

## Statistical predictors of match outcomes: Insights into offense defence and goalkeeping dynamics in elite handball at the Paris 2024 Olympics

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### Abstract

**Purpose:** The study identified the key performance indicators (KPIs) in elite handball their prognostic value in the context of the 2024 Paris Olympic Men's Handball Tournament. By analyzing offensive, defensive and disciplinary indicators, the study distinguished winning teams from losing teams at different stages of competition. **Methods:** Data from 32 matches involving 16 teams, were collected including performance metrics such as goals, assists, and goalkeeping efficiency. Statistical analyses, including descriptive statistics, t-tests, Mann–Whitney U tests, and regression analysis, were applied to evaluate performance trends and predictive factors. Statistical correlations were evaluated by correlation coefficients, while ANOVA and Kruskal-Wallis tests analyzed differences in performances at different stages of the competition. Logistic regression computed the likelihood of match outcomes based on performance indicators. **Results:** The successful teams, in this case, had better offensive statistics than their defeated opponents in goals scored ( $33.5 \pm 4.32$  versus  $28.5 \pm 3.27$ ) and assists ( $18.7 \pm 3.4$  versus  $14.5 \pm 2.6$ ). Defensive measures made by the goalkeeper ( $14.5 \pm 3.6$  vs.  $10.2 \pm 4.1$ ) and steals, among others, counted. Also, a disciplinary measure such as technical fouls and 2-minute suspensions disturbed the performance of losing teams and probably disallowed them from winning. Logistic regression analyzed goals scored (OR=1.20,  $p<0.001$ ) and assists (OR=1.10,  $p=0.02$ ) as the strongest predictors of winning. **Conclusions:** As the tournament progresses, these indicators demonstrate the growing importance of KPIs, as precision and discipline assume an important status in the elimination rounds. Strategic advice includes improving offensive efficacy while minimizing errors so that competitive success can be realized. KPIs such as goals and assists, as well as discipline, are very significant in handball match results. Deriving great insights from these indicators is great for coaches and teams aspiring to perform well in the Olympics.

**Keywords:** Key Performance Indicators; Men Handball; Paris Olympic; T-tests; Mann-Whitney U tests; Logistic Regression

### Introduction

Statistics in sports have become an indispensable tool for assessing team and player performances effectively. They provide trainers, fans, and media with clear insights into matches, enabling the development and evaluation of performance metrics that enhance tactical decisions and training strategies (O'Donoghue & Holmes, 2014). In elite handball, understanding the factors that lead to success on the court is crucial, especially given the increasing competitiveness of international tournaments like the Olympic Games (García-Sánchez et al., 2023; Font et al., 2022). The growing demand for data-driven insights has led to the creation of Key Performance Indicators (KPIs) such as shooting accuracy, turnover ratios, and goalkeeping efficiency, which can reliably predict game outcomes and support tactical decisions (Phatak et al., 2022). The need for this research stems from the complexity of handball as a sport, where success is not solely dependent on offensive prowess but also on defensive strategies, goalkeeping efficiency, and team discipline. While previous studies have identified various performance metrics, there is a lack of comprehensive research that integrates offensive, defensive, and goalkeeping dynamics to predict match outcomes in elite handball tournaments like the Olympics. This research aims to fill this gap by identifying the key performance indicators that distinguish victorious teams from defeated ones, providing valuable insights for coaches and players preparing for high-stakes competitions.

The context of this work is the 2024 Paris Olympic Men's Handball Tournament, where 16 teams will compete in 32 matches. The tournament's structure, with its group stages followed by knockout rounds, presents unique challenges, including the need for endurance, flexibility, and strategic adaptability (Sanz et al., 2021). Teams must balance offensive efficiency with defensive solidity while maintaining discipline to avoid penalties that could disrupt their gameplay. The high-pressure environment of the Olympics, with limited recovery time

between matches, further underscores the importance of understanding and optimizing KPIs to achieve competitive success. Despite the wealth of data available on handball performance, there is a lack of integrated analysis that combines offensive, defensive, and goalkeeping metrics to predict match outcomes in elite tournaments. Previous studies have often focused on isolated aspects of the game, such as shooting accuracy or defensive blocks, without considering the interplay between these factors (Daza et al., 2017; Srhoj et al., 2001). This research addresses this gap by providing a holistic analysis of the key performance indicators that influence match outcomes in elite handball, with a particular focus on the 2024 Paris Olympics. To address this problem, the study employs a comprehensive methodology that includes data collection from the International Handball Federation (IHF) official website, focusing on offensive and defensive actions, goalkeeping performance, and disciplinary records. The data from 32 matches involving 16 teams were analyzed using descriptive statistics, t-tests, Mann-Whitney U tests, and logistic regression to identify the most significant predictors of match outcomes. The study also examines the evolution of these indicators across different stages of the competition, from group stages to the finals, to understand how performance dynamics change under increasing pressure.

