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The impact of video assistant referee (VAR) on match performance variables at men's FIFA World Cup tournaments

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Abstract

This study explored how the video assistant referee (VAR) has influenced match performance variables at Fédération Internationale de Football Association (FIFA) World Cup tournaments. Comparative analysis was undertaken of matches played during the FIFA 2018 World Cup ($n = 64$) tournament, where VAR was employed, and those played during the 2014 World Cup ($n = 64$) tournament, where VAR was not employed. The following performance variables were recorded and analysed for each of the matches played: goals, penalties, corner kicks, yellow cards, red cards, offsides, playing time during the first half, playing time during the second half and total playing time. After the introduction of VAR, there were significant ($p < 0.05$) increases in the number of penalties, as well as playing time during the first half, second half and total playing time. In contrast, a significant ($p < 0.05$) decline was observed in the number of offsides after VAR was implemented. The current findings have practical implications for improvement of VAR implementation guidelines at FIFA World Cup competitions.

Keywords

Video technology, referee, football, match, decision-making

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Introduction

Technical officials play an integral role in sporting competitions, and the importance of this role is highlighted by the potential impact that correct or incorrect decisions can have on a game's outcome.[1] As such, decision-making is commonly cited as the most important overall skill for effective officiating.[2,3] Football referees are required to make quick and accurate decisions during a match, taking into account various sources of information.[4–6] Researchers have identified that referees' decision-making may be influenced by various factors, which include, but are not limited to, external game factors, such as crowd noise,[7,8] match status and match location,[9,10] as well as within-game pressure from players and coaches.[11–13]

From an in-game perspective, there are many characteristics and constraints of decision-making for referees. Researchers have indicated that referees' decisions are often made spontaneously under strict time and information constraints[14]; require deep prior knowledge and efficiency in appraising and processing perceptual information[15]; and involve a high degree of mental and physical fatigue.[16,17] Studies demonstrate that contextual factors, such as position and time, can influence the decision-making of referees.[18,19] Due to the dynamic nature of football, during certain passages of play, the referee's line of vision may be obscured by players,[20] which can affect the quality of decisions made. As the referee may not see all critical perceptual cues to inform their decisions, errors of judgement can occur.[6] For example, researchers have found that when referees were either too close or too far away from a match event, there was an increased risk of missing important visual information, potentially leading to an incorrect decision.[21,22] Therefore, being in the appropriate position to ensure an adequate field of view is an important consideration when making game-based

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infringement based decisions.[23] Further, a referee's decision-making performance is under constant scrutiny from the media and supporters, with each decision potentially having a considerable impact on the outcome of the game[5,6]; in high-performance environments, refereeing decisions can have significant financial implications for a club (e.g. team revenue, sponsorship, player recruitment, promotion and relegation).[1,24]

In 2018, in an effort to reduce the likelihood of referee decision-making errors, the Fédération Internationale de Football Association (FIFA) undertook a technological innovation in which a video assistant referee (VAR) protocol was incorporated into the Laws of the Game.[25–27] According to the laws of football, VAR is only used to review four match-changing situations: direct red card incidents; penalty decisions and offences leading up to a penalty; goals and offences leading up to a goal (i.e. offside, handball); mistaken identity.[28,29] According to the VAR protocol, the review assistant reviews all video streams and replays of these game-changing scenarios. If a VAR check identifies a clear and evident mistake on the part of the referee or an assistant referee, the review assistant then communicates the error to the on-field referee to allow them to review their original decision, which they may overturn.[6] From a practical perspective, decisions based on objective judgement involving offside incidents prior to a goal being scored can be changed solely by the VAR review – a process called a VAR-only review. In the case of subjective decisions, such as violent conduct leading to a red card, the video-assistant referee communicates with the on-field referee to review the footage directly on a monitor near the pitch prior to making a final decision on the incident (on-field review).[6]

