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Distribution and Statistical Analysis of Refereeing Decisions

János TÓTH Jr.[1*], Gábor DANKOVICS[1], János TÓTH Sr.[1]

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ABSTRACT. Introduction: Refereeing decisions, often influenced by biases like home advantage, play a crucial role in football outcomes. The introduction of Video Assistant Referee (VAR) in 2018 has sought to reduce subjective errors and improve fairness, leading to increased decision accuracy and potentially encouraging more confident attacking play inside the penalty area. **Objective:** The aim of this research was to explore the impact of the introduction of the VAR technology on the ratio of penalties, ball touches inside the penalty area, and attacking entry methods in the OTP Bank League. **Methods:** Data from the 2018/19 to the 2023/24 seasons were obtained from the Wyscout database. Statistical analyses employed Welch's t-test and Pearson's correlation. **Results:** The results showed a significant drop in penalty rates after VAR was introduced ($p = 0.0496$), with more ball touches inside the penalty area. Unexpectedly, the link between dribbling and penalties weakened, becoming negative post-VAR. Meanwhile, pass-based entries showed a strong positive correlation with penalties ($r = 0.94621$). Although overall entries rose, changes in specific entry types weren't statistically significant. **Conclusion:** The study found that the introduction of VAR in Hungarian top league reduced penalties, increased touches in the penalty area, and shifted attacking strategies by emphasizing pass-based entries over dribbling, highlighting VAR's impact on both refereeing and team tactics.

Keywords: *football, VAR, referee decisions, match analysis*

[1] Football Department, Hungarian University of Sports Science, Budapest, Hungary
[*] Corresponding author: toth.janos@tf.hu

INTRODUCTION

Refereeing decisions in football play a decisive role in determining match outcomes, especially regarding the awarding of penalty kicks. Throughout the sport's history, the role of referees has evolved, while match officiating has become increasingly complex (Bartha, 2006). Nevertheless, decision-making, even at the highest level, can be affected by a multitude of internal and external factors. Previous research has demonstrated that home advantage and subconscious referee bias are observable phenomena in professional sport, including football (Sors et al., 2021; Nevill et al., 2017; Harari, 2009). Such influences can often lead to decisions that favor one team, particularly the home side.

Studies on refereeing bias have addressed several aspects, ranging from the effect of crowd presence (Nevill et al., 2017; Işın and Gómez Ruano, 2023) to the sequential influence of prior decisions (Plessner and Betsch, 2001; Schwarz, 2011). Against this backdrop, the introduction of a technology capable of reducing subjective interference and promoting fairer officiating gained particular significance.

The Video Assistant Referee (VAR), officially introduced in 2018, was designed to support referees in the accurate assessment of critical incidents, particularly goals, penalties, red cards, and cases of mistaken identity (FIFA, 2018; Lago-Peñas, Gómez-Ruano et al., 2019). Beyond enhancing fairness, the system also aimed to maintain match flow (FIFA, 2018/19). Its application has yielded measurable outcomes: effective playing time has increased, and decision accuracy, for instance in the Premier League, rose from 82 percent to 96 percent (Li, Wang and Zhang, 2024; Brown, 2024). Although public and professional opinion remains divided (Ipsos, 2024; The Guardian, 2025), several studies confirm that VAR reduced erroneous calls and altered player behavior, including the decline of simulation (Li et al., 2024).

However, the impact of VAR extends beyond refereeing objectivity, it may also have shaped team attacking strategies. Research suggests that attacking players act more boldly inside the penalty area, as the risk of incorrect calls has diminished with VAR (Pérez, Ortega-Toro and Giménez, 2020; Buraimo, Migali and Simmons, 2020). Other investigations argue, however, that its primary effect lies in the more objective adjudication of existing situations, rather than a structural change in attacking play (Kolbinger & Lames, 2019).

This study seeks to determine how the introduction of VAR affected the number of penalties awarded, team activity within the penalty area, and entry strategies in the Hungarian top division (OTP Bank League). By comparing data from three pre-VAR and three post-VAR seasons using statistical methods, the research aims to provide an objective picture of whether technology increased

decision-making fairness and altered attacking philosophies. Ultimately, the goal is to contribute to the understanding of domestic tactical and refereeing trends.

HYPOTHESES

H1: The penalty rate significantly decreased after the introduction of VAR.