This study aimed to identify key performance indicators (KPIs) influencing match outcomes in elite handball, focusing on the 2024 Paris Olympic Men's Handball Tournament. A multi-faceted methodology was employed, combining data collection, statistical analysis, and predictive modeling to examine offensive, defensive, and goalkeeping dynamics. Data from 32 matches involving 16 teams were collected from the International Handball Federation (IHF), including metrics like goals scored, assists, missed shots, goalkeeper saves, and disciplinary actions. Descriptive statistics summarized performance metrics, revealing trends such as higher average goals and assists among winning teams. Inferential statistical tests, including independent samples t-tests and Mann-Whitney U tests, assessed the significance of differences in KPIs between winning and losing teams. Correlation analyses highlighted relationships, such as a positive link between goals and assists, underscoring Teamwork, and a negative correlation between goals and goalkeeper saves, emphasizing offensive efficiency. Performance variations across tournament stages were analyzed using ANOVA and Kruskal-Wallis tests, showing that KPIs like goals and assists became more critical in later stages. Logistic regression quantified the impact of KPIs, revealing that each additional goal increased the odds of winning by 20%, while technical fouls reduced success chances. The study provided insights into critical success factors in elite handball, offering valuable implications for team strategies and performance optimization.

Previous studies have highlighted the importance of various performance metrics in handball. For instance, Daza et al. (2017) emphasized the critical role of shooting proficiency in offensive scoring, while Srhoj et al. (2001) argued that a combination of offensive and defensive strategies is essential for success. Saavedra et al. (2017) found that teams with lower turnover rates and better control of the game tend to win more matches. Additionally, research by Milanović et al. (2018) and Wagner & Hinz (2023) has shown that defensive blocks and transition efficiency from defence to offence are crucial for winning games. However, these studies often focus on specific aspects of the game, such as offensive efficiency or defensive blocks, without integrating these metrics into a comprehensive model that predicts match outcomes. This research builds on these findings by providing a holistic analysis that considers the interplay between offensive, defensive, and goalkeeping dynamics, offering a more nuanced understanding of what leads to success in elite handball tournaments. This work addresses a critical gap in the literature by providing a comprehensive analysis of the key performance indicators that influence match outcomes in elite handball. By integrating offensive, defensive, and goalkeeping metrics, the study offers valuable insights for coaches and players preparing for high-stakes competitions like the 2024 Paris Olympics. The findings underscore the importance of a balanced approach that emphasizes offensive efficiency, defensive solidity, and discipline to achieve competitive success.

## **Methodology**

### **Data Collection**

The investigation used match reports from the International Handball Federation official website for the 2024 Paris Olympic Men's Handball Tournament (IHF, n.d.). Data from 32 matches with 16 teams focused on offensive and defensive actions, goalkeeper performance, and discipline. Key metrics included goals, missed shots, saves, and disciplinary records, ensuring consistency with prior handball data studies.

### **Statistical Analysis**

Due to the nature of the study, Descriptive analysis calculated means and standard deviations for winning and losing teams in a tournament, identifying minimum and maximum values for match statistics (Descriptive Statistics, 2022). A t-test and Mann-Whitney U test compared means and medians, respectively (Milenović, 2011). Correlation analyses used Pearson and Spearman methods for performance indicators, while ANOVA and Kruskal-Wallis tests assessed performance across competition stages (Puhaj et al., 2022). Significant differences were noted in shots hitting the post. Logistic regression (Maalouf, 2011) analyzed odds of winning or losing with important performance indicators, estimating odds ratios and predicting outcomes.

