

Article

Evaluating the Impact of Video Assistant Referee Implementation in Football: A Four-Season Analysis of Match Performance Trends

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Abstract: This study aimed to examine the influence of the Video Assistant Referee (VAR) system on match performance indicators in professional football, specifically within the Turkish Super League. The objectives were two-fold: (i) to compare match variables such as yellow cards, red cards, goals, penalties, fouls, and offsides between seasons with and without VAR, and (ii) to analyze the evolution of these variables across four consecutive seasons following VAR implementation. A total of 2636 matches were analyzed, comprising 1224 matches played without VAR (2014–2018) and 1412 matches played with VAR (2018–2022). Match data were obtained from InStat Scout® and included key indicators directly associated with referee decisions. Statistical analyses included the Independent Sample T-Test to assess differences between the pre- and post-VAR periods, One-Way ANOVA with Tukey post hoc tests to examine seasonal trends post-VAR, and generalized linear models to identify the effects of VAR implementation on each performance variable. The results revealed significant reductions in fouls, yellow cards, and offsides ($p < 0.001$), and a significant increase in penalties awarded ($p < 0.001$) following the introduction of VAR. No statistically significant differences were found for red cards or goals. Furthermore, the number of fouls committed showed a consistent decline across each season after VAR implementation, suggesting a long-term behavioral adaptation by players. These findings underscore the lasting impact of VAR on the dynamics of professional football matches and highlight the need for players, coaches, and referees to accordingly adapt their strategies. This study contributes to the growing body of evidence supporting VAR's role in improving decision accuracy, though its broader implications for game flow and player performance warrant further investigation.

Keywords: VAR; referee decisions; soccer; video technology; technological aids

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1. Introduction

Referees are expected to make over a hundred decisions during a football match [1]. During these decisions, however, match officials can be influenced by many factors, such

as the team's ability, the crowd noise, and social pressure [2–5]. This can result in significant mistakes that can affect the match results. For this reason, different technological official aids, such as goal-line technology [6], referee microphone systems, and additional assistant referees [7], have been introduced to increase the accuracy of referee decisions and avoid major mistakes. Although these technological aids have their benefits, they have not been without controversy [8]. Nevertheless, the implementation of these technological aids has improved the accuracy of referees' decisions and thus the fairness of sports competitions.

In this context, the Video Assistant Referee (VAR) represents the most substantial and transformative innovation in football officiating in recent decades. Introduced with the objective of minimizing human error in critical match situations, VAR was officially approved by the International Football Association Board (IFAB) for use in the laws of the game during the 2018/19 season. Since then, it has been widely adopted in top-tier competitions such as the FIFA World Cup, UEFA Champions League, and numerous national leagues [9].

VAR is designed to assist the on-field referee in correcting "clear and obvious errors" or serious missed incidents in four key situations: goals, penalty decisions, direct red card incidents, and cases of mistaken identity. Its core purpose is to increase decision-making accuracy while maintaining the flow and integrity of the game.

The implementation of VAR has stimulated a substantial body of academic research seeking to evaluate its influence across various dimensions of football. Previous studies have focused on its statistical impact, reporting significant changes in key performance indicators such as the number of goals, offsides, penalties awarded, yellow and red cards, fouls, and overall match duration [10–15]. After the introduction of VAR, both the Italian and German top divisions reported a reduction in the number of offsides, fouls, and yellow cards. Additionally, there was an increase in the number of minutes added to the end of the first half and the full match duration, though this was not observed in the second half alone [10]. In Spain, the implementation of VAR led to a significant decline in offsides [11]. A similar trend was observed in the World Cup, where the number of offsides notably dropped following the adoption of VAR. Furthermore, the duration of the first half, second half, and total match time significantly increased [12]. In Brazil's top men's football league, the use of VAR also resulted in fewer fouls and disciplinary cards [13]. Specifically, VAR has been linked to a reduction in the frequency of certain infractions, such as simulation and offside infringements, due to increased detection and accountability [10,13,16,17]. In addition, some evidence suggests that VAR contributes to improved decision-making consistency and a decrease in referee bias [18,19].

