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The influence of the video assistant referee on the UEFA European Championship

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Abstract

Background Video Assistant Referee (VAR) as a high-tech aid was introduced into football in 2018 to enhance the officiating accuracy of referees. At the 2020 UEFA European Championship, VAR was used for the first time. This study aims to investigate the impact of VAR on the UEFA European Championship.

Methods The sample includes all matches of EURO 2016 (without VAR, $n=51$) and EURO 2020 (with VAR, $n=51$), in a total of 102 matches. For each game, nine VAR-related variables were recorded: goals, penalties, red cards, yellow cards, fouls, offsides, first-half game time, second-half game time and total game time. The tournaments pre and post the introduction of VAR were compared using a Mann-Whitney U test.

Results The results of this study revealed that the introduction of VAR led to a significant increase in the first-half match time ($Z=2.52$, $p=0.012$, ES = 0.13), the second-half match time ($Z=2.80$, $p=0.005$, ES = 0.16), total game time ($Z=3.74$, $p<0.001$, ES = 0.28) and the number of goals ($Z=2.25$, $p=0.024$, ES = 0.10), whereas a significant decrease in yellow cards ($Z=-2.55$, $p=0.011$, ES = 0.13) was observed.

Conclusions The findings of this study may have practical implications for optimizing VAR-related implementation regulations and the referee's officiating strategies at the UEFA European Championship competitions.

Keywords Video assistant referee, Football, Performance analysis, Referee, Decision-making

Introduction

Football, as the world's most popular sport, attracts tens of millions of fans and players. In football matches, the referee often plays a crucial role as the judge of the game. The referee is required to ensure the fairness of the game, however, there are still many factors that might affect the accuracy of their decision-making. These factors include, but not limited to, perceptual limitations [1], home advantage [2, 3], crowd noise [4, 5], previous decisions [6], social forces [7], match location [8], and even the pressure from the players and coaches [2, 7, 9]. As such, errors of judgment and bias in officiating may be difficult to avoid.

In recent years, the link between sports and technology has become increasingly close, and the numerous misjudgment cases have become the main reason for the

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introduction of technology to the football officiating field. Therefore, technologies such as the goal line technology [10], vanishing spray [11] and the video assistant referee technology [12] have been developed. Among them, the VAR technology belongs to one of the most important technological inventions, which has made a remarkable contribution to improving the fairness of football games [13].

Video Assistant Referee was officially introduced into football competitions in 2018 [14]. According to the VAR's procedure [15], VAR will only intervene in four game-changing situations: goals and offenses leading up to a goal, direct red card incidents only (not second yellow card/caution), mistaken identity, penalty decisions and offenses leading up to a penalty decision. During the game, if VAR detects clear mistakes associated with any of these four match-changing situations, the VAR team will inform the referee via the headset. The referee will be recommended to confirm, revise or re-examine their judgment, and the referee could conduct an on-field review (examine the video slow-motion replay in the review area) before making the final call [12, 14, 15]. Notably, VAR cannot replace the decisions made by the referee but only assists the referee in their decision-making.

Video Assistant Referee has been controversial since its introduction, and even though VAR can help referees enhance the accuracy of their decision-making, the debate about the practical application of VAR in professional football matches has never settled. These voices have argued that VAR may impact the pace and flow of the match [13, 16], the attending experience [17] and increase the financial burden of the organization [18]. However, at its first appearance in the FIFA World Cup in 2018, VAR performed well in terms of enhancing referees' decision accuracy from 95.6 to 99.5%, which signaled that the cooperation between the referees and the VAR technology will be a major trend in the future [19, 20].

More currently, VAR-related research has mainly focused on analyzing the impact of VAR on officiating accuracy and match performance indicators. In terms of the officiating accuracy, a study that investigated a total of 2,195 matches in 13 different professional leagues showed that the refereeing accuracy increased by 6.2% after the introduction of VAR compared to the time without VAR [21]. Regarding the match performance metrics, Bao and Han [13] explored the impact of the VAR technology on the English Premier League, they found that after the introduction of VAR, the time of play and the number of fouls increased significantly, in contrast, the number of offsides significantly decreased. Similar results were also found in two VAR-related studies [18, 22]. However, the difference is the study of the Chinese Super League [18] and the study of the German Bundesliga [22] found that the home advantage was diminished after the introduction of VAR. Furthermore, Kubayi et al. [23] reported that after VAR was applied to the men's FIFA World Cup, the playing time (first-half time, second-half time and total time) and the number of penalties increased. Meanwhile, the number of offsides decreased. However, a study on the women's FIFA World Cup discussed that VAR system only affects the length of the game and has no effect on other match metrics [24]. Hence, it can be implied that the influence of VAR on different tournaments or leagues might differ depending on the sex (gender), league officiating style, and football culture [25].