H2: The strongest relationship between entries into the penalty area and the penalty rate was consistently associated with dribble-based entries, both before and after the introduction of VAR.

H3: A significant increase can be observed in certain types of entry methods after the introduction of VAR, as teams attack the penalty area more deliberately.

MATERIALS AND METHODS

This study analyzed data from the OTP Bank League covering the 2018/19 to 2023/24 seasons, collected from the Wyscout database. The primary focus was on ball touches inside the penalty area, awarded penalties and their ratios, and the methods of entry into the box.

Data was compiled for both home and away performances, including all penalty kicks awarded (missed attempts included). The dataset was organized by venue, and the penalty rate was calculated relative to total touches inside the penalty area. Entry methods were classified into three categories: crosses, dribbles, and passes.

Since data were not available for all clubs across all six seasons, the analysis was restricted to the accessible dataset. To test the first and third hypotheses, Welch's t-test was applied to identify significant differences, while the second hypothesis was examined using Pearson's correlation to assess the strength of associations between entry methods and penalty rates.

RESULTS

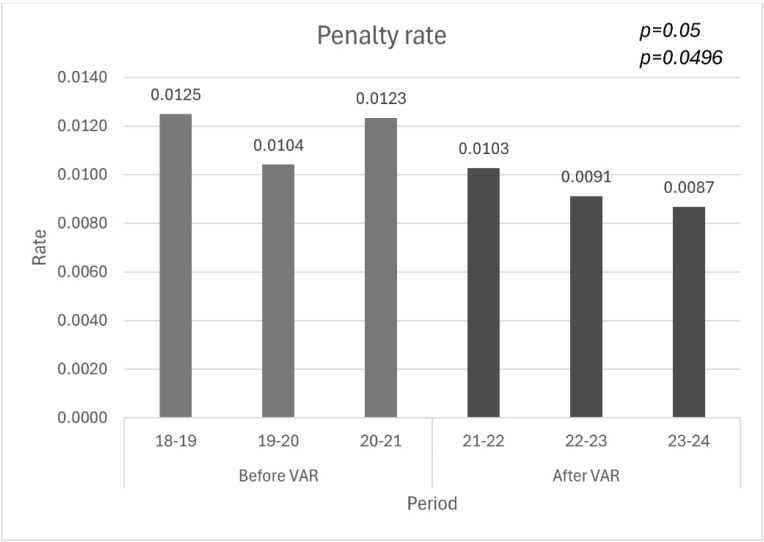

Figure 1. Penalty rate before and after VAR

The statistical results show that the number of penalties decreased while the number of ball touches increased after the introduction of VAR. According to the t-test ($p = 0.0496$), the penalty rate significantly declined following the implementation of the system, indicating that with the same number of touches inside the penalty area, fewer penalties were awarded (Figure 1).