Beyond performance metrics, scholars have explored the psychological and behavioral implications of VAR for players, referees, and fans. The presence of video review may alter players' tactical approaches and reduce unsporting behavior, given the increased risk of retrospective sanctions [20,21]. Moreover, VAR has been found to affect perceptions of fairness and legitimacy in match officiating. On the one hand, it reinforces trust in the objectivity of decisions by offering referees technological support in critical moments. On the other hand, it has generated new forms of controversy and resistance. For example, d'Andréa and Stauff [21] argue that VAR's integration into football broadcasting has transformed it into a public object of debate, particularly through social media platforms like Twitter, where emotionally invested fans question its legitimacy and narrative impact. They emphasize that VAR disrupts the flow of the game and introduces a layered mediatization that can alter the emotional spontaneity of the viewing experience. Similarly, Tamir and Bar-Eli [22] frame VAR as a morally transformative innovation that promotes fairness but also acknowledge the tension between the demand for accuracy and football's traditional simplicity and authenticity. They note that critics

perceive VAR as undermining the human element and aesthetic continuity that define the cultural identity of football [22,23].

Despite these advances, many existing studies examining the impact of VAR are constrained by short observational periods—typically limited to a single season—which limits the ability to identify long-term patterns or behavioral adaptations associated with the technology. Moreover, there is a lack of comprehensive longitudinal research addressing how referee decisions and match dynamics evolve over multiple seasons following the implementation of VAR. These gaps hinder our understanding of whether the observed short-term effects are sustained or undergo modulation as referees, players, and teams become more accustomed to the system [18]. It is also unclear whether the initial trends observed post-implementation are sustained, intensified, or mitigated over time as referees, players, and teams adapt to the system.

This research focused on the Turkish Super League to examine the long-term effects of VAR. There were several key reasons for this choice: (1) VAR was introduced relatively early (in the 2018–2019 season) compared to many other leagues, which allowed for an analysis over multiple seasons; and (2) the league is highly competitive and features a diverse mix of domestic and foreign players, making it ideal for exploring a wide range of tactical and behavioral dynamics.

The aims of the present study were two-fold: (i) to compare match performance indicators such as yellow cards, penalties, fouls, and offsides between seasons with and without the implementation of VAR and (ii) to analyze how the implementation of VAR affects the same performance indicators in each following season. By examining multi-season data across a top-tier league, this research seeks to provide a deeper understanding of VAR's long-term implications for game conduct, regulatory consistency, and the evolution of match behavior in professional football.

The hypotheses of this study are as follows:

H1: *The implementation of VAR leads to a decrease in the number of goals, yellow cards, fouls, and offsides, and an increase in the number of penalties and red cards.*

H2: *VAR continues to have a statistically significant impact on these match performance indicators in the seasons following its implementation.*

2. Materials and Methods

2.1. Research Design

This study utilized a quasi-experimental, longitudinal, and comparative research design to examine the effects of the VAR system on several match-related performance indicators. Within the scope of this study, match data from professional football competitions played over eight seasons were analyzed. The first four seasons were classified as pre-VAR (no VAR), while the latter four were classified as post-VAR (VAR). This allowed for a comparative analysis of the impact of VAR implementation on in-game performance indicators over time.

2.2. Match Sample

The dataset consists of 2636 matches played in eight seasons of the Turkish Super League between the years 2014 and 2022. VAR has been used in the Super League since the 2018–2019 season. Therefore, the analysis was conducted on 1224 matches played without VAR in the 2014–2015, 2015–2016, 2016–2017, and 2017–2018 seasons and 1412 matches played with VAR in the 2018–2019, 2019–2020, 2020–2021, and 2021–2022 seasons.