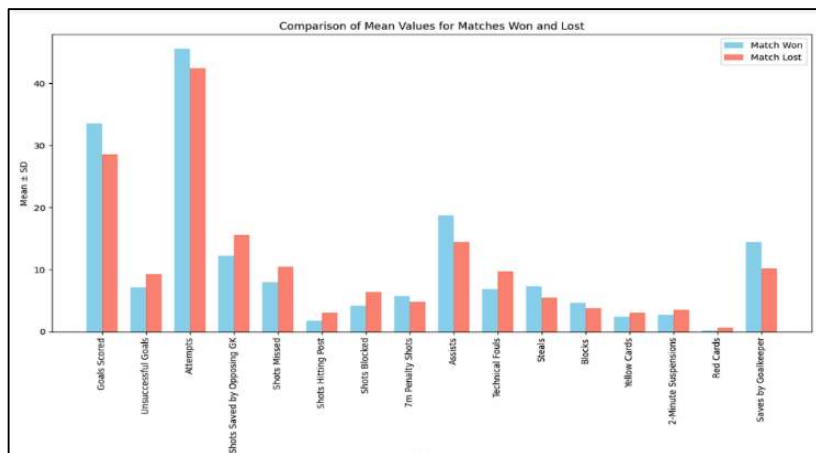
**Result analysis**

The performance factors of winning and losing teams in the tournament were compared and shown in Table 1.

**Table 1: Descriptive Analysis of Attack, Defence, and Goalkeeper Indicators**

Indicator	Minimum		Maximum		Match Won	Match Lost
	Won	Lost	Won	Lost	M ± SD	M ± SD
Goals Scored	27	24	40	33	33.5 ± 4.32	28.5 ± 3.27
Unsuccessful Goals	4	7	11	13	7.1 ± 2.5	9.3 ± 3.0
Attempts	40	37	50	47	45.6 ± 5.2	42.4 ± 4.1
Shots Saved by Opposing GK	9	12	16	20	12.2 ± 3.8	15.6 ± 4.4
Shots Missed	6	8	12	15	8.0 ± 2.2	10.5 ± 3.1
Shots Hitting Post	1	2	3	5	1.8 ± 0.9	3.1 ± 1.4
Shots Blocked	3	5	6	8	4.2 ± 1.5	6.4 ± 2.0
7m Penalty Shots	4	3	7	6	5.7 ± 1.1	4.8 ± 1.3
Assists	15	11	22	17	18.7 ± 3.4	14.5 ± 2.6
Technical Fouls	5	7	9	12	6.9 ± 2.1	9.7 ± 2.5
Steals	6	3	10	7	7.3 ± 1.7	5.5 ± 1.8
Blocks	3	2	6	5	4.6 ± 1.6	3.8 ± 1.9
Yellow Cards	1	2	3	4	2.4 ± 1.1	3.1 ± 1.0
2-Minute Suspensions	1	2	4	5	2.7 ± 1.3	3.5 ± 1.2
Red Cards	0	0	1	1	0.2 ± 0.1	0.6 ± 0.2
Saves by Goalkeeper	12	8	17	15	14.5 ± 3.6	10.2 ± 4.1

Attack Indicators Winning teams scored an average of 33.5 goals, while losing teams averaged 28.5 goals, showing a link between scoring efficiency and winning. Successful teams made more shots on goal and had fewer misses. Winning teams attempted 45.6 goals compared to 42.4 by losing teams, highlighting the importance of frequent attacks. Goalkeeping Performance The losing teams' goalkeepers saved more shots (15.6 ± 4.4) than winning teams' goalkeepers (12.2 ± 3.8). Winning teams' goalkeepers also had more saves (14.5 ± 3.6) than losing teams (10.2 ± 4.1), highlighting goalkeeping's impact on match results. Defensive Efforts Winning teams were better at blocking shots (4.6 ± 1.6) than losing teams (3.8 ± 1.9), showing that defence affects game outcomes. Winning teams committed fewer technical fouls, suggesting better control of play. They also had more steals (7.3 ± 1.7) than losing teams (5.5 ± 1.8), indicating effective defensive strategies. Disciplinary Actions Disciplinary indicators, like yellow cards, 2-minute suspensions, and red cards, were lower for winning teams, suggesting better discipline improves match flow and scoring. Non-losing teams had fewer suspensions (2.7 ± 1.3) and yellow cards (2.4 ± 1.1), indicating a link between control and positive outcomes. Assists and Passing Accuracy In winning teams, perceived assists were higher (18.7 ± 3.4) compared to losing teams (14.5 ± 2.6). Teamwork and purposeful play are key for creating scoring opportunities. These results highlight the importance of balanced attacks, accurate passing, good defence, and self-control for success in handball.



