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Dr. Joel Paul

University of Trinidad and Tobago, Trinidad
& Tobago.

*CORRESPONDENCE

Andrea Guntara Adi Very Sandra
andrea.23003@mhs.unesa.ac.id

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- Andrea Guntara Adi Very Sandra
- Achmad Widodo
- Himawan Wismanadi
- Taufiq Hidayat
- Pudjijuniarto
- Heryanto Nur Muhammad



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Predicting Match Success Through Scoring Efficiency in Elite Men's Indoor Hockey: Field Goals Versus Penalty Corners

Andrea Guntara Adi Very Sandra^{1*}, Achmad Widodo¹, Himawan Wismanadi¹, Taufiq Hidayat¹, Pudjijuniarto¹, Heryanto Nur Muhammad¹¹Faculty of Sports and Health Sciences, State University of Surabaya, Indonesia.

ABSTRACT

Background & objective: Men's indoor hockey is a high-intensity invasion sport in which goal-scoring efficiency serves as a critical determinant of competitive success. Despite the strategic importance of different scoring modes, comparative investigations examining the relative relationships between field goals, penalty corner goals, and match outcomes remain limited, particularly in Southeast Asian elite competitions. This study aimed to examine and compare the relationships between field goals, penalty corner goals, and team victories in men's indoor hockey at the SEA Games 2025.

Materials & Methods: A quantitative observational design employing systematic notational analysis was applied to 26 team-match observations derived from 13 official matches involving five national teams. Match outcome was coded as win (1) or loss (0), while field goals and penalty corner goals served as independent variables. Descriptive statistics, Kolmogorov-Smirnov and Shapiro-Wilk normality tests, Spearman's rank correlation, Mann-Whitney U tests, and binary logistic regression were employed to analyze the data.

Results: Field goals accounted for 60.0% of total goals ($n = 72$), while penalty corner goals contributed 40.0% ($n = 48$). Both scoring modes were significantly associated with match outcome; however, penalty corner goals exhibited a stronger correlation with victories ($p = .788$, $p < .001$) than field goals ($p = .583$, $p = .002$). The Mann-Whitney U test confirmed significantly higher scoring ranks for winning teams in both categories, with a larger separation observed for penalty corner goals ($U = 11.00$, $Z = -3.94$, $p < .001$). Logistic regression indicated that a one-goal increase in penalty corner goals was associated with a 12.09-fold increase in the odds of winning ($\text{Exp}(B) = 12.09$), compared with a 5.23-fold increase for field goals. The model explained 86% of the variance in match outcome (Nagelkerke $R^2 = .86$) with 88.5% classification accuracy.

Conclusions: Although open-play goals provide the primary scoring volume, penalty corner efficiency plays a more decisive role in determining team victories in elite men's indoor hockey. These findings offer evidence-based insights for tactical planning and training prioritization in competitive indoor hockey.

Keywords

indoor hockey; field goals; penalty corner goals; team victories; performance analysis; SEA Games.

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INTRODUCTION

Global and Theoretical Context

Across invasion team sports, competitive success depends not only on creating attacking opportunities but also on converting them into scores. This distinction between opportunity creation and opportunity conversion provides a useful framework for understanding how different scoring modes may relate to match outcomes (Lamas et al., 2020). Possession, territorial control, and attacking frequency can indicate how a team constructs pressure, but they do not necessarily show whether that pressure produces goals. In hockey, where matches may be decided by a small number of scoring events, the type and effectiveness of the finishing action may therefore be particularly consequential (Cooper & Pulling, 2020; Sarmento et al., 2022).

Men's indoor hockey offers a distinctive context for examining this relationship. Its confined court, rapid transitions, and limited time and space place substantial technical and cognitive

demands on players (James et al., 2021, p. 653370; Mallo, 2020; McGuinness et al., 2017). These constraints shape both open-play attacks and the circumstances in which set plays occur. Field goals arise from open-play sequences and can reflect coordinated movement, ball circulation, circle penetration, and finishing under defensive pressure (Rico-González et al., 2020; Stöckl & Morgan, 2013). Penalty corner goals, by contrast, follow a structured restart in which teams can rehearse roles and routines, potentially reducing some uncertainty in execution (Knoester & Leeuw, 2025; Vinson et al., 2013). These scoring modes consequently represent different attacking processes rather than interchangeable goal totals.

The opportunity-creation and conversion framework predicts that both scoring modes should be positively associated with winning: a team that scores more goals is more likely to win. It also suggests a possible difference in the strength of association.

Penalty corners provide a relatively controlled setting for organizing a shot, while field goals emerge from more variable sequences involving opponent pressure and transitions. (Hughes et al., 2025; Moon et al., 2018, p. 86). This could make penalty corner scoring especially consequential in closely contested matches. However, a structured opportunity is not automatically a successful one: execution, defensive responses, and match context can all affect whether it becomes a goal. The relative contribution of penalty corner and field-goal scoring must therefore be tested rather than assumed.