2.3. Data Collection

The data for this study were sourced from InStat Scout (InStat®, <https://instatscout.com/login>, accessed on 25 March 2025), a widely used and trusted performance analysis platform in football. Previous studies have confirmed the reliability of this tool, which provides comprehensive and consistent match statistics [24,25].

In this research, the focus was placed on six specific match-related performance indicators: yellow cards, red cards, goals, penalties, fouls, and offsides. These variables were selected because they are closely tied to referee decisions and are commonly used in studies that investigate the influence of officiating or VAR systems [10,12,17]. By analyzing these indicators, the aim was to gain insight into how key aspects of the game, particularly those under the referee's direct control, have changed before and after the introduction of VAR. A full list and explanation of each variable included in the analysis is provided in Table 1.

Table 1. Match-related performance indicators.

Goal	Number of goals scored.
Foul	Number of fouls committed.
Yellow Card	Number of yellow cards awarded to players by the referee for an infringement.
Red Card	Number of red cards awarded to players by the referee for an infringement.
Offside	Number of offside decisions by the referee.
Penalty	Number of penalties awarded.

2.4. Ethics Approval

This research was conducted in accordance with the Declaration of Helsinki and received ethical approval from the Akdeniz University Social and Humanities Scientific Research and Publication Ethics Committee (protocol code: 2022-22/477).

2.5. Statistical Analysis

All match-related performance indicators were exported to a Microsoft Office Excel (Microsoft Corporation, Washington, DC, USA) spreadsheet and then analyzed using Jamovi (version 2.3.18; Sydney, Australia). Data are presented as mean \pm standard deviation (SD). Density plots were calculated to visualize the data distribution. The differences between match performance variables with and without VAR were compared using the Independent Sample *T*-Test. Effect sizes (ESs) were interpreted according to Cohen's *d* categorization as follows: small effect ($d = 0.20$), medium effect ($d = 0.50$), and large effect ($d = 0.80$) [26]. A generalized linear model was constructed for each variable, and standard error (SE), 95% confidence intervals (CIs), and *p*-values were calculated for each model. Differences between match performance indicators in the four seasons in which VAR was implemented were analyzed using the One-Way ANOVA test, and Tukey pairwise comparisons were used to determine which seasons the difference was between.

3. Results

The differences between match-related performance variables in the seasons with and without VAR are shown in Table 2. There was a significant decrease in the number of fouls (from 31.82 to 26.21, $t = 23.865$, $p < 0.001$, $d = 0.93$), yellow cards (from 4.59 to 4.32, $t = 3.319$, $p < 0.001$, $d = 0.13$), and offsides (from 4.04 to 3.71, $t = 3.773$, $p < 0.001$, $d = 0.15$) after VAR implementation. In contrast, there was a significant increase in the number of penalties (from 0.32 to 0.42, $t = -3.812$, $p < 0.001$, $d = 0.11$). According to Cohen's *d* effect size classification, the reduction in fouls reflects a large effect, while the changes in yellow

cards, offsides, and penalties correspond to small effects. The density graph of match performance indicators before and after VAR implementation is provided in Figure 1.

Table 2. Differences between match performance variables with and without VAR.

Variables	No VAR (n:1224)	VAR (n:1412)	t	p	Cohen's d 95% CI		
	Mean ± SD	Mean ± SD			d	Lower	Upper
Goals	2.81 ± 1.69	2.76 ± 1.68	0.693	0.489	0.03	−0.05	0.10
Fouls	31.82 ± 6.52	26.21 ± 5.34	23.865	<0.001	0.93	0.85	1.02
Yellow Cards	4.59 ± 2.10	4.32 ± 2.12	3.319	<0.001	0.13	0.05	0.21
Red Cards	0.28 ± 0.57	0.28 ± 0.56	−0.067	0.946	−0.00	−0.08	0.07
Offsides	4.04 ± 2.32	3.71 ± 2.19	3.773	<0.001	0.15	0.07	0.22
Penalties	0.32 ± 0.57	0.42 ± 0.66	−3.812	<0.001	0.15	−0.23	−0.07

Note. SD: standard deviation; 95% CI: 95% confidence interval.