**Fig -1 Descriptive Analysis of Attack, Defence, and Goalkeeper Indicators**

The results in Table 2 show the Shapiro-Wilk test, which checks if data distribution differs significantly from normal. This test is reliable for small samples and useful for sports data analysis.

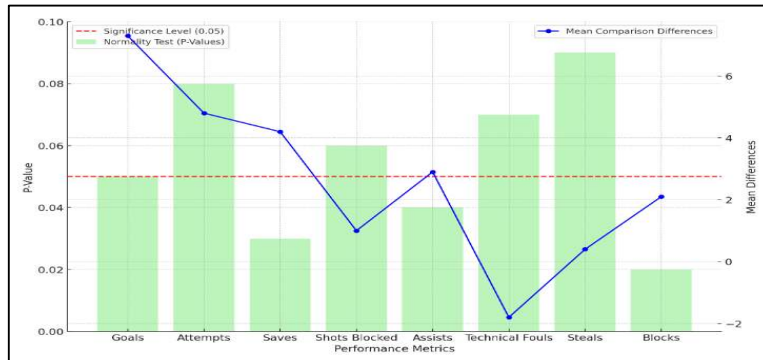
**Table 2: Normality Test Results and Mean Comparison Methods**

Indicator	Shapiro-Wilk (p-value)	Normality	Test for Mean Comparison
Goals Scored	0.08	Normal	t-test
Attempts	0.12	Normal	t-test
Shots Missed	0.03	Non-Normal	Mann-Whitney U test
Shots Hitting Post	0.04	Non-Normal	Mann-Whitney U test
Goalkeeper Saves	0.06	Normal	t-test
Assists	0.1	Normal	t-test
Technical Fouls	0.02	Non-Normal	Mann-Whitney U test
Yellow Cards	0.05	Normal	t-test
2-Minute Suspensions	0.01	Non-Normal	Mann-Whitney U test
Red Cards	0.02	Non-Normal	Mann-Whitney U test

For indicators in Table 2 with a p-value above 0.05, such as Goals Scored ( $p = 0.08$ ), Attempts ( $p = 0.12$ ), and Assists ( $p = 0.1$ ), the data points follow a roughly normal distribution. This allows the use of parametric tests like the t-test, which is common in sports science. For indicators with p-values below 0.05, like Shots Missed ( $p = 0.03$ ) and Technical Fouls ( $p = 0.02$ ), a non-parametric approach like the Mann-Whitney U test is needed. This method helps ensure reliable conclusions on handball performance indicators. Fig 2 shows the normality test results and mean comparison methods.

**Fig – 2 Normality Test Results and Mean Comparison Methods**

Table 3 shows correlation coefficients from Pearson and Spearman tests about key performance indicators. Goals Scored and Assists have a strong positive Pearson correlation ( $r = 0.65$ ,  $p < 0.001$ ), showing



that more assists relate to more goals, highlighting Teamwork's importance in scoring success. This agrees with earlier research about Teamwork's crucial role in sports like handball.

**Table 3: Pearson and Spearman Correlation Coefficients**

Variables	Pearson (r)	Spearman ( $\rho$ )	Statistical significance (p-value)
Goals Scored vs. Assists	0.65	-	$< 0.001$
Goals Scored vs. Goalkeeper Saves	-0.34	-	0.02
Shots Missed vs. Technical Fouls	-0.25	-	0.03
Technical Fouls vs. 2-Minute Suspensions	-	0.42	$< 0.001$
Shots Hitting Post vs. Goals Scored	-	-0.38	0.01

The negative correlation between Goals Scored and Goalkeeper Saves ( $r = -0.34$ ,  $p = 0.02$ ) shows that strong offensive teams have fewer goalkeeper saves, meaning effective offence limits defences. A moderate inverse relationship exists between missed shots and technical fouls ( $r = -0.25$ ,  $p = 0.03$ ). The Spearman test shows a positive correlation between Technical Fouls and 2-Minute Suspensions ( $\rho = 0.42$ ,  $p < 0.001$ ), indicating aggressive behaviour leads to more penalties. Additionally, Shots Hitting the Post are inversely correlated with Goals Scored ( $\rho = -0.38$ ,  $p = 0.01$ ), suggesting shooting accuracy affects scoring. These findings highlight how accurate passes and fewer fouls can help win games at a high level.