Previous research primarily concentrated on exploring the impact of VAR on different leagues, however studies investigate the impact of VAR on international football tournaments other than FIFA World Cup are still limited. There are only two studies discussed VAR's effects on international football tournaments, which suggested a clear research gap to understand the impact of VAR on international football competitions [23, 24]. Additionally, according to a detailed investigation, there is no study has investigated the impact of VAR on the UEFA European Championship, which shows an research opportunity to provide statistic evidence to understand the impact of VAR on this top performance and highly popular international football tournament across Europe. Therefore, this study aims to explore the VAR's impact on the UEFA European Championship by comparing changes in VAR-related match variables pre (EURO 2016) and post (EURO 2020) the implementation of VAR. However, given that it is uncertain what changes will VAR brings to the UEFA European Championship.

To develop our hypotheses, this research formulated several key assumptions based on previous research on the impact of VAR on other leagues. First, relevant data suggested that the intervention of VAR has impact on the duration of the game [13, 18, 23, 24]. We, therefore, assumed that the overall length of the match including both first haft and second haft significantly increases after the introduction of VAR. Additionally, it is the VAR interfere, especially the slow-motion replay that helps referees to scrutinize fouls in the penalty area, could have significant impact on the length of game [15, 23]. Moreover, we have reason to assume that the number of penalties might be affected by the use of VAR, as result of fouls committed in the penalty area are likely to be carefully reviewed [14]. Further to this, based on VAR's protocol [14, 15], VAR will monitor the game automatically throughout the match, it may make players highly cautious, especially when they are in defense. A study on Spanish La Liga also reported a decrease in the number of yellow cards after the introduction of VAR. As such, we assumed that the number of yellow cards might be significantly decreased with the implementation of VAR.

Last, no significant differences were found in the number of offsides, goals, red cards and fouls between before and after the introduction of VAR in FIFA Women's World Cup [24]. It is worth to test similar metrics in UEFA European Championship and see if the findings are consistent.

To investigate the impact of VAR, two hypotheses are suggested: (i): The introduction of VAR resulted in increases in first and second-half time, full-game time and the number of penalties; instead, the number of yellow cards decreased; and (ii): No statistical differences are detected between the number of goals, red cards, offsides and fouls with the use of VAR.

Methods

Samples

Following a quantitative research design, the sample of this study consists of 51 matches in EURO 2016 (without VAR) and another 51 matches in EURO 2020 (with VAR), for a total of 102 matches. Each UEFA European Championship has 36 group stage matches and 15 knock-out stage matches. During EURO 2020 (postponed to 2021 due to the COVID-19), VAR was used for the first time in UEFA European Football Championship. Therefore, the VAR-related match metrics were collected, analyzed and compared between these two competitions.

Procedures

Similar to previous studies, the nine-match metrics (first-half game time, second-half game time, full-game time, goals, penalties, fouls, offsides, red cards and yellow cards) were obtained for each game [13, 18, 26]. It is worth mentioning that only data from regular time (90 min + stoppage time) were analyzed in this study. All the game statistics were obtained from the EURO official website (https://www.uefa.com/), notably, the statistics are publicly available. To our knowledge, OPTA Sports-data company provides the game statistics for the UEFA European Championship. The reliability of OPTA's stats has been proven to be acceptable for use in academic research [27].

Data analysis

All data were imported into the IBM SPSS software (ver.27.0) and R 4.4.1 for analysis and the significance level was set at $p < 0.05$. The descriptive statistics of the EURO 2016 and EURO 2020 match performance variables before and after the introduction of VAR were performed and the means, quartiles and standard deviations were presented in Table 1. The Kolmogorov-Smirnov (KS) test showed that all game variables did not follow a normal distribution before and after the introduction of VAR. Therefore, the non-parametric Mann-Whitney U test was used to compare the differences between the game variables of EURO 2016 and EURO 2020. To

Table 1 Results of descriptive statistics (median and IQR) and Mann-Whitney U-tests for game statistics without VAR (EURO 2016) and with VAR (EURO 2020)

