates. This difference in slopes represents a key tactical insight: while increasing the proportion of 6-meter shots generally improves winning probability for all teams, this strategy is substantially more effective in women's handball than in men's handball, suggesting that optimal shooting strategies may differ significantly between genders. To illustrate these effects with concrete examples: For a women's team playing at home, increasing their 6-meter shot percentage from the average (approximately 20%) to 30% would increase their winning probability from 52% to 69%. In contrast, the same 10 percentage point increase for a comparable men's team would only raise their winning probability from 45% to 50%.

The random effects structure reveals important insights about team-level variation. The team random intercept shows substantial variance, indicating significant differences in baseline performance across teams that aren't captured by our fixed effects. Interestingly, the match-level random effect has extremely small variance, suggesting minimal unexplained variation attributable to specific matches after accounting for team effects and our fixed predictors. The nearly perfect negative correlation between the team random intercept and team quality slope suggests that

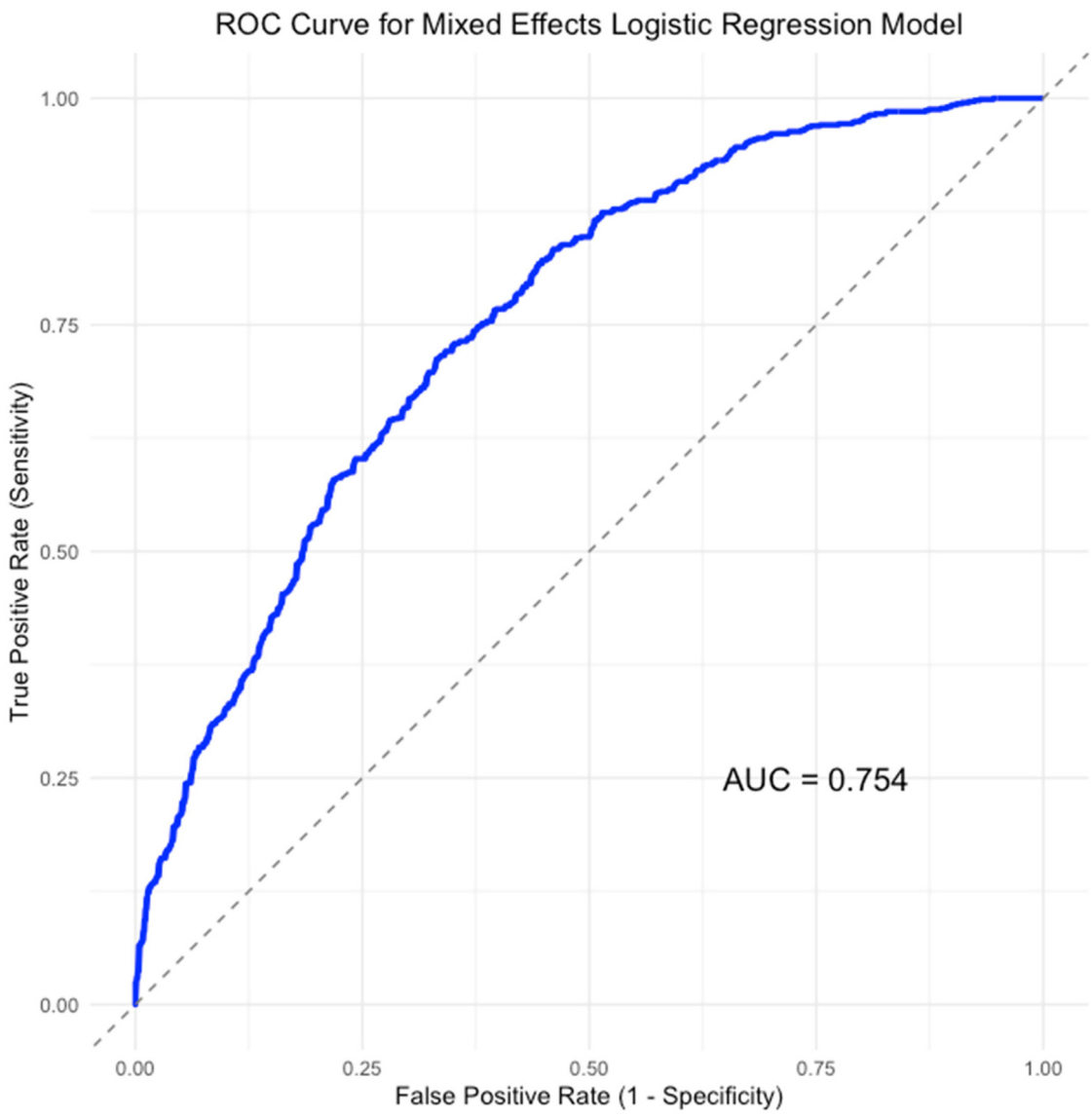

Figure 2. ROC curve for the mixed-effects logistic regression model.

teams with higher baseline winning probabilities show smaller effects of team quality on performance.

These findings demonstrate that while increasing the proportion of 6-meter shots generally improves winning probability for all teams, this strategy is significantly more effective for women's teams than for men's teams. This gender difference in the effectiveness of 6-meter shots represents a key tactical consideration for coaches and suggests that optimal shooting strategies may differ between men's and women's handball.

To evaluate the predictive performance of our model, we conducted a Receiver Operating Characteristic (ROC) analysis, which assesses how well the model discriminates between wins and losses. As shown in Figure 2, the ROC curve plots the true positive rate (sensitivity) against the false positive rate (1-specificity) across various threshold settings. The area under the ROC curve (AUC) was 0.754, indicating moderate discriminative ability. This suggests that our model, incorporating 6-meter shot percentage, gender, their interaction, and home advantage effectively predicts match outcomes with substantially better accuracy than chance (which would yield an AUC of 0.5, represented by the diagonal dashed line). This analysis provides further validation of our model's utility for understanding factors that influence success in handball matches.