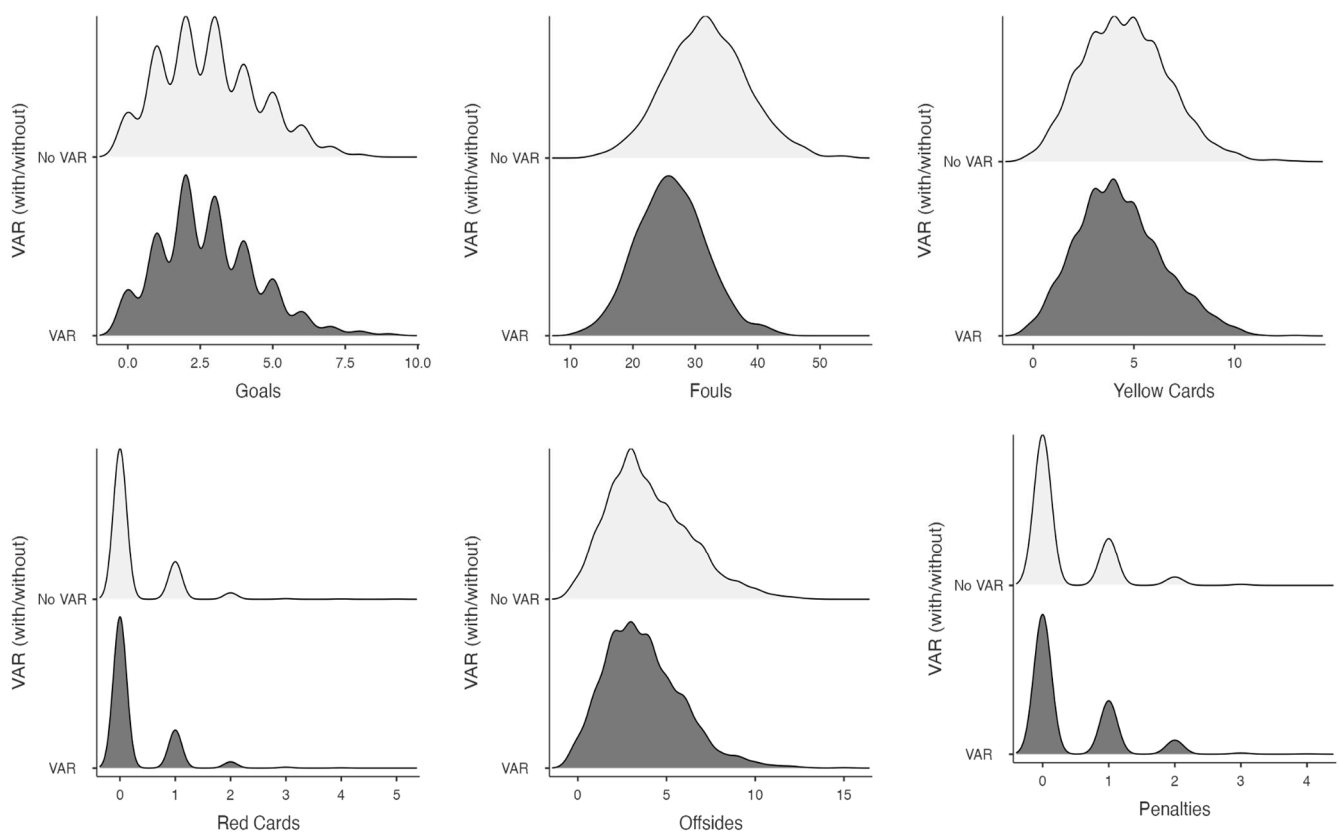


Figure 1. Density graph of match performance indicators before and after VAR implementation.