Critical Review of Existing Evidence

Research on hockey scoring supports the importance of examining both the production and conversion of opportunities, but the evidence is uneven across formats, populations, and outcomes. A systematic review of field-hockey performance analysis identified a limited body of work, with studies addressing patterns of play, penalty-corner strategies, and specific game actions; it also noted the potential value of more holistic analyses of team and opponent interactions (Lord et al., 2021). This evidence base cautions against treating a single match indicator as a complete account of performance. At the same time, it underscores the practical value of studying scoring events, which are directly connected to the outcome coaches seek to influence.

Studies of penalty corners show that structured opportunities can be consequential, while also demonstrating that their success depends on tactical and contextual features. In elite women's indoor hockey, an analysis of 36 round-robin matches recorded 319 penalty corners, of which 72 (22.6%) resulted in a goal. Logistic regression identified the side from which the corner was taken and the goalkeeper's decision to rush as relevant predictors of the outcome (Vinson et al., 2013). This study offers directly relevant evidence from the indoor format and illustrates how tactical details can shape conversion. However, it examined the success of individual penalty corners rather than whether penalty-corner goals were more strongly associated with team victories than field goals. (Hughes et al., 2025; Zainuddin & Jakiwa, 2024, p. 453). Its women's league sample also differs from an international men's tournament, limiting direct generalization.

Evidence from outdoor hockey likewise indicates that scoring patterns vary with competition and opponent context. A comparison of Chinese women's performances across Olympic and national competitions analyzed match statistics using notational methods and non-parametric comparisons; its findings emphasized the need to improve opportunity conversion against stronger international opposition (Huo et al., 2024). Separately, a study of 140 matches across four international women's competitions from 2017 to 2022 compared scoring patterns across continents and reported regional differences in some indicators (연구원 et al., 2022). These studies broaden the evidence beyond a single league, but they concern women's outdoor hockey and do not directly estimate the relative association of field-goal and penalty-corner goals with winning in men's indoor competition. Differences in format, population, opposition quality, and measured outcomes may help explain why results from one setting cannot simply be transferred to another.

More broadly, analyses of team sports distinguish between generating opportunities and converting them, and caution that performance indicators should be interpreted in relation to the sport's scoring structure and match dynamics (Lamas et al.,

2020; Sarmiento et al., 2022). Yet comparisons of specific goal types against match outcomes remain less common than descriptive accounts of scoring or analyses of how an individual set play succeeds (Csiernik et al., 2025, p. 1648102; Kim et al., 2019, p. 2202). The available studies also use varied units of analysis—from individual penalty corners to team and match statistics—and different outcomes, making direct comparison of effect magnitude difficult. Consequently, evidence that penalty corners are strategically important does not by itself establish that penalty-corner goals have a stronger relationship with winning than field goals. Small or competition-specific samples, differences in gender and format, and a focus on event-level rather than match-level outcomes are plausible reasons for this unresolved question.

Research Gap, Novelty, and International Contribution

Although previous studies show that penalty corners are structured and potentially high-impact scoring opportunities, and that conversion efficiency matters in hockey, it remains unclear whether penalty-corner goals are more strongly associated with winning than field goals among elite men's indoor teams competing in a Southeast Asian international tournament. This is a specific gap in outcome-focused evidence, not simply an absence of descriptive statistics about indoor hockey. The distinction matters because the practical recommendation to prioritize set-play scoring should depend on its relative relationship with match success, not solely on its tactical prominence.

The present study addresses this gap by comparing two scoring modes in the same competition and relating each to the same binary match outcome. It uses team-match observations from all 13 men's indoor hockey matches at the SEA Games 2025 and combines descriptive, correlational, group-comparison, and logistic-regression analyses. This tournament-wide observational design provides a competition-specific comparison between field goals and penalty-corner goals, extending event-focused indoor research to the match-outcome level. Its contribution is therefore contextual and comparative; the limited number of matches and observational design do not support causal conclusions or broad generalization to all elite hockey competitions. By examining a Southeast Asian men's indoor tournament, the study also adds evidence from a competition context that is less represented in the cited international literature.

Objectives and Hypotheses

The primary objective was to examine and compare the relationships between field goals, penalty-corner goals, and winning outcomes in men's indoor hockey at the SEA Games 2025. A secondary objective was to assess whether winning and losing teams differed in their field-goal and penalty-corner scoring and to estimate the combined association of these scoring variables with the odds of winning.

It was hypothesized that (H1) both field goals and penalty-corner goals would be positively associated with winning; (H2) winning teams would score more field goals and penalty-corner goals than losing teams; and (H3) penalty-corner goals would show a stronger association with winning than field goals. These are associational hypotheses consistent with the observational design and the planned correlation, group-comparison, and binary logistic-regression analyses. They do not imply that either scoring mode independently causes victory.

MATERIALS AND METHODS

Participants and Competition Context

The study sample comprised all matches played in the men's indoor hockey tournament at the SEA Games 2025, held in Thailand. A total of 13 matches were analyzed, producing 26 team-match observations ($N = 26$). Five national teams participated in the tournament: Thailand, Malaysia, Indonesia, the Philippines, and Singapore. All matches from the group stage through the knockout phase, including classification and medal matches, were included to ensure full representation of competition performance. This census sampling approach eliminated selection bias and maximized the ecological validity of the dataset (Lames, 2023).