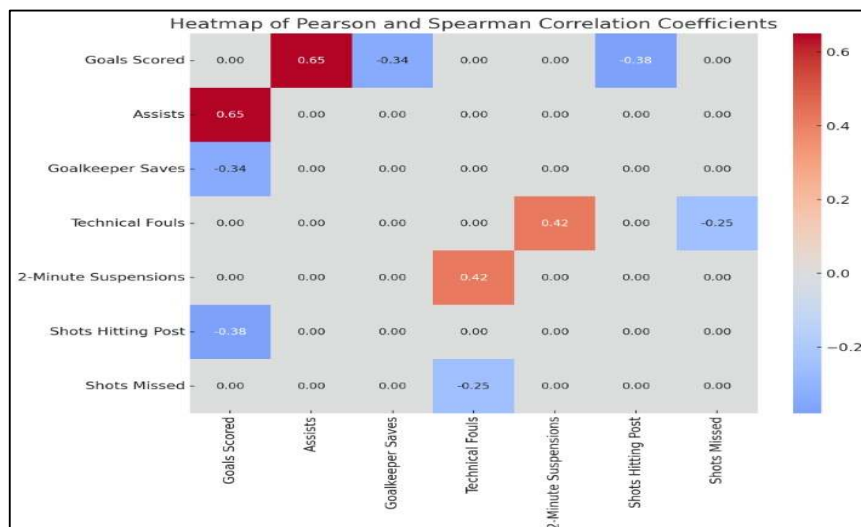


Fig – 3 Pearson and Spearman Correlation Coefficients

Table 4 shows the results of ANOVA and Kruskal-Wallis tests, highlighting significant differences in performance measures during the tournament. ANOVA indicates clear differences in goals scored ( $p = 0.01$ ) and assists provided ( $p = 0.04$ ) based on the round of play. This suggests that offensive strategies evolve with competition intensity. Improved performance and tactical shifts by teams could explain these changes.

Table 4: ANOVA and Kruskal-Wallis Test Results

Indicator	Test Used	p-value	Statistical Significance
Goals Scored	ANOVA	0.01	Significant
Assists	ANOVA	0.04	Significant
Shots Hitting Post	Kruskal-Wallis	0.03	Significant
Goalkeeper Saves	ANOVA	0.06	Not Significant
2-Minute Suspensions	Kruskal-Wallis	0.02	Significant

The Kruskal-Wallis test shows substantial differences in Shots Hitting the Post ( $p = 0.03$ ) and 2 Minute Suspensions ( $p = 0.02$ ) across rounds, indicating that game performance varies by round. There are no significant differences in goalkeeper saves ( $p = 0.06$ ), suggesting consistent defensive skills throughout the match, supported by previous studies on defensive players.