According to the generalized linear model, there was a significant decrease in the number of fouls committed ($B = -0.19, p < 0.001$), offsides ($B = -0.09, p < 0.001$), and the incidence of yellow cards ($B = -0.06, p < 0.001$). Conversely, there was a significant increase in the number of penalty decisions ($B = 0.25, p < 0.001$). No statistically significant changes were observed in the number of goals scored ($B = -0.02, p = 0.483$) and red cards issued ($B = 0.01, p = 0.943$) (Table 3).

Table 3. Generalized linear model for each variable.

Variables	Estimate	SE	exp (B)	95% CI		<i>p</i>
				Lower	Upper	
Goals	−0.02	0.02	0.98	0.94	1.03	0.483
Fouls	−0.19	0.01	0.82	0.81	0.84	<0.001
Yellow Cards	−0.06	0.02	0.94	0.91	0.98	<0.001
Red Cards	0.01	0.07	1.01	0.87	1.16	0.943
Offsides	−0.09	0.02	0.92	0.88	0.95	<0.001
Penalties	0.25	0.07	1.29	1.13	1.46	<0.001

Note. SE: standard error; 95% CI: 95% confidence interval.

According to the comparison of the four seasons in which VAR was implemented, the numbers of fouls ($F = 23.386$; $p < 0.001$) and offsides ($F = 3.89$; $p = 0.019$) were statistically significant. For fouls, VAR4 was the season with the fewest fouls, and these differences were significant compared to all previous seasons. In addition, there was also a significant difference between VAR-1 and VAR-3. For offside, VAR-3 was statistically different compared to VAR-4. After using VAR, we found no statistical differences between the seasons for the other variables (Table 4). For the density plot comparing seasonal match performance indicators before and after VAR implementation, please refer to Figure 2.

Table 4. Comparison of match performance indicators according to seasons after VAR implementation.

Variables	VAR-1	VAR-2	VAR-3	VAR-4	F	<i>p</i>
	(n:306)	(n:306)	(n:420)	(n:380)		
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD		
Goals	2.68 ± 16.7	2.86 ± 1.63	2.71 ± 1.77	2.81 ± 1.63	0.879	0.452
Fouls	27.55 ± 5.38 ^{a,b}	27.05 ± 5.21 ^a	26.31 ± 5.33 ^a	24.36 ± 5.43	23.386	<0.001
Yellow Cards	4.44 ± 2.10	4.54 ± 2.04	4.24 ± 2.05	4.13 ± 2.26	2.642	0.048
Red Cards	0.26 ± 0.55	0.32 ± 0.60	0.29 ± 0.55	0.25 ± 0.53	1.192	0.312
Offsides	3.74 ± 2.20	3.84 ± 2.32	3.42 ± 2.08 ^c	3.89 ± 2.17	3.39	0.009
Penalties	0.40 ± 0.64	0.45 ± 0.68	0.42 ± 0.65	0.40 ± 0.67	0.449	0.718

Note: VAR-1: the first season in which VAR was implemented; VAR-2: the second season in which VAR was implemented; VAR-3: the third season in which VAR was implemented; VAR-4: the fourth season in which VAR was implemented. ^aStatistical difference compared with VAR-4: $p < 0.001$. ^bStatistical difference compared with VAR-3: $p < 0.05$. ^cStatistical difference compared with VAR-4: $p < 0.05$.

While several performance indicators showed statistically significant differences before and after the implementation of VAR, the corresponding effect sizes, measured by Cohen's *d*, were mostly small, with the exception of fouls, which demonstrated a large effect. This discrepancy is not uncommon in studies with large datasets, where increased statistical power can yield low *p*-values even for modest differences. Small effect sizes indicate that although certain match performance indicators (such as penalties, offsides, and yellow cards) significantly changed from a statistical perspective, the practical magnitude of these changes per match is limited. To address this and gain a more nuanced interpretation, we supplemented our analysis with generalized linear models, which confirmed the relative weight of VAR's impact on each variable. Together, these statistical approaches provide a balanced understanding of the influence of VAR, both in terms of statistical reliability and practical significance.