Study Design and Organisation

This study employed a quantitative observational research design based on systematic notational analysis to examine the relationships between field goals, penalty corner goals, and match outcomes in men's indoor hockey at the SEA Games 2025 (O'Donoghue et al., 2017). The design was correlational in nature and aimed to identify statistical associations between goal-scoring modes and competitive success without inferring causal relationships. Notational analysis was selected as the methodological framework due to its established validity in performance analysis research across invasion team sports. The dependent variable was match outcome, operationalized as a binary variable coded as win (1) or loss (0). Matches decided by shoot-out were coded as wins for the shoot-out winner and losses for the opposing team. The independent variables were the number of field goals and the number of penalty corner goals scored by each team in each match. All variables were treated as count data at the team-match level.

Data Sources and Collection Procedures

Match performance data were obtained from the official website of the International Hockey Federation (FIH). Official match reports, play-by-play summaries, and statistical records published on the FIH platform were used as primary data sources. Data were recorded at the team-match level for each fixture. For every match, the total number of goals scored by each team and the corresponding match outcome were extracted. All goals scored during regulation time and decisive phases, including shoot-outs where applicable, were included in the dataset. Goals were classified using a standardized coding framework aligned with official hockey performance analysis conventions. Field goals were operationally defined as goals scored during open-play situations without a preceding set-play restart. Penalty corner goals were defined as goals scored directly following the award of a penalty corner, including drag-

flick conversions, deflections, and direct shots from the set-play routine. Penalty stroke goals were documented for completeness but were excluded as independent variables in the main analyses due to their limited frequency ($n = 0$).

Statistical Analysis

Descriptive statistics were calculated for all variables, including minimum, maximum, mean, standard deviation, and total frequencies. Distributional characteristics were assessed using the Kolmogorov-Smirnov and Shapiro-Wilk tests to evaluate normality assumptions. As both field goals and penalty corner goals exhibited significant deviations from normal distribution, non-parametric statistical procedures were applied in all subsequent inferential analyses. Spearman's rank correlation coefficient (ρ) was used to examine bivariate associations between scoring modes and match outcome. Differences in scoring performance between winning and losing teams were analyzed using the Mann-Whitney U test, with mean rank comparisons used to quantify the magnitude of group separation. Statistical significance was set at $\alpha = .05$ for all tests. To assess the combined influence of field goals and penalty corner goals on the probability of winning, binary logistic regression analysis was conducted using the enter method. Model fit was evaluated using the omnibus test of model coefficients, Nagelkerke R^2 , classification accuracy, and the Hosmer-Lemeshow goodness-of-fit test. Odds ratios ($\text{Exp}(B)$) were calculated to estimate the relative contribution of each scoring mode to match outcome. All statistical analyses were performed using IBM SPSS Statistics (Version 29.0). Two-tailed tests were applied throughout.

To ensure data reliability, all goal classifications were independently cross-checked against official match summaries published on the FIH website. A consistent coding framework was applied across all 13 matches to minimize recording errors and ensure coding consistency. Intra-rater reliability was assessed through re-coding of a random subsample of three matches (23.1%), yielding a Cohen's kappa of .96, indicating near-perfect agreement. Inclusion of all tournament matches enhanced ecological validity, while the use of official FIH competition data supported content validity.

Ethical Considerations

Ethical approval was obtained from the Research Ethics Committee, Faculty of Sports and Health Sciences, Universitas Negeri Surabaya, Indonesia (Approval No. Unesa-FIK/Re/EA-4431, 11 February 2025). The study analyzed secondary data derived exclusively from publicly accessible records published by the International Hockey Federation. No personal, medical, or otherwise sensitive athlete information was collected or utilized.

RESULTS

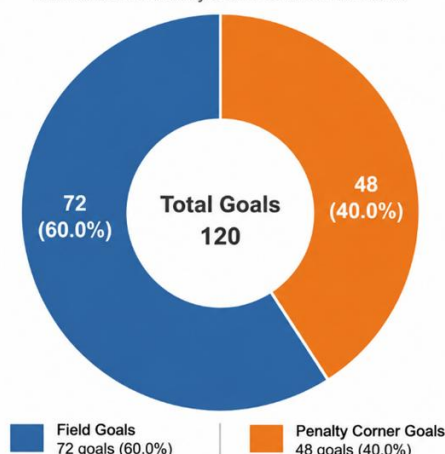
The analysis comprised 26 team-match observations derived from 13 matches played during the men's indoor hockey tournament at the SEA Games 2025. A total of 120 goals were recorded across the competition. Descriptive analysis was conducted to characterize the distribution and variability of each scoring mode.

Table 1. Overall Distribution of Scoring Modes Across All Team-Match Observations

Goal Type	Total Goals	Percentage (%)
Field Goals	72	60.0
Penalty Corner Goals	48	40.0
Total	120	100.0

As presented in Table 1, field goals accounted for 72 goals

(60.0%), while penalty corner goals contributed 48 goals (40.0%). Open-play situations constituted the primary source of scoring during the tournament; however, penalty corners represented two-fifths of all goals, demonstrating their substantial contribution to overall scoring output. To provide a clearer visual summary of the overall scoring composition, Figure 1 presents the proportional distribution of field goals and penalty corner goals across all team-match observations.