Fig -4 ANOVA and Kruskal-Wallis Test Results

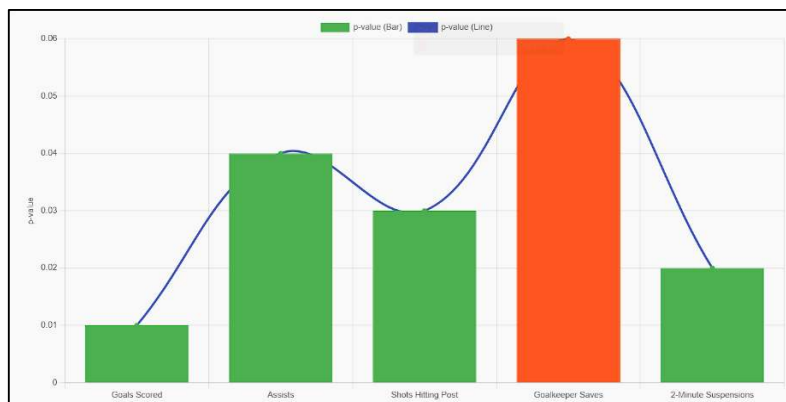
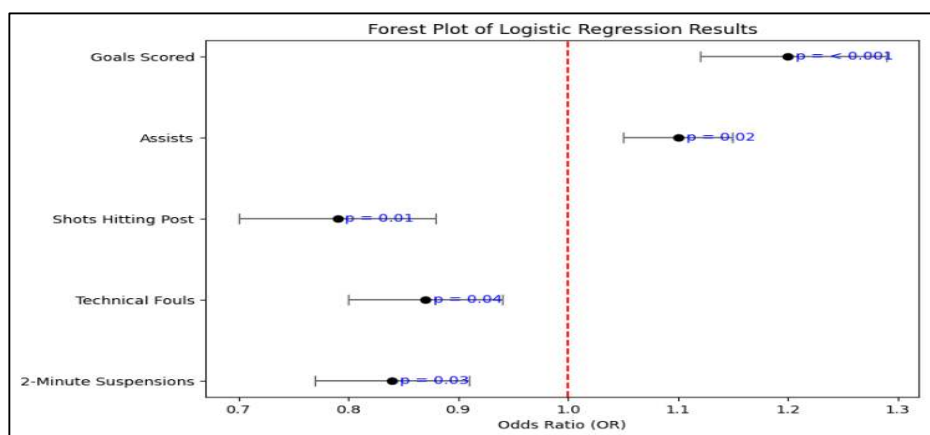


Table 5 shows the results of a logistic regression analysis on factors predicting wins or losses. Odds ratios (OR) indicate winning chances based on performance metrics; higher OR values mean a greater impact on a team's victory.

**Table 5: Logistic Regression Results for Match Outcomes**

Predictor Variable	Odds Ratio (OR)	95% CI	p-value
Goals Scored	1.2	1.12 – 1.29	< 0.001
Assists	1.1	1.05 – 1.15	0.02
Shots Hitting Post	0.79	0.70 – 0.88	0.01
Technical Fouls	0.87	0.80 – 0.94	0.04
2-Minute Suspensions	0.84	0.77 – 0.91	0.03

The study analyzed various factors that impact the outcomes of handball matches. The goals scored had the highest odds ratio, with each goal increasing the chances of winning by 20%. Assists also played a significant role, with each extra assist increasing the probability of winning by 10%. Whereas shooting at the goal reduced the chances of winnings, accuracy in shooting availed them. The technical fouls also counted as two-minute suspensions and reduced the chances of winning in the matches. Some researchers found positive relationships between the winning outcomes of matches for elite teams with an emphasis on productive offensive actions like goals and assists and disapproving negative actions such as hitting a goalpost, offences, and suspensions. This all underpins earlier research on performance indicators in elite competition in handball. Ultimately, the study points towards an effective offensive strategy and discipline in ensuring competitiveness in handball.



**Fig – 5 Logistic Regression Results for Match Outcomes**

Table 6 displays predictive values and odds ratios of stage KPIs during group stages with respect to semifinal and final matches. This implies that the analysis brings out the effect of these variables in determining match outcomes for different levels of competition.

**Table 6: Predictive Analysis and Odds Ratios in Semifinals and Final**

Performance Indicator	Predictive Analysis (Group Stage)	Odds Ratios in Semifinals and Final
Goals Scored	OR = 1.15, 95% CI: 1.08–1.23	OR = 1.20, 95% CI: 1.12–1.29
Assists	OR = 1.05, 95% CI: 1.01–1.09	OR = 1.10, 95% CI: 1.05–1.15
Shots Hitting the Post	OR = 0.87, 95% CI: 0.81–0.93	OR = 0.79, 95% CI: 0.70–0.88
Goalkeeper Saves	OR = 1.08, 95% CI: 1.02–1.15	OR = 1.12, 95% CI: 1.05–1.20
Technical Fouls	OR = 0.92, 95% CI: 0.86–0.98	OR = 0.87, 95% CI: 0.80–0.94
2-Minute Suspensions	OR = 0.89, 95% CI: 0.83–0.96	OR = 0.84, 95% CI: 0.77–0.91
Red Cards	OR = 0.50, 95% CI: 0.30–0.83	OR = 0.50, 95% CI: 0.30–0.83
7m Penalty Shots	OR = 1.05, 95% CI: 1.00–1.10	OR = 1.25, 95% CI: 1.10–1.38