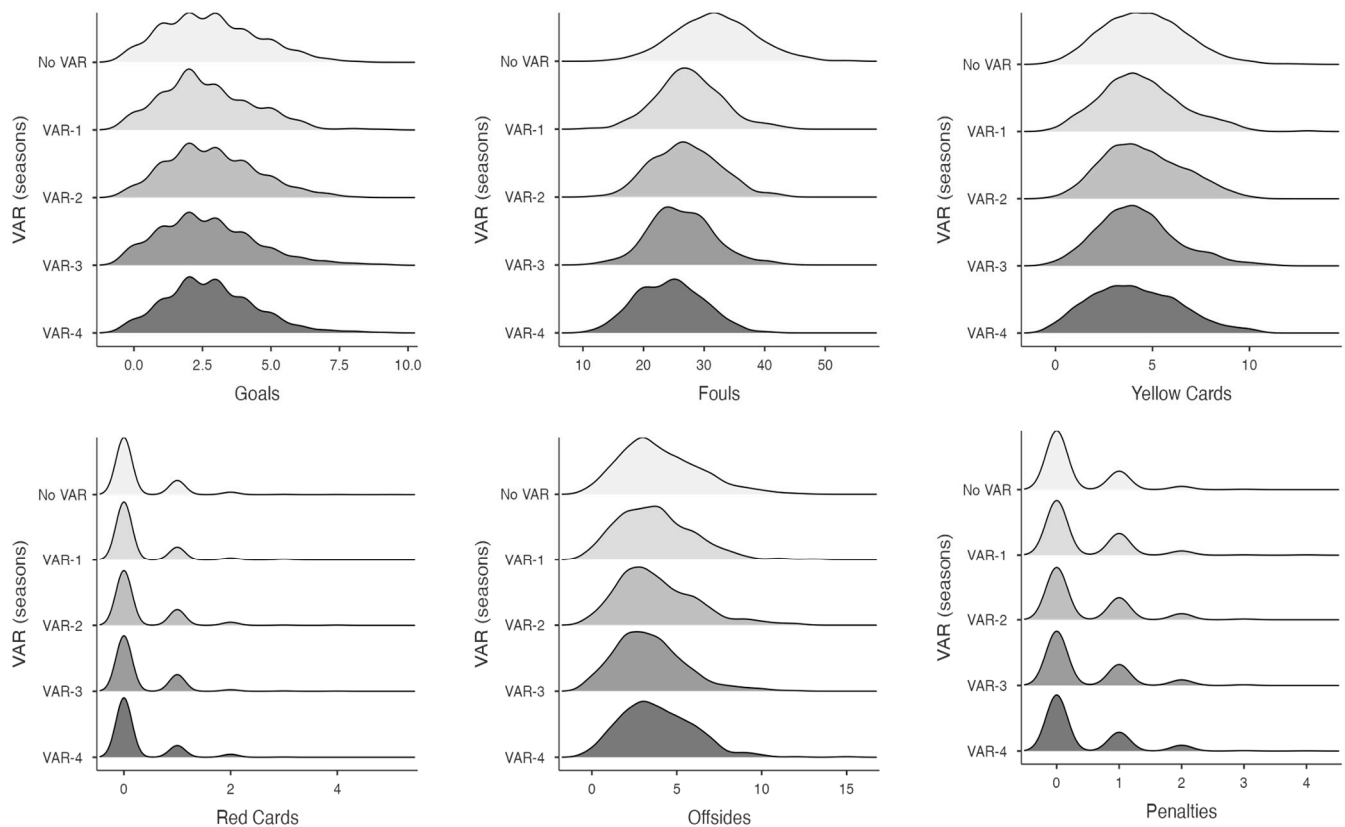


Figure 2. Density plot comparing seasonal match performance indicators before and after VAR implementation.