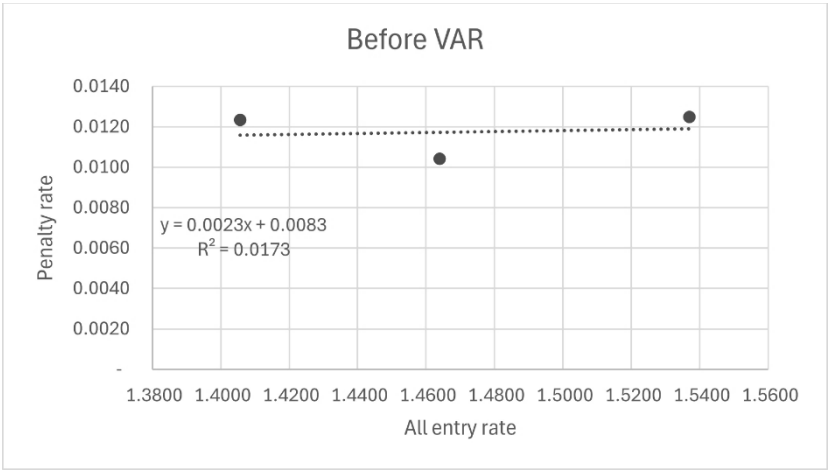

Figure 2. Pearson's correlation: Total entry - penalty rate before VAR

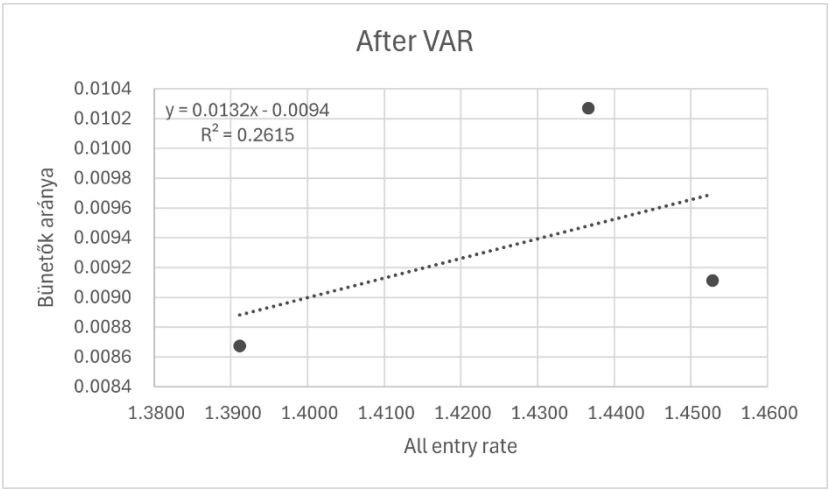

Figure 3. Pearson's correlation: Total entry - penalty rate after VAR

Correlation analysis revealed that the relationship between entry ratios and penalties became stronger after the adoption of VAR as depicted by Figure 2 and 3. In the pre-VAR period, the coefficient (r = 0.13139) suggested only a weak positive link, while in the post-VAR period (r = 0.51139) a moderate positive correlation emerged.

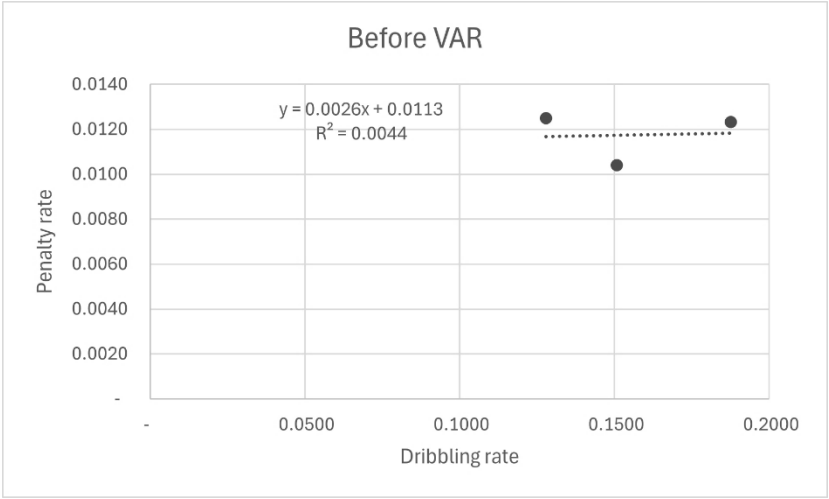

Figure 4. Pearson correlation: Dribbling – penalty rate before VAR

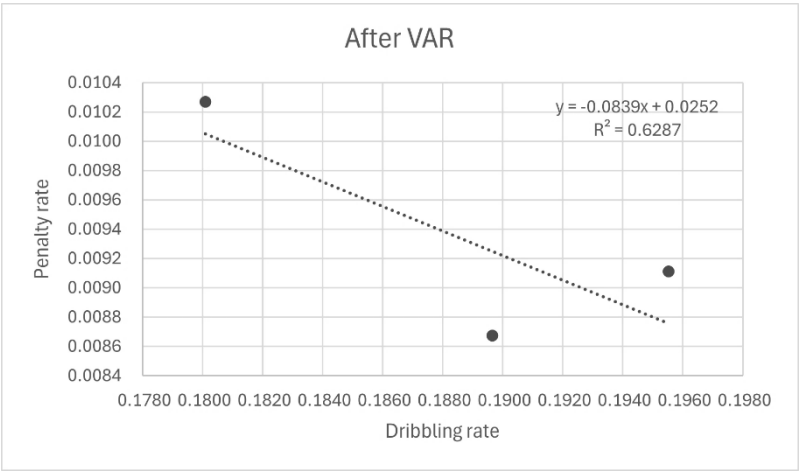

Figure 5. Pearson correlation: Dribbling – penalty rate after VAR

The relationship between entries with dribbling and the proportion of awarded penalties shows a significantly different pattern before and after the introduction of VAR, shown of Figure 4 and 5. In the pre-VAR period, a weak positive correlation (r = 0.06638) indicates no meaningful connection between this type of entry and penalties. In contrast, the strong negative correlation observed after VAR (r = -0.79292) suggests that an increase in dribbling entries into the penalty area actually reduces the likelihood of penalties being awarded.