Discussion

The aim of this study was to study shot selection in handball by examining i) the prevalence of high- and low-probability

shots in semi-professional handball, ii) whether taking high-probability shots was associated with winning and iii) whether there were any differences between the men's and women's leagues. In line with the general trend in the literature, we found that low-probability shots are used more than high-probability shots.[2,4,7] This is somewhat counterintuitive, as shots from areas closer to the goal are more likely to be successful.[2] However, it's important to note that whether an attacking team can create a high-probability scoring opportunity is not solely up to the attacking team. In many ways, the defensive team is the arbiter of scoring and can therefore determine the quality of the scoring opportunity to some degree,[21] as outlined in O'Donoghue's[22] Interacting Performance Theory. In fact, the internal logic of handball requires the backcourt players to create space for themselves or their teammates by forcing defenders to react to their actions. As the back court players play this active function in the attacking scheme, interactions (passes) between the back court players are far more frequent than interactions between them and the rest of the team.[23]

In many ways, the crux of our argument relates to whether the defense or the offense plays a larger role in determining where the shots come from. All defensive schemes have strengths and weaknesses and can to some degree influence which chances materialize. For example, the 6:0 defense invites more low-probability shots while securing the high-probability shooting area. On the other hand, more aggressive defense schemes, such as the 5:1 defense (man-to-man or zone), disrupt the flow of the offense. This makes it more difficult to create shooting opportunities from the low-probability area, while also increasing the possibilities of turnovers.[24] With this in mind, it can seem logical to think that the selection of high- or low-probability shots depends on the type of defense the opponent has opted for. Still, it will also depend on the attacking team's tactical decisions or preferences. In recent years, there are teams that have been able to prioritize high-probability shots with great effect, with SC Magdeburg being a prime example. That team has been assembled specifically to play this style of handball and is quite deliberate when it comes to the execution of the tactics this paper proposes.[25] A more accessible scheme (i.e., not as dependent on long-term recruitment or available personnel) is the 7:6 attack, where the goalkeeper is pulled, and an extra pivot player is fielded. However, this system has yielded varying results and often results in easy goals into an empty goal for the opposing team.[26]

Perhaps unsurprisingly, the results of the present study showed that there is a higher probability of winning matches if high-probability shots are used. This applied to an even greater extent to women's teams. A possible explanation for the gender differences is that women occupy relatively less space on the field than men (see Pedersen et al.[27] for an exhaustive comparison from the soccer context), leaving more space from which good shooting opportunities can be created. This aligns with previous studies where successful women's teams were found to be effective from close range, and 6-meter shots were the largest predictor of winning.[9,20] Another possible explanation is shot velocity. Men can throw significantly harder than women[28] and have previously been found to be more effective from 9-meters than women.[20] The men can score from a distance with relative ease and since creating space around the 6-meter line may be onerous, they may opt for the low-probability shot. Interestingly, teams have been found to invite the opposition to take 9 m shots late in balanced matches by taking a passive defensive stance.[20] Whether this is the result of fatigue or calculated risk taking is unknown.

Causal inference methods have provided new ways to analyze decision-making in invasion sports using observational data. Wu et al.[29] showed that crossing in soccer can be effective when analyzed through propensity score matching. Similarly, Epasinghege Dona and Swartz[30] demonstrated that playing at a high pace increases shot opportunities, while their later work on throw-ins found advantages in backward and long throw-ins.[31] These studies highlight the value of player tracking data and propensity score methods in approximating randomization. Applying similar causal methodologies to handball could clarify whether shot selection is driven by tactical preference or defensive constraints, deepening our understanding of the sport.

This study has some limitations. First, this study takes a static perspective, focusing on the game-related statistics as "the final result" without considering what occurred at each moment of the match (dynamic perspective).[10] Consequently, the potential influence of specific game situations such as defender positions, shot quality, and shot angle on subsequent play was not examined. Future studies could build on the current study by including the aforementioned factors in their models, consequently adding to relevant literature from other related invasion sports such as football and ice hockey where those factors have been studied extensively.[32–34] It is also important to note that the numerical situation of the attack was not considered, and this has been shown to affect tactical decisions.[26] Furthermore, we analyzed a semi-professional league, and whether these findings hold true in professional leagues (such as the German or French leagues) or national championships with different competition systems (i.e., Olympic Games, World Championships, or European Championships) is unknown.

Conclusion

This study found that low-probability shots were more common than high-probability shots and that high-probability shots were associated with winning in the

Icelandic elite division. This was more pronounced in the women's league. These results invite us to consider whether this favoring of low-probability shots is something that teams consciously pursue (i.e., they utilize players who are good long-distance shooters) or if it is perhaps forced upon them by the game situation (i.e., they are not able to create high-probability chances because the opposing team plays a strong defense around the 6-meter line). Understanding this causal relationship could help coaches refine offensive strategies to optimize shot selection. Given the effectiveness of causal inference in other invasion sports, future research should apply similar frameworks to handball. Propensity score matching or other causal modeling techniques could provide deeper insights into how tactical decisions shape shot selection. This study could also be followed up with qualitative interviews of handball coaches, where they expand on their tactical choices and elucidate both the opportunities and challenges associated with the studied approach

Author statements

Data is openly available at Figshare (https://doi.org/10.6084/m9.figshare.26712430.v1). All authors have approved the final version of the manuscript. With all data being openly available online, no ethical approval was required, and no informed consent was obtained.

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Supplemental material

Supplemental material for this article is available online.

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