	No VAR				VAR							
	Mean	Median	Q1	Q3	Mean	Median	Q1	Q3	Z	p	ES	ESI
1st Half Time	46.69	47.00	46.00	47.00	47.49	47.00	46.00	49.00	2.52	0.012*	0.13	M
2nd HalfTime	49.37	49.00	49.00	50.00	50.04	50.00	49.00	51.00	2.80	0.005*	0.16	L
Total Time	96.06	96.00	95.00	97.00	97.53	97.00	96.00	99.00	3.74	0.000*	0.28	L
Penalties	0.24	0.00	0.00	0.00	0.33	0.00	0.00	1.00	0.95	0.343	0.02	S
Goals	2.12	2.00	1.00	3.00	2.78	3.00	2.00	4.00	2.25	0.024*	0.10	M
Yellow Cards	3.98	4.00	2.00	6.00	2.96	3.00	2.00	4.00	-2.55	0.011*	0.13	M
Red Cards	0.06	0.00	0.00	0.00	0.12	0.00	0.00	0.00	1.04	0.297	0.02	S
Fouls	23.84	24.00	19.00	27.00	23.08	22.00	18.00	28.00	-0.62	0.535	< 0.01	S
Offsides	3.78	4.00	2.00	5.00	3.73	3.00	2.00	5.00	-0.74	0.459	0.01	S

Note. *: $p < 0.05$

further present the variability quantitatively, effect sizes (ES) were estimated using the η^2 statistic with the following formula:

$$\eta^2 = Z^2/(N-1)$$

where Z means the standardized test statistic of the Mann-Whitney U test and N means the number of samples. Thresholds for ES were defined as follows: small effect (0.01), medium effect (0.06), and large effect (0.14) [28].

Results

Table 1 shows the results of the descriptive statistics and the Mann-Whitney U test for the performance variables of the UEFA European Championship games in the seasons without VAR (EURO 2016) and with VAR (EURO 2020). After the introduction of VAR, there was a significant increase in second half time (Z = 2.80, $p = 0.005$, ES = 0.16, large effect), total time (Z = 3.74, $p < 0.001$, ES = 0.28, large effect); meanwhile, there was a considerable increase in first half time (Z = 2.52, $p = 0.012$, ES = 0.13, medium effect), number of goals (Z = 2.25, $p = 0.024$, ES = 0.10, medium effect); while the number of yellow cards (Z=-2.55, $p = 0.011$, ES = 0.13, medium effect) decreased appropriately.

Figure 1 illustrates the estimated marginal means (95% CI) pre and post the introduction of VAR in the UEFA European Championship, indicating that there is an increase in the length of the game (first half, second half, full time) and the number of goals, while there is a decrease in the number of yellow cards. It is worth mentioning that 0 corresponds to EURO 2016 without the use of VAR, 1 corresponds to EURO 2020 with the use of VAR.

Discussion

Video Assistant Referee was introduced to reduce the possibility of unfair and controversial decisions by officials, thereby promoting the fairness of football matches. EURO 2020 is a landmark since VAR technology was first applied in this tournament. Our research results are the first indication through statistical evidence of what impact VAR has had on the UEFA European Championship. This research demonstrates two main findings: (i) with the introduction of VAR, the playing time (first half time, second half time and full time) and the number of goals has significantly increased; and (ii) meanwhile, the number of yellow cards decreased significantly.

With the application of VAR, the duration of first-half, second-half, and full game time increased. These findings are consistent with the results found in other international football competitions (Men's and Women's FIFA World Cup) and domestic professional football leagues [13, 18, 23, 24, 26, 28]. There has been some criticism that VAR's frequent interventions would lead to excessive growth in the match time, causing the match to become lengthy and less enjoyable to watch [18, 24, 29, 30]. However, the findings of our research show that, in the UEFA European Championship, the added time caused by VAR is not too lengthy. The statistical evidence indicates that the first-half game time only increased by 0.8 min (46.69 min. without VAR vs. 47.49 min. with VAR), the second-half game time only added about 0.7 min (49.37 min. without VAR vs. 50.04 min. with VAR), and the full game time also only extended around 1.5 min (96.06 min. without VAR vs. 97.53 min. with VAR). In short, our findings show that VAR does increase the game time, but not greatly.