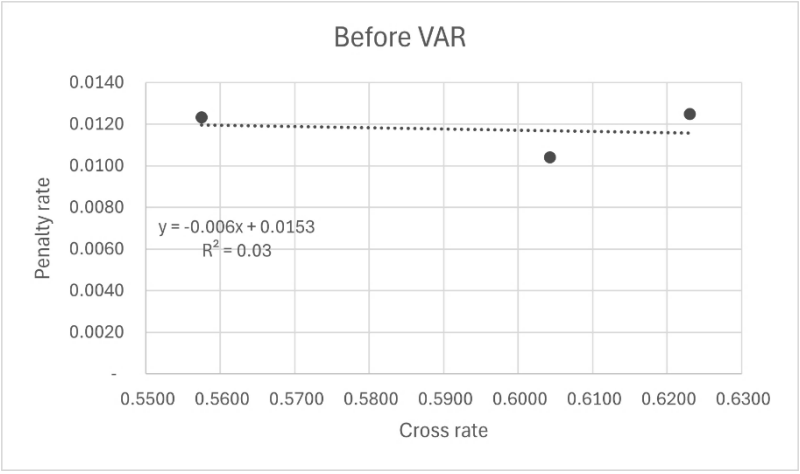

Figure 6. Pearson's correlation: Cross-to-penalty ratio before VAR

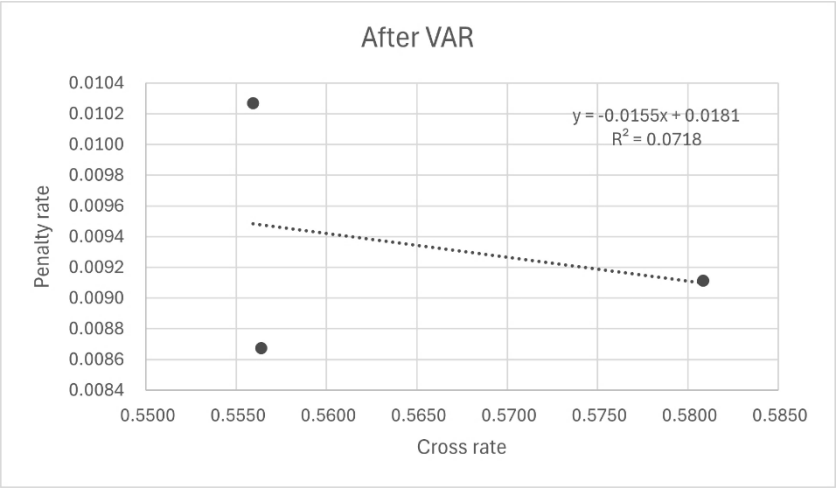

Figure 7. Pearson's correlation: Cross-to-penalty ratio after VAR

Cross-based entries showed weak negative relationships in both periods, illustrated on Figure 6 and 7 (pre-VAR r = -0.17316, post-VAR r = -0.26787).