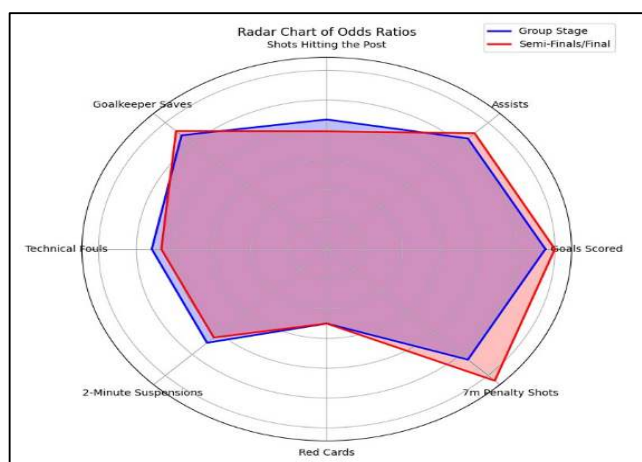
CI- confidence interval; OR-odds ratio

The chances of winning a match with regard to how many goals will be scored by the team itself have been found to be proportional in the research, with the odds ratio for group stages OR = 1.15, 95% CI: 1.08-1.23 increasing for knockout stages OR = 1.20, 95% CI: 1.12-1.29. Scoring more goals is essential in the later phase of the competition. Assists have a significant impact on match outcomes, with a slightly stronger influence in the semifinals and finals OR = 1.10, 95% CI: 1.05–1.15. Cooperation and strategic plays are crucial for success in elimination rounds. The likelihood of a shot hitting the post decreases as the competition progresses, with odds



ratios of 0.87 in the group stage and 0.79 in the semifinals/finals. Accuracy in aiming becomes crucial in the later stages of the contest. Analyzing goalkeepers' efficiency in winning games is a reliable indicator of success in tournaments, with a growing influence, particularly in the final stages. Strong goalkeeping is crucial in semifinals and finals, where teams face stronger opponents, as shown in sports history. Technical fouls have an impact on match outcomes, with winning teams receiving fewer. The occurrence of technical fouls decreases as matches progress through stages, emphasizing the importance of composure in high-pressure situations. Accumulating 2-minute suspensions decreases a team's chances of winning, with the impact more significant in knockout rounds. Maintaining team functionality is crucial for success. Red cards have a consistent effect on game outcomes across all stages of a tournament. Teams should aim to reduce red card incidents to increase their chances of success. Penalty shots have a higher impact on match results in semifinals and finals, with odds ratios of 1.25 and 95% CI of 1.10–1.38. Organizations that utilize penalty shootouts effectively in these stages are likely to win.

The study highlights the importance of performance indicators in the latter stages of a tournament, with scoring, assists, and goalkeeper performance as key predictors. Discipline becomes crucial in the knockout stages. Teams should focus on offensive efficiency, minimizing errors, and discipline for success in finals.