Note. Field goals represented the primary scoring mode, while penalty corner goals contributed a substantial proportion of total goals.

Figure 1. Distribution of Goal-Scoring Modes Across the Tournament. Field goals accounted for the largest proportion of total scoring output, contributing 72 goals or 60.0% of all goals recorded. Penalty corner goals contributed 48 goals or 40.0%, indicating that set-play situations represented a substantial source of scoring in men's indoor hockey at the SEA Games 2025.

As shown in Figure 1, field goals constituted the dominant scoring mode across the tournament. Nevertheless, the 40.0% contribution of penalty corner goals highlights the strategic importance of set-play efficiency in elite men's indoor hockey performance.

Table 2. Descriptive Statistics of Field Goals and Penalty Corner Goals (N = 26)

Variable	Min	Max	M	SD	Sum	N
Field Goals	0	14	2.77	3.19	72	26
PC Goals	0	5	1.85	2.01	48	26

Table 2 indicates that teams scored an average of 2.77 field goals per match (SD = 3.19) compared with 1.85 penalty corner goals per match (SD = 2.01). Field goals exhibited a wider range (0–14) and greater dispersion than penalty corner goals (range 0–5), indicating that open-play scoring was more variable across matches, whereas penalty corner scoring occurred within a narrower performance band.

Normality Test Results

Table 3. Normality Test Results for Scoring Variables

Variable	K-S p	Shapiro-Wilk p
Field Goals	.011	< .001
PC Goals	< .001	< .001

As shown in Table 3, both field goals and penalty corner goals significantly deviated from a normal distribution ($p < .05$ for all tests), justifying the application of non-parametric statistical procedures in all subsequent inferential analyses.

Spearman's Rank Correlations Between Scoring Variables and Match Outcome

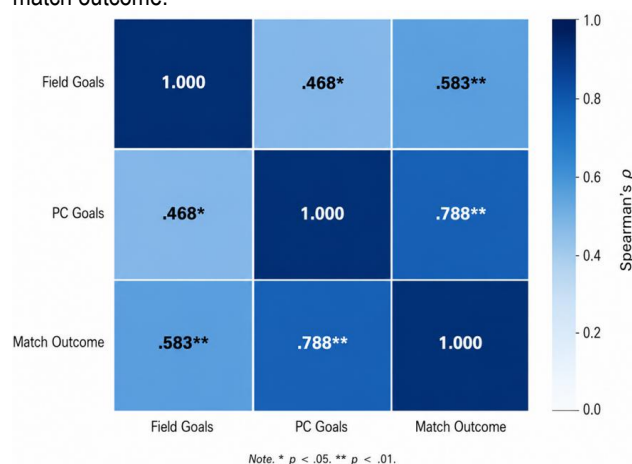
Table 4. Spearman's Rank Correlations Between Scoring Variables and Match Outcome

Variable	FG	PC	Match Outcome
Field Goals	1.000	.468*	.583**
PC Goals	.468*	1.000	.788**
Match Outcome	.583**	.788**	1.000

Note. * $p < .05$. ** $p < .01$.

Table 4 reveals that both scoring modes were significantly associated with match outcome. Field goals demonstrated a moderate positive correlation with victory ($p = .583$, $p = .002$), while penalty corner goals exhibited a strong positive correlation ($p = .788$, $p < .001$). The inter-correlation between field goals and penalty corner goals ($p = .468$, $p = .016$) indicates that teams with higher open-play attacking output also tended to score more

frequently from set-play situations, suggesting a general scoring competency factor. To provide a clearer visual representation of the strength of association among scoring modes and match outcome, Figure 2 presents a Spearman correlation heatmap. This visualization highlights the comparative magnitude of the relationships between field goals, penalty corner goals, and match outcome.



Note. * $p < .05$. ** $p < .01$.

Figure 2. Spearman Correlation Heatmap Between Scoring Modes and Match Outcome

As shown in Figure 2, penalty corner goals exhibited the strongest positive association with match outcome, indicating that teams scoring more frequently from penalty corners were more likely to win matches. Although field goals were also significantly associated with victory, the magnitude of the correlation was lower than that observed for penalty corner goals. This pattern supports the interpretation that penalty corner efficiency represents a more decisive scoring factor in determining match success in elite men's indoor hockey. The moderate correlation between field goals and penalty corner goals further suggests that successful teams tend to demonstrate scoring effectiveness across both open-play and set-play contexts.