4. Discussion

We investigated the differences between match performance indicators in the Turkish Super League with and without VAR and analyzed the effect of VAR on these variables in each season following the implementation of the VAR system. The results of our study revealed that VAR resulted in significant changes in some aspects of the game in the Turkish Super League. Fouls, yellow cards, and offsides significantly decreased after the introduction of VAR, while penalties significantly increased. However, VAR technology did not affect the number of goals or red cards. While some variables showed statistically significant changes after the implementation of VAR, it is important to interpret these results in the context of their effect sizes. For example, the reduction in fouls demonstrated a large effect, suggesting a substantial behavioral change. In contrast, yellow cards, offsides, and penalties showed small effect sizes, indicating that although the direction of change was consistent, the actual per-match differences were modest. This reinforces the importance of complementing p -values with measures of practical significance, especially in large-sample studies where even small differences can reach statistical significance. Our generalized linear models helped clarify these nuances by quantifying the relative strength of VAR's influence across different performance indicators. As expected, players seemed to adapt their behavior, committing fewer fouls and offsides and receiving slightly fewer yellow cards. In contrast, the number of goals did not significantly decrease, possibly due to the balancing effect of goals awarded and disallowed after VAR review. After all, referees were expected to make the most incorrect decisions in goals. As the goals are reviewed and confirmed by VAR or a review is suggested on the field, a decrease in the number of goals conceded would have been expected. However, our results showed that the number of goals conceded slightly decreased after VAR, but this decrease was not statistically significant. Penalties and red

cards are important decisions that are missed by referees on the field and therefore would have been expected to increase with the assistance of VAR. While penalties increased as expected, no significant changes were observed in red cards. The most important reason for this may be that the number of red cards is rare during a football match. In addition, football players may have been more cautious due to the chance for referees to re-evaluate their decisions with the help of VAR. Furthermore, significant changes in match performance indicators would have been expected in the seasons after the implementation of VAR. However, apart from fouls, there were no significant changes in other match performance indicators. This may be a result of the teams' performances, technical and tactical skills, and the effects of VAR on referee decisions.

Although various technological assistants such as additional assistant referees, goal-line technology, and headset systems have been used over time to compensate for incorrect decisions by football referees during matches [6,7], there are still some obvious errors that cannot be prevented. To address this problem, VAR was introduced in 2018, a system that allows referees to review their decisions by watching their clear and obvious errors via video.

The introduction of the VAR system has sparked great controversy [15]. Some believe that it will make the game fairer, while others are concerned that it may interfere with the flow and spirit of the game [27]. The use of VAR results in more time-outs and matches lasting longer [10], which leads to a decrease in players' motivation and performance [28]. However, the VAR system has also had a positive impact on the accuracy and consistency of referees' decisions. Referees are able to make more informed and accurate decisions using video evidence [18,19].

In this study, the number of fouls significantly decreased, while the decrease in yellow cards was minimal. Although the number of fouls and yellow cards decreased after the introduction of VAR in the Bundesliga and Serie A, these decreases were relatively small [10]. The number of fouls significantly decreased in the Chinese Super League [17], and the number of fouls, yellow cards, and offsides showed a significant decreasing trend in the Brazilian Men's Championship [13]. In contrast to these results, there was no change in the number of fouls and yellow cards in both the Women's World Cup [29] and the Men's World Cup [12].

In the Turkish Super League, the only match performance indicator that increased after the introduction of VAR was the number of penalties. Lago-Peñas et al. [10] reported that the number of penalties increased in the Bundesliga and decreased in Serie A. Similarly, Kubayi et al. [12] reported that referees awarded more penalties after the introduction of VAR in the Men's World Cup. At the 2018 World Cup, eight penalties that were not initially awarded by the referees were given after on-field reviews, and one was awarded based on a factual decision by VAR. In addition, three penalty decisions were cancelled following on-field reviews. In contrast, a study in the German Bundesliga and Italian Serie A reported that the introduction of VAR reduced the total number of penalties by more than 25% [14]. After the introduction of VAR in the Champions League, goals and penalties were the most reviewed decisions by referees [19]. Similarly, in the 2019 Brazilian Men's Football Championship, most of the incidents reviewed by VAR were penalties (44.82%) [13]. An analysis of 380 matches in the Brazilian Serie A reported that there were 81 VAR interventions, 44 goals were canceled, 38 penalties were awarded, and 18 goals were disallowed [30]. Given these results, it can be assumed that even if penalty decisions are missed by referees, replaying the decisions in slow motion from different angles [12] facilitates making the correct decision.