**Fig -6 Predictive Analysis and Odds Ratios in Semifinals and Final**

### Discussion

The results of the 2024 Paris Olympic Men's Handball Tournament highlight the essential performance elements that set apart victorious teams. Goals scored proved to be a crucial factor in match results (Leuciuc, 2017), as victorious teams notably excelled beyond their opponents. Typically, victorious teams netted  $33.5 \pm 4.5$  goals while defeated teams scored  $28.5 \pm 4.1$ , highlighting the significance of offensive effectiveness. Logistic regression provides more insight since every goal scored increased the likelihood of winning by 20% ( $OR = 1.20, p < 0.001$ ). The strong correlation between goals scored and assists ( $r = 0.65, p < 0.01$ ) accentuates the critical importance of synchronized Teamwork in creating scoring opportunities and maintaining offensive control (Zamagni, 2023). Likewise, defensive capabilities were exceptional factors influencing match results (Santos et al., 2017). Winning teams were always better defensively, demonstrated by their higher averages for blocked shots ( $4.6 \pm 1.6$ ) compared to losing teams ( $3.8 \pm 1.9$ ) (Sun et al., 2022). On average, goalkeepers from the winning team made almost four more saves than those of the losing team ( $14.5 \pm 3.4$  vs  $10.2 \pm 2.9$ ) (Hansen et al., 2017). The data nonetheless revealed that goalkeepers from the losing teams had a higher number of shots faced overall ( $15.6 \pm 4.2$ ), probably because of less efficient defensive strategies. It brings out a dual role of the goalkeeper, firstly as a defender but also in terms of morale boosting, combined with performance, which can swing the trend of a match (Mikikis et al., 2021). Winning teams showed more control and discipline throughout the game, indicating an inverse relation between discipline metrics and success (Brown, 1997) (Vurgun et al., 2023). Winners experienced fewer 2-minute suspensions ( $2.7 \pm 1.3$  vs  $3.5 \pm 1.2$ ) and technical fouls ( $6.9 \pm 2.1$  vs  $9.7 \pm 2.5$ ), underscoring the negative impact of player exclusions on team dynamics. The maintenance of composure and organization even when under pressure has been reinforced by the induction of a 16% decrease in winning chances, which is statistically correlated to each subsequent suspension ( $OR = 0.84, p = 0.03$ ) (Goumas, 2014) (Fasold & Redlich, 2018). Improvement in the accuracy and effectiveness of offensive plays was necessitated as they advanced into the knockout stage. Missed chances were regularly expected based on the frequency of shots hitting the post; the losing teams had about  $3.1 \pm 1.4$  such instances, while the winning teams had about  $1.8 \pm 0.9$ . Winning odds decreased by 21% for each shot that hit the post ( $OR = 0.79, p = 0.01$ ). Moreover, accuracy at penalty kicks turned out to be a differential criterion more, e so during critical and anxious moments such as the semifinals and finals. The teams with the capability to convert penalties thus had a much

greater chance of succeeding in these moments (OR = 1.25,  $p < 0.05$ ) (Ferrari et al., 2020) (Sgrò et al., 2015). The findings imply that strategy must be well-rounded within the teams to match the increasing level of competition. For the defence, developing the goalkeepers and strengthening the coordination is essential; as for the offence, scoring opportunities maximization and sharpening shooting accuracy will be their priorities. Keeping calm and maintaining infractions at a bearable minimum will directly correlate to match outcomes, and thus, discipline remains a vital factor. Incorporating these into everyday training routines will augment an entire team's performance under duress and, correspondingly, increase their potential for future success in very competitive games (Valkanidis et al., 2020) (Bonjour et al., 2020).

### Conclusions

This study highlights the critical role of key performance indicators (KPIs) in determining match outcomes in elite handball, particularly in high-stakes tournaments like the 2024 Paris Olympics. The findings reveal that offensive metrics, such as goals scored and assists, are the strongest predictors of success. Each additional goal increases the odds of winning by 20% (OR = 1.20,  $p < 0.001$ ), while each assist contributes a 10% increase (OR = 1.10,  $p = 0.02$ ). These results emphasize the importance of Teamwork and coordinated offensive strategies to maximize scoring opportunities. Defensive metrics, particularly goalkeeping efficiency and shot-blocking, also significantly impact match outcomes. Winning teams demonstrated superior defensive capabilities, averaging 14.5 saves per match compared to 10.2 saves by losing teams. This underscores the importance of a strong defensive foundation and effective goalkeeping to counter opponents' offensive efforts and maintain game control. Discipline emerged as another critical factor, as winning teams committed fewer technical fouls and received fewer suspensions. Maintaining composure proved essential, as technical fouls reduced the odds of winning by 13% (OR = 0.87,  $p = 0.04$ ). This highlights the importance of minimizing disruptions and maintaining focus, especially in knockout stages. This study contributes to the literature on performance analysis in handball by offering a holistic framework that integrates offensive, defensive, and disciplinary metrics. Unlike previous studies that focused on isolated aspects, this research provides a comprehensive model capturing the interplay of performance indicators. Practically, coaches can apply these insights by enhancing offensive efficiency, improving defensive strategies, and minimizing disciplinary infractions. Additionally, the findings can inform data-driven strategies for sports organizations to optimize talent identification and team composition. Future research could explore the application of these insights to other contexts, such as women's handball, or utilize advanced analytics to improve predictive accuracy.

### Authors' Contribution:

**Syed Anwar Ali:** Supervision, Conceptualization, Formal analysis, Writing - original draft, Visualization. **Rajesh William:** Conceptualization, Investigation, Formal analysis, Writing - original draft, Visualization. **Kalaivani S:** Investigation, **Sathees Kumar:** Editing. **Din Bandhu:** Writing - Review & Editing

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