Comparison of Scoring Variables by Match Outcome

Table 5. Mean Rank Comparison of Scoring Variables by Match Outcome

Variable	Result	n	Mean Rank	Δ Rank
Field Goals	Loss	13	9.19	8.62
	Win	13	17.81	
PC Goals	Loss	13	7.85	11.30
	Win	13	19.15	

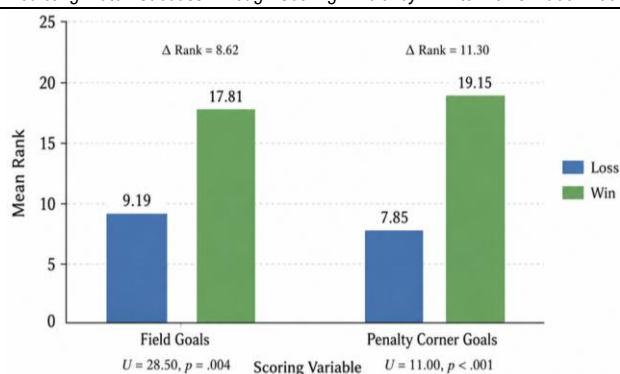
Table 5 demonstrates that winning teams consistently achieved higher mean ranks for both scoring modes. The mean rank difference for penalty corner goals (11.30 points) exceeded that for field goals (8.62 points), indicating a stronger separation between winning and losing teams based on penalty corner scoring performance.

Scoring Differences Between Winning and Losing Teams

Table 6. Mann-Whitney U Test Results for Scoring Differences Between Winning and Losing Teams

Variable	U	Z	p
Field Goals	28.50	-2.92	.004
PC Goals	11.00	-3.94	< .001

As shown in Table 6, both scoring modes differed significantly between winning and losing teams. The lower U value (11.00) and larger absolute Z score (-3.94) for penalty corner goals indicate a stronger discriminatory effect compared with field goals ($U = 28.50$, $Z = -2.92$, $p = .004$), confirming that penalty corner scoring more effectively differentiates match outcomes.



Note. Winning teams showed higher mean ranks in both scoring variables, with a larger separation for penalty corner goals.

Figure 3. Mean Rank Differences in Scoring Variables by Match Outcome. The figure compares the mean ranks of field goals and penalty corner goals between winning and losing teams. Winning teams showed higher mean ranks in both scoring variables. The rank separation was larger for penalty corner goals (Δ Rank = 11.30; $U = 11.00$, $p < .001$) than for field goals (Δ Rank = 8.62; $U = 28.50$, $p = .004$), indicating that penalty corner scoring more strongly differentiated match outcomes.

As illustrated in Figure 3, winning teams consistently recorded higher mean ranks than losing teams for both field goals and penalty corner goals. However, the difference was more pronounced for penalty corner goals, suggesting that set-play scoring efficiency provided a stronger discriminatory indicator of match success. This finding reinforces the Mann–Whitney U test results and supports the interpretation that penalty corner goals represent a more decisive scoring variable in elite men's indoor hockey.

Regression Model Fit and Classification Accuracy

Table 7. Binary Logistic Regression Model Fit and Classification

Accuracy	
Indicator	Value
Omnibus χ^2 (df = 2)	26.95
p-value	< .001
Nagelkerke R^2	.86
Overall Classification Accuracy	88.5%
Hosmer–Lemeshow p	.999

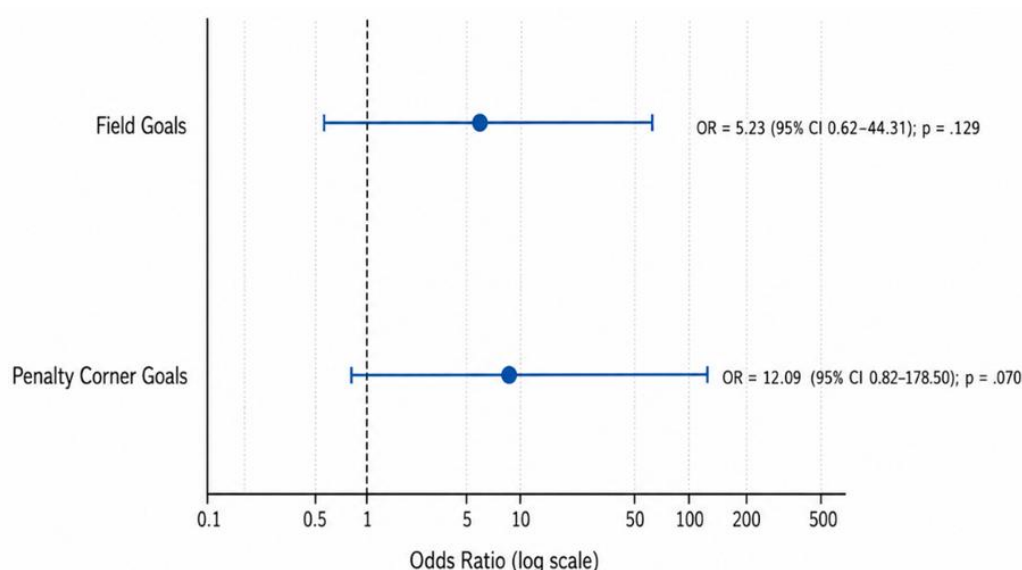
Table 7 indicates that the logistic regression model was statistically significant ($\chi^2(2) = 26.95$, $p < .001$) and explained 86% of the variance in match outcome (Nagelkerke $R^2 = .86$). The model correctly classified 88.5% of cases, and the non-significant Hosmer–Lemeshow test ($p = .999$) confirmed excellent model fit.