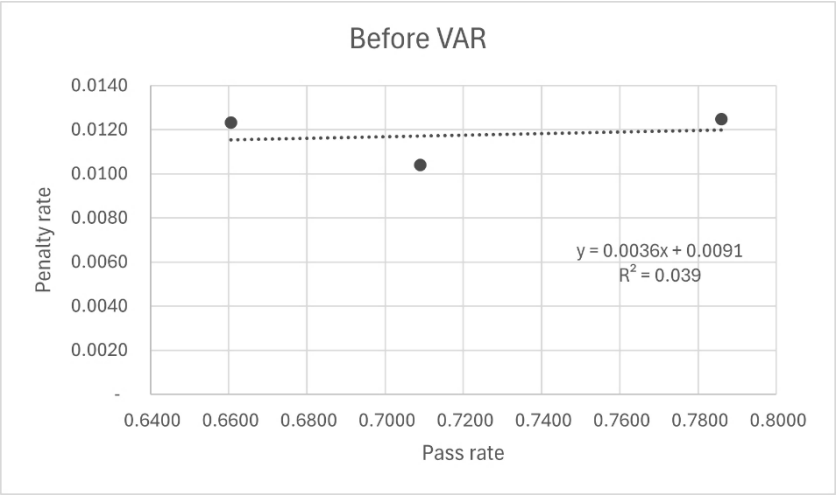

Figure 8. Pearson's correlation: Pass-to-penalty rate before VAR

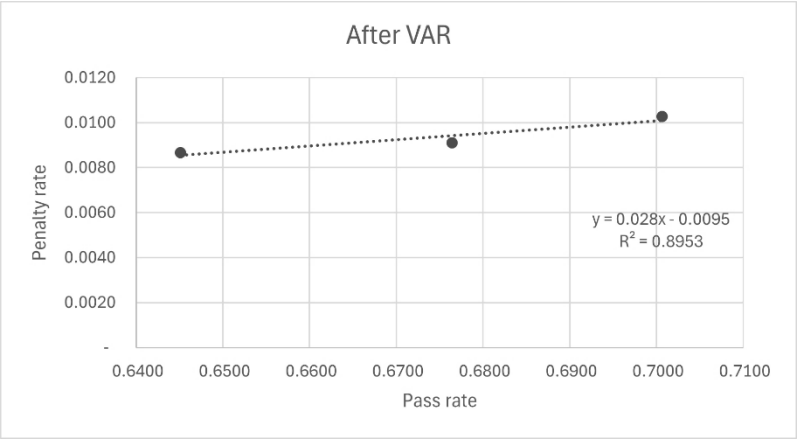

Figure 9. Pearson's correlation: Pass-to-penalty rate after VAR

Figure 8 and 9 show a dramatic strengthening of the relationship between pass-based entries into the penalty area and awarded penalties following the introduction of VAR. While the pre-VAR period exhibited only a weak positive correlation (r = 0.19754), this value rose sharply after VAR to a high level of 0.94621, indicating an almost perfect positive linear relationship.

Table 1. Data of all ball handling methods before and after VAR

Period	Season	All ball handling	Dribble	Cross	Pass	Total ball handling average
Before VAR	2018-2019	8 860	737	3 592	4 531	8 881
	2019-2020	9 005	927	3 717	4 361	
	2020-2021	8 777	1 171	3 481	4 125	
After VAR	2021-2022	9 094	1 140	3 519	4 435	9 267
	2022-2023	9 407	1 266	3 761	4 380	
	2023-2024	9 301	1 268	3 720	4 313	
SUMMARY OF TTEST	-	**0.0313**	0.1455	0.5274	0.7879	-

The results indicate that not all types of entries showed a significant increase before and after the introduction of VAR, summarized by Table 1. While there was a statistically significant rise in the total number of entries (p = 0.0313),

the p-values for individual entry types (dribbling, crosses, passes) exceeded the 0.05 threshold, meaning the changes in these categories are not statistically significant. This suggests that although the overall number of entries into the penalty area increased with the introduction of VAR, no comparable, significant change can be observed in the individual entry types.

DISCUSSION

Based on the results, the research hypotheses formulated from literature can be summarized as follows.

The first hypothesis assumed that the introduction of VAR significantly reduced the penalty rate in the Hungarian NB1 league. This assumption is supported by the results, and therefore the hypothesis is accepted. Although the present findings partly differ from international experiences, they still show several parallels with other leagues. In LaLiga, VAR increased refereeing accuracy, yet its impact on penalty frequency remained inconsistent: greater sensitivity to minor contacts raised penalty numbers in some matches but had no effect in others (Lago-Peñas et al., 2021). At the FIFA Women's World Cups, VAR similarly reduced incorrect decisions while improving the detection of smaller infringements (Zhang et al., 2022). In contrast, the decline in penalties in the NB I suggests that VAR exerted a deterrent effect, encouraging more cautious defending inside the penalty area. Other leagues also demonstrate heterogeneous outcomes: in Italy, Germany and Brazil, VAR either increased penalty awards by revealing minor contacts (Lago-Peñas, Rey & Kalén, 2019) or reduced them through shifts in decision-making patterns and greater referee caution (Meneguite et al., 2022). Broader analyses, including research on the European Championship, further show that VAR influences match structure, foul detection and referee bias, though the magnitude and direction of these effects vary across competitions (Veldkamp & Koning, 2023; Işın & Yi, 2024).