Another finding revealed that the introduction of VAR led to a significant reduction in the number of yellow cards. This finding is consistent with the results reported by Işın and Yi [31]. It is well known that VAR has a limited scope of intervention, which does not examine yellow card incidents. However, VAR's monitoring throughout the game may make players highly cautious, especially when attempting some foul play. Such cautiousness in the way players approach the game might be the main reason for the reduction in the number of yellow cards [26]. In addition, it is worth mentioning that, in such an important tournament as the UEFA European Championship, the player always tends to be more cautious about their behavior to minimize the likelihood of being shown a yellow card. This potential impact of VAR on player's behavior reflects its wider influence beyond decision-making [32]. From the perspective of psychology, VAR potentially has some complicated effects on the players' mental activities, thus affecting the dynamics of the match.

In addition, after the introduction of VAR, the number of goals significantly increased, which is different from other previous research reported that there was no significant change in the number of goals. For such a finding that has never been reported before, there are three possible explanations. First, from the perspective of officiating, the goals that might be missed due to the referee's visual limitation, misjudgments, or the flash-lag effect are corrected by VAR intervention to be valid, thus increasing the number of goals. Second, the relatively small sample size of this study (as only 51 matches are played in each UEFA European Championship) may also lead to different results from other studies (with a larger sample size). Third, as EURO 2020 was held during the COVID-19 pandemic, UEFA's Executive Committee has revised the substitution rule to reduce the players' physical burden and protect their health. According to the temporary amendment introduced to Law 3 of the IFAB Laws of the Game, teams will be allowed to use a maximum of five substitutes at EURO 2020 [33]. The increased number