Regression Coefficients Predicting Match Victory

Table 8. Logistic Regression Coefficients Predicting Match Victory

Predictor	B	SE	Wald	p	Exp(B)	95% CI
Field Goals	1.655	1.091	2.30	.129	5.23	0.62–44.31
PC Goals	2.492	1.373	3.29	.070	12.09	0.82–178.5

Table 8 reveals that both scoring modes increased the likelihood of winning, with odds ratios exceeding 1.0. A one-goal increase in field goals was associated with a 5.23-fold increase in the odds of winning ($B = 1.655$, $Wald = 2.30$, $p = .129$), whereas a one-goal increase in penalty corner goals was associated with a 12.09-fold increase ($B = 2.492$, $Wald = 3.29$, $p = .070$). Although neither individual predictor reached statistical significance at the .05 level when entered simultaneously—likely attributable to the limited sample size ($N = 26$) and the resulting reduction in statistical power—the substantially larger odds ratio for penalty corner goals indicates a stronger relative influence on match outcome.



Note. Both scoring variables increased the odds of winning, with a stronger relative effect observed for penalty corner goals.

Model summary: Omnibus $\chi^2(2) = 26.95$, $p < .001$; Nagelkerke $R^2 = .86$; classification accuracy = 88.5%; Hosmer–Lemeshow $p = .999$.

Figure 4. Odds Ratios of Scoring Variables Predicting Match Victory: The forest plot displays the odds ratios and 95% confidence intervals for field goals and penalty corner goals as predictors of match victory. Both scoring variables showed odds ratios above 1.0, indicating a positive association with the likelihood of winning. Penalty corner goals showed a larger odds ratio ($OR = 12.09$; 95% $CI = 0.82–178.50$; $p = .070$) than field goals ($OR = 5.23$; 95% $CI = 0.62–44.31$; $p = .129$), suggesting a stronger relative predictive contribution to match outcome.

As shown in Figure 4, both field goals and penalty corner goals increased the odds of match victory. However, penalty corner goals demonstrated a higher odds ratio than field goals, indicating a stronger relative contribution to winning probability. Although the confidence intervals were wide and crossed the null value of 1.0, likely due to the limited tournament sample size, the overall

logistic regression model showed strong explanatory and classification performance. This finding supports the interpretation that penalty corner scoring efficiency may play a more decisive role than open-play scoring in predicting victory in elite men's indoor hockey.

DISCUSSION

Principal Findings

The study's objective was to assess whether field goals and penalty-corner goals were associated differently with match outcomes. The results support the hypothesis that both scoring modes are related to winning, and that the observed relationship is stronger for penalty-corner goals. The higher correlation, larger mean-rank separation, and larger estimated odds ratio for penalty-corner goals all point in that direction (Hughes et al., 2025; Laird & Sutherland, 2003, p. 24). However, the distinction between unadjusted association and adjusted prediction is important: neither scoring variable was statistically significant in the logistic regression when both were entered simultaneously. Thus, the evidence supports a stronger observed relationship for penalty-corner scoring, but does not establish that its adjusted effect is statistically distinguishable from that of field goals. This nuanced relationship aligns with existing literature on set-piece influence in hockey and rink sports, where systematic execution during dead-ball situations frequently functions as a primary driver of success in high-level matches (Arboix-Alió et al., 2021; Galekwa et al., 2024, p. 47).

Statistical significance and practical importance should also be interpreted separately. The between-outcome comparisons were statistically significant for both scoring modes, while the regression coefficients were imprecise and did not meet the conventional significance threshold. The penalty-corner odds ratio was larger, but its wide confidence interval and overlap with the field-goal interval make the size and comparative strength of the effects uncertain. A higher point estimate alone is not proof that one predictor contributes significantly more than another. Likewise, the model's overall classification accuracy and Nagelkerke R^2 describe performance within this small sample; they should not be taken as evidence that the model will classify outcomes equally well in other tournaments (Bennett et al., 2020, p. 316; Francis et al., 2019, p. 1438). Moreover, the inherent complexity of team sports and the rarity of decisive game situations necessitate a cautious interpretation of these findings, as individual actions can disproportionately influence match results (Schlenger et al., 2023, p. 90). Furthermore, contextual variables such as match status or temporal phases of play—which were not accounted for in this analysis—often modulate how these individual scoring opportunities impact team performance and overall success (Troiani et al., 2026, p. 884). In competitive settings, such nuances often align with research indicating that penalty corners involve complex, multi-phase execution—including initial delivery, stopping, and final shot—which can be more influential in deciding game outcomes than simpler open-play sequences (Vasiljev et al., 2021).