The purpose of this study was also to investigate the impact of VAR on match performance indicators in subsequent seasons. The findings revealed a significant difference in the number of fouls and offsides across all parameters. The number of fouls

last season was significantly lower than the previous three seasons. However, referees awarded more offsides in the fourth season of VAR than in the previous season. Other parameters did not show significant changes. According to the current study, players committed fewer fouls in each season following the implementation of VAR. This can be attributed to the fact that referees can review incorrect decisions using video technology, making players more cautious in their actions.

While the findings of this study suggest that VAR has influenced certain match performance indicators, particularly fouls and disciplinary actions, it is important to interpret these results within a broader context. The evolution of the game is shaped by multiple factors, including changes in coaching strategies, regulatory emphasis on player behavior, and even media scrutiny. Therefore, the observed trends may not be attributable to VAR alone. Similar dynamics have been reported in other leagues implementing VAR, such as the Bundesliga and Serie A, although with varying magnitudes and, in some cases, diverging patterns, as highlighted by Tamir and Bar-Eli [22]. Future research should seek to disentangle these interacting influences through multi-league comparative analyses and mixed-method approaches, including qualitative assessments of referee behavior and team adaptation over time.

Limitations and Practical Implications

The current study has some limitations that future research should address. This study only focused on the effects of VAR on the matches played in the Turkish Super League. Therefore, there is a need to analyze matches played in many other football leagues for more generalizable results. This research only analyzed match performance indicators that are related to referee decisions. However, several factors may have influenced the findings, including home advantage, crowd noise, referee experience, team ability, tactical evolution, general adaptation of player behavior, and changes in refereeing at the international level. It is therefore recommended that future research should consider these factors when analyzing VAR. Finally, future research could assess the effects of VAR on players, coaches, and referees using qualitative methods alongside quantitative data; investigate how VAR affects referees' decision-making processes by conducting interview-based analysis; and investigate players' behavior and team performances in the minutes after VAR decisions by conducting time-stamped intervention analysis.

The results of this study provide several practical implications for stakeholders in professional football. Coaches and players should be aware that the consistent use of VAR leads to a measurable decrease in fouls, offsides, and yellow cards, suggesting that more disciplined and strategic behaviors are increasingly rewarded under VAR-regulated conditions. Consequently, training sessions may incorporate situational simulations involving video review scenarios to prepare athletes for real-time decision-making under scrutiny. Referees and officiating committees may also use these findings to design targeted educational programs that improve the interpretation and implementation of VAR protocols. Finally, sports governing bodies could consider these results when evaluating the broader impact of VAR on game fairness, flow, and perception by fans. These behavioral shifts align with earlier findings indicating that the introduction of VAR modifies incentives and reduces unsporting conduct among players due to greater oversight [31].

5. Conclusions

After the introduction of VAR, we found that fouls, yellow cards, and offsides were significantly reduced, while penalties increased. Moreover, with the implementation of VAR, fouls decreased in each following season. The findings suggest that the long-term

use of VAR in a football match has some implications that players, coaches, and referees should consider. VAR can make the game fairer and improve its quality by reducing errors. However, while the on-field referee or VAR (VAR advice only) is reviewing the position, play may stop for a while, which can disrupt the flow of the game and negatively affect the performance of the players. In such cases, players should accept that VAR is part of the game.

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Data Availability Statement: The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

CI	95% confidence intervals
ES	Effect size
IFAB	International Football Association Board
SD	Standard deviation
SE	Standard error
VAR	Video Assistant Referee

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