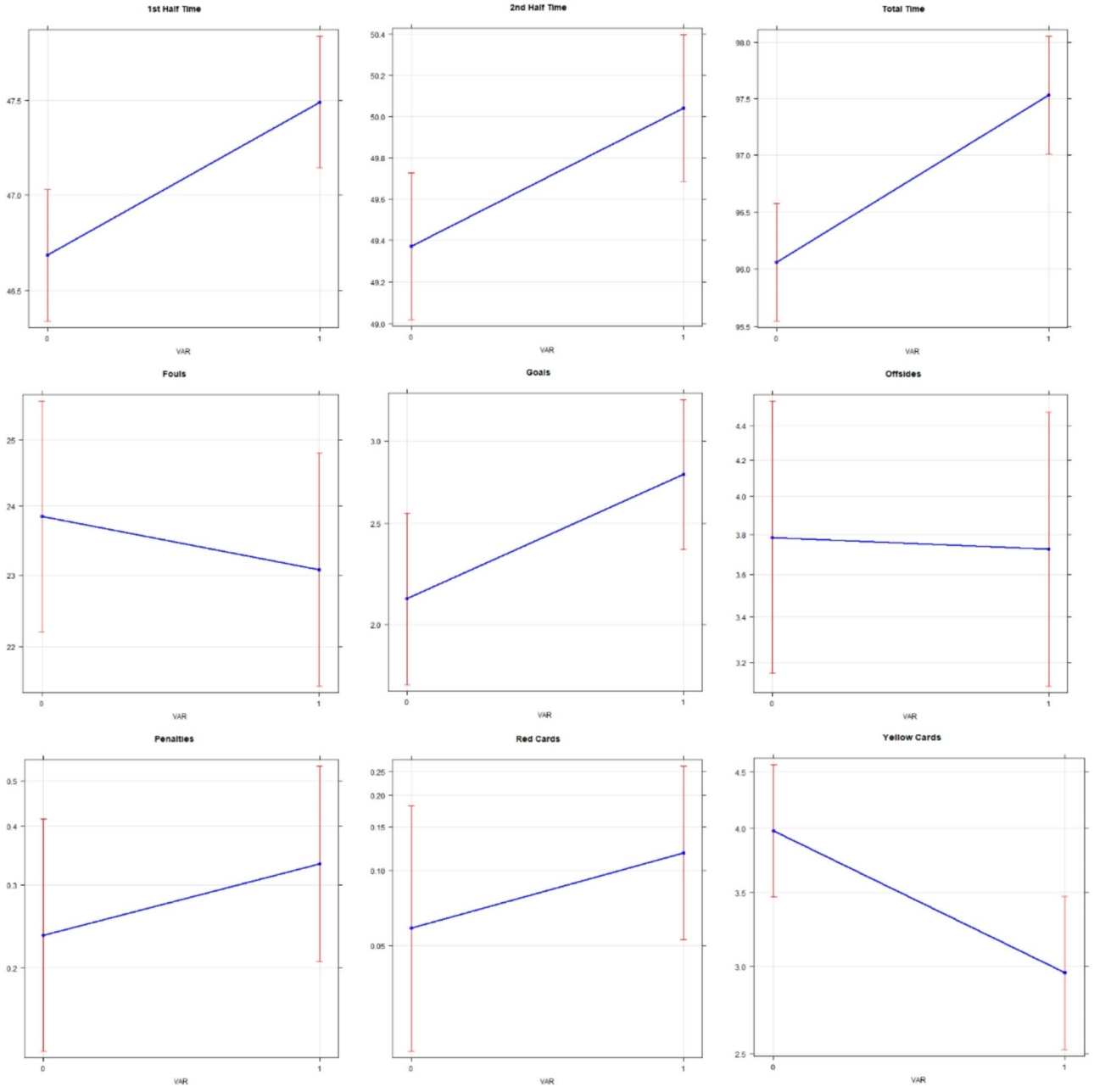

Fig. 1 Changes in match performance variables before and after the introduction of VAR

of substitutions could help the team maintain a higher level of fitness and performance, as well as allowing for more tactical options. Under the monitoring of VAR, this might contribute to an increase in the team's scoring opportunities. Notably, this phenomenon is less related to the present study. However, since EURO 2020 was held during a special period (the COVID-19 pandemic), it needs to be considered and mentioned.

In terms of the limitations of this study, some highlights should be presented. The argument arising in some studies is that VAR has ruined the passion for football [29, 34]. Hence, the perceptions of supporters, coaches, players, and referees regarding VAR technology should be included in future studies. Moreover, the stage of the competition (group stage and knock-out stage) could also be considered in future research, as the knock-out stage tends to be more important than the group stage. Carlos et al. [26] also mentioned this in their study. In addition, future investigations could be conducted with multiple UEFA European Championships before and after the introduction of VAR. A study with a larger sample size would not only validate the results of the present

research, but also increase the statistical reliability. Last, it is worth mentioning that the lack of investigation of the changes in the effective playing time (net playing time) after the introduction of VAR is the most critical limitation of this study. As in football matches, the effective playing time is far more important than total match duration. If the effective playing time is reduced with the use of VAR, footballers and supporters may endure longer interruptions without additional gameplay action, leading to unnecessary fatigue and frustration without improving the flow of the match. Hence, the investigation of effective playing time should be considered in future studies to explore the deeper effects of VAR on playing time.

Regarding the practical applications, the findings of this research might help professionals better inform the multifaceted influence of VAR on elite football competitions, especially top national team competitions like the UEFA European Championship. Further, this study may also inspire professionals on how to optimize VAR-related officiating and coaching strategies. In addition, hopefully, this study might help some anti-VAR fans change their views about VAR technology.

Conclusion

This study was conducted to explore the impact of VAR on the UEFA European Championship by comparing the changes in VAR-related match variables before and after the introduction of VAR. There are two main findings. First, the introduction of VAR significantly increased the game time (first-half game time, second-half game time and full game time) and the number of goals scored. Second, following the application of VAR, significantly fewer yellow cards were shown. Significant changes in the match indicators were observed, but not excessive. Therefore, it is concluded that the introduction of VAR did not have excessive influence on the UEFA European Championship. Additional studies are still needed to explore the impact of VAR on elite football matches in the future as well. It is believed that with the development of technology, awareness and the optimization of officiating regulations, current drawbacks of VAR (e.g. VAR disrupts the pace and flow of the game, prolonged interventions, etc.) will be addressed in the future. VAR shall be an essential part of the football game, making it fairer and more exciting.

Abbreviations

VAR Video Assistant Referee

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Author contributions

Rui Bao: Conceptualization, Data curation, Data analysis, Methodology, Writing–original draft, Writing–review & editing. Miguel Ángel Gómez Ruano: Conceptualization, Methodology, Writing– review & editing. Ruixia Shi: Data curation, Data analysis. Xinpu Wang: Supervision, Writing– review & editing. Bo Han: Supervision, Writing– review & editing. All authors reviewed the manuscript.

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Data availability

All data were extracted from: https://www.uefa.com/.

Declarations

Ethics approval and consent to participate

No ethics approval and consent to participate was needed in this study.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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