The second hypothesis proposed that dribbling-based entries into the penalty area would show the strongest correlation with the penalty rate both before and after the introduction of VAR. However, the findings do not support this hypothesis, which must therefore be rejected. The data indicates that pass-based entries demonstrated the strongest correlation with awarded penalties in both the pre-VAR and post-VAR periods, rather than dribbling-based entries. The broader literature, particularly Kolbinger and Lames (2019), emphasizes that VAR's primary purpose is to enhance refereeing accuracy rather than reshape attacking structures. Based on this, one might expect that relationships between penalty-area actions and penalty awards would remain stable after VAR's introduction, as the technology evaluates existing situations more objectively

rather than altering attacking styles. However, the present findings diverge from this assumption. Across both pre-VAR and post-VAR periods, passing entries into the penalty area showed the strongest association with penalty frequency, whereas dribbling entries were less correlated.

The relationship observed between dribbling entries and the penalty rate suggests that, although such actions are dynamic and often used to create individual scoring opportunities, defensive players may respond to them with greater awareness and caution. The introduction of VAR appears to have reduced the likelihood of penalties being awarded for minimal contact following individual runs, particularly in the absence of clear fouls. Furthermore, with the awareness of VAR review capabilities, defenders tend to act more carefully in these scenarios, which may have decreased the effectiveness of dribbling-based entries.

In contrast, the strong correlation between pass-based entries and penalty awards may be attributed to the nature of these situations, which often result in sudden and direct attacking opportunities. In such cases, the attacking player typically receives the ball facing the goal, placing significant pressure on defenders. These scenarios increase the likelihood of defensive errors or fouls, especially within the penalty area. Additionally, VAR allows for the review and sanctioning of previously unnoticed infractions, such as slight pushes or mistimed tackles. This effect is particularly pronounced in pass-based attacking sequences, which more frequently lead to goal-scoring opportunities and are subject to greater scrutiny by both referees and the VAR system.

The third hypothesis assumed that a significant increase would be observed in the different types of ball entries into the penalty area in the post-VAR period compared to the pre-VAR period, based on the expectation that teams would attack the penalty area more intensively. While the overall number of entries increased significantly, no individual entry type showed a statistically significant change. Therefore, this hypothesis is also rejected.

The findings suggest that teams have not focused on developing a single method of entry but have instead aimed to increase overall attacking volume. As a result, attacking strategies appear to be multidimensional, flexible, and adaptable, allowing teams to optimize their choice of entry methods based on specific match situations. Comparing these results with prior research confirms the multidimensional nature of VAR's impact. Studies by Pérez, Ortega-Toro and Giménez (2020), and Buraimo, Migali and Simmons (2020) found that VAR encouraged more active attacking play, increasing attempts inside the penalty area. While my aggregated data support this trend, a closer examination of entry methods aligns more closely with Kolbinger and Lames (2019) where teams did not prioritize one specific entry mode but instead expanded overall attacking volume using diverse and flexible approaches.

In summary, out of the three hypotheses, only one was supported by the results.

CONCLUSION

This study examined the impact of the introduction of the Video Assistant Referee (VAR) on refereeing decisions in Hungarian NB1, with particular focus on the awarding of penalty kicks and changes in team attacking strategies. The research was motivated by firsthand observations gathered over more than fifteen years of participation in amateur football, where referee decisions often appeared inconsistent or biased. These experiences provided the initial motivation for a systematic, data-driven investigation of the phenomenon.

The analysis covered six seasons, from 2018/19 to 2023/24, divided into two periods: three seasons before and three seasons after the implementation of VAR. The study focused on the relationship between touches inside the penalty area, different types of attacking entries, and the frequency of awarded penalties. Statistical methods, including Welch's t-test and Pearson correlation, were employed to analyze the data.

The findings indicate that the proportion of awarded penalties declined following the introduction of VAR, while the number of touches inside the penalty area increased. This suggests that VAR contributed to filtering out incorrect decisions. Regarding entry methods, pass-based entries were most strongly associated with penalties, contrary to the original assumption that dribbling would have the strongest link. Although the total number of entries increased, the differences between individual entry types did not reach statistical significance.

The aim of this study was to highlight how VAR has influenced refereeing decisions and indirectly shaped the nature of attacking play in the Hungarian top division. Furthermore, the research is intended to provide a foundation for future studies and to support further analyses related to the use of VAR. It is hoped that the findings contribute to a better understanding of the role of technology in football, particularly in relation to events occurring in the attacking third of the pitch.

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