Comparison with International Evidence

The finding that penalty corners may be consequential is consistent with international hockey research emphasizing the tactical and technical demands of set plays. In an analysis of 36 matches in the English Women's Premier Division indoor competition, 72 of 319 penalty corners resulted in goals, and the likelihood of scoring varied with tactical factors such as the side from which the corner was taken and goalkeeper positioning (Vinson et al., 2013). This supports the interpretation that penalty corners are not interchangeable scoring events: their outcomes may depend on the execution and defensive responses within a structured situation. The present study complements that work by comparing penalty-corner goals with field goals in relation to match results, rather than modelling the success or failure of

individual corners. Furthermore, while aggregate models provide a macro-level overview of scoring efficacy, they may obscure the nuance inherent in sequence-dependent play (Vegt et al., 2024, p. 35).

Evidence from outdoor and international competitions also suggests that penalty-corner tactics and outcomes vary across populations and contexts. Analysis of successful corners in international men's and women's hockey identified differences in the skills used, player involvement, passing, and shot location (Mosquera et al., 2007). Research on the Chinese women's team across Olympic and domestic competitions likewise found that performance indicators differed with competition context and opponent quality, cautioning against treating scoring patterns as stable across levels of play (Huo et al., 2024, p. 10). These studies support contextual interpretation, but they do not directly test whether penalty-corner goals are more predictive of winning than field goals in men's indoor hockey. Consequently, future analytical frameworks should incorporate additional contextual variables—such as match score-line, ball possession, and fixture location—to better disentangle the influence of scoring methods on match results (James et al., 2022, p. 2087).

Some evidence also cautions against interpreting the present result as a universal advantage for set-play scoring. In a Malaysian women's league sample, drag-flick execution differed between winning and losing teams, whereas other penalty-corner shot types did not (Zainuddin & Jakiwa, 2024, p. 448). In a separate analysis of Chinese women's hockey, higher-performing teams' scoring was also associated with greater volumes of circle entries and shots, illustrating how opportunity creation and conversion can both matter (Huo et al., 2024, p. 10). Differences from the current study may reflect sex, competition level, indoor versus outdoor format, tournament structure, and whether the analysis measures goals, attempts, or specific tactical actions (Csiernik et al., 2025, p. 1648102; González-Ródenas et al., 2023, p. 10). A comparison of goal counts alone cannot identify whether the observed penalty-corner relationship arose from more corners awarded, higher conversion, stronger attackers, or particular match situations. Furthermore, research underscores that current box-score methodologies often exhibit low sensitivity to the non-linear, adaptive dynamics that characterize these pivotal game moments (Lamas et al., 2020, p. 12).

The broader evidence base remains limited. A systematic review of field-hockey performance analysis identified a relatively small set of studies and recommended more holistic analyses incorporating spatial and temporal variables and player-opposition interactions (Lord et al., 2021). Accordingly, the present results contribute a focused comparison from Southeast Asia, but should be viewed as complementary to—not a replacement for—research based on larger, more varied international datasets. Furthermore, future investigations should integrate objective data on player physical conditioning and rotation patterns, as these factors may modulate the consistency of execution during high-pressure set-piece scenarios (Morencos et al., 2018, p. 1156).

Theoretical, Methodological, and Practical Implications

The findings are compatible with a performance framework in which match success reflects both the creation of opportunities and the capacity to convert them under different constraints. Penalty corners provide a more structured attacking situation

than open play, potentially allowing teams to rehearse coordinated movements and exploit specialized skills. Open-play goals, in contrast, emerge from less predictable interactions among players, space, and defensive pressure (Araújo et al., 2006, p. 665; Ribeiro et al., 2019, p. 513). The results therefore refine, rather than overturn, the idea that attacking effectiveness is multidimensional: in this sample, both scoring modes were relevant, but penalty-corner outcomes appeared more strongly differentiated by match result.

Methodologically, the study's comparison of correlations, rank differences, and regression estimates gives a broader description than reliance on a single performance indicator. At the same time, goals are endpoint measures. They do not reveal the sequence leading to a goal or distinguish chance creation from conversion. Future analyses can extend this approach by recording opportunities, penalty corners awarded, conversion rates, shot characteristics, and the tactical actions preceding scoring, while accounting for opponent quality and match state.

For coaching, the results support maintaining both open-play development and structured penalty-corner preparation. Coaches may use varied routines, rehearsed delivery and finishing options, and defensive-response practice, while continuing to develop ball circulation, space creation, and circle finishing (Huo et al., 2024, p. 11; Lord et al., 2021). These are feasible priorities, not proof that allocating more training time to penalty corners will cause more wins (Ahmad et al., 2024). Decisions should be informed by a team's own match data, including the number and quality of opportunities and the time and resources required to improve conversion. The study did not assess intervention effectiveness or cost-effectiveness; therefore, it cannot establish an optimal training allocation or justify broad policy changes.

Strengths and Limitations

A strength of the study is its use of official tournament matches and a direct comparison of two clearly defined scoring modes in an elite men's indoor setting. Examining both team-match observations and match outcomes also makes the analysis relevant to coaches and performance analysts. However, the sample comprises only 13 matches and 26 team-match observations from one tournament. The small, context-specific sample limits power, precision, and transferability to other countries, competition levels, seasons, or women's hockey. It also means that the high model-fit and classification estimates may be unstable and require external validation.

The analysis uses goal counts rather than attempts, opportunities, or conversion rates. It therefore cannot determine whether penalty-corner goals were more strongly associated with winning because teams earned more corners, converted them more efficiently, or differed in other aspects of performance (Moon et al., 2018, p. 86; Zainuddin & Jakiwa, 2024, p. 453). Potential

confounders—including match status, score differential, opposition strength, team quality, and competition stage—were not included. Moreover, the two observations from each match are related, and teams may appear in multiple matches; treating all observations as independent could understate uncertainty unless this dependence is addressed. The findings should consequently be interpreted as exploratory associations, not causal effects.

The available description does not establish whether missing observations occurred, whether coding was conducted by blinded assessors, or whether inter-rater reliability was tested. These procedures should be reported because subjective event classification and knowledge of match results could influence coding. Multiple comparisons across correlations, rank tests, and regression estimates also increase the possibility of chance findings; the results warrant replication and, where appropriate, adjustment or prespecification of primary outcomes. Finally, the wide regression confidence intervals, small sample, and uncertainty around model assumptions mean the estimates are not precise enough to support individual-level prediction. Larger samples, clustered or match-level models, and transparent reporting of coding, missingness, and sensitivity analyses would mitigate these concerns.

Future Research

Future work should replicate the analysis across multiple SEA Games editions and include men's and women's teams from Asian, European, and other international competitions. Multi-tournament prospective or retrospective designs with larger samples should account for repeated teams and within-match dependence, and report confidence intervals alongside effect estimates. Video-based coding could capture penalty corners awarded and converted, shot attempts, tactical routines, goalkeeper responses, circle entries, and the timing and score context of each event. This would help test mechanisms linking set-play execution to winning and examine whether opponent quality, team strength, match status, or competition stage moderates that relationship.

Intervention studies could evaluate whether specific penalty-corner training methods improve execution and transfer to competitive matches, with follow-up across a full season or multiple tournaments. Implementation studies should document coaching time, equipment, staff capacity, and adherence to training protocols; cost-effectiveness analysis could assess whether observed performance benefits justify those resources. Independent, preregistered replications using harmonized coding definitions across countries would clarify how robust the findings are across playing styles and competition formats. Until such evidence is available, the present results are best treated as a useful, preliminary contribution to understanding scoring and match outcomes in elite men's indoor hockey.

CONCLUSION

This study demonstrates that both field goals and penalty corner goals are significantly associated with team victories in men's indoor hockey at the SEA Games 2025. Field goals accounted for the majority of scoring output (60.0% of total goals), confirming the fundamental importance of open-play attacking quality. However, penalty corner goals demonstrated a consistently stronger relationship with winning outcomes, evidenced by higher correlation values ($p = .788$ vs. $.583$), larger performance differences between winning and losing teams (mean rank difference = 11.30 vs. 8.62), and a greater increase

in winning probability per additional goal scored ($\text{Exp}(B) = 12.09$ vs. 5.23). These findings indicate that while open-play scoring provides the primary goal volume, penalty corner efficiency plays a more decisive role in determining match success in elite indoor hockey.

The theoretical contribution of this study lies in extending the performance analysis framework for indoor hockey by demonstrating the differential predictive value of distinct scoring modes, providing empirical evidence from an underrepresented competitive context. Practically, these findings support a dual

emphasis in coaching practice: sustained development of open-play attacking capabilities alongside systematic enhancement of penalty corner routines, with particular attention to conversion efficiency under competitive conditions. Future research should expand the analytical scope to include multi-tournament

datasets, incorporate process-level metrics such as shot attempts and conversion rates, and examine the interaction between scoring modes and contextual variables including match status and opposition quality.

DECLARATIONS

Ethical Approval

Ethical approval for this study was granted by the Research Ethics Committee, Faculty of Sports and Health Sciences, Universitas Negeri Surabaya, Indonesia, under approval number Unesa-FIK/Re/EA-4431, dated 11 February 2025.

Consent to Participate

Not applicable. This study used secondary data obtained exclusively from publicly accessible official competition records published by the International Hockey Federation (FIH). No direct participation of human subjects was required, and no personal, medical, or other sensitive individual-level information was collected or analyzed.

Consent for Publication

Not applicable. The study did not involve identifiable individual participants, personal photographs, or individually identifiable data. All analyses were based on publicly available team-level and match-level competition data.

Author Contributions (CRediT)

Conceptualization: Authors 1, 2, 4

Methodology: Authors 1, 3, 6.

Formal analysis: Author 2, 5

Investigation: Authors 1 & 6

Data curation: Authors 1, 2, 3 & 6

Writing – original draft: Authors 1, 3 & 5

Writing – review & editing: Authors 4, 5 & 6

Visualization: Authors 1 & 2

Project administration: 3 & 4

All authors have read and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

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Conflict of Interest

The authors declare that they have no conflict of interest related to the research, authorship, or publication of this article.

Data Availability

The data analyzed in this study were derived from publicly accessible official competition records published by the International Hockey Federation (FIH). The underlying data are available through the official FIH competition records and match statistics. The study did not collect or use private, confidential, or personally identifiable participant data.

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