VAR has been used in many domestic and international football competitions.[29] In the 2018 World Cup, 95.60% of refereeing decisions were correct without VAR, and 99.35% were correct with VAR.[30] Further, analysis of 13 national leagues (i.e. Australia, Belgium, China, Czech Republic, England, France, Germany, Italy, Netherlands, Poland, Portugal, South Korea and USA) demonstrated that the use of VAR improved decision accuracy from 92.1% to 98.3%.[6] Therefore, based on the evidence, the VAR system improves the accuracy of decisions for situations requiring temporal (exact moment) and spatial (the position of the ball relative to the player) precision.[6] From a match performance perspective, Lago-Peñas et al.[27] found that the introduction of VAR in the Italian Serie A and the German Bundesliga reduced the number of fouls, offsides and yellow cards. In addition, following the introduction of VAR to the Chinese Super League, Han et al.[29] reported that the number of fouls and offsides declined considerably; in contrast, playing time in both halves of the match increased significantly. The total playing time in the Spanish La Liga increased in games with a VAR review.[25] While these studies provide evidence to support the effectiveness of VAR for use in domestic competitions, a limitation of the current literature is the lack of understanding of how VAR may impact international competitions, especially the FIFA World Cup. This is an important consideration, as researchers have indicated that style of play and match performance indicators vary depending on the level of competition.[31,32] Therefore, it may be possible that the use and implementation of VAR varies between domestic and international competitions. Further, researchers have recommended that additional investigation is required to understand the impact of VAR on match performance indicators.[25]

Although several studies have analysed the influence of VAR on football matches in domestic leagues,[25,27,29] no previous study has examined the impact of its implementation on match performance indicators at international competitions, such as the FIFA World Cup. Therefore, the aim of this study was to investigate how the introduction of the VAR system at the 2018 FIFA World Cup influenced the match performance indicators in comparison to the previous tournament where VAR was not employed (i.e. 2014 FIFA World Cup tournament).

Methods

Match sample

Data included all 128 matches played during the 2014 and 2018 FIFA World Cup tournaments. Sixty-four matches played without VAR at the 2014 FIFA World Cup and 64 matches played with VAR at the 2018 FIFA World Cup were analysed and compared.

Selected performance variables and data collection

Consistent with previous studies,[25,27,29] analysis was conducted to examine match performance variables closely linked to refereeing decisions: goals, penalties, corner kicks, yellow cards, red cards, offsides, playing time during the first half, playing time during the second half and total playing time. Data were obtained from the database of InStat, a sports performance analysis company based in Moscow, Russia. The inter-observer reliability of InStat football match data has been reported to be within acceptable limits.[33] This study received ethical approval from the institutional research ethics committee.

Data analysis

Data were reported as mean (M) and standard deviation (SD). The Kolmogorov–Smirnov test was conducted and indicated that all match performance indicators were non-normal distributed ($p < 0.05$). The Mann–Whitney U test was used to compare differences between the selected match performance variables with and without VAR. Further, a generalised linear

Table 1. Match performance indicators before and after the introduction of VAR at 2014 and 2018 FIFA World Cup competitions.

Variables	VAR (2018)		No VAR (2014)		*Z*	*p*-Value	Cohen's *d*
	M	SD	*M*	SD			
Goals	1.32	1.16	1.32	1.23	−0.26	0.796	0.00
Penalties	0.23	0.46	0.10	0.30	−2.44	0.015*	0.33
Corner kicks	4.70	2.43	5.20	2.91	−0.96	0.339	0.19
Yellow cards	1.71	1.31	1.41	0.96	−1.60	0.111	0.26
Red cards	0.03	0.17	0.08	0.27	−1.65	0.100	0.22
Fouls	13.52	4.62	14.53	5.10	−1.51	0.131	0.21
Offsides	1.31	1.15	2.20	2.19	−3.31	0.001*	0.51
Playing time first half	48.89	2.12	47.97	1.54	−4.58	0.000*	0.50
Playing time second half	51.58	1.57	49.92	1.17	−8.80	0.000*	1.20
Total playing time	100.47	2.83	97.89	2.08	−8.16	0.000*	1.04

M: mean; SD: standard deviation.
*Significant at $p < 0.05$.

Table 2. Generalised linear model for each match performance indicator.

Variables	Estimate	95% CI		*p*-Value	BIC
		Lower	Upper		
Goals	0.000	−0.052	0.052	1.000	388.24
Penalties	−0.205	−0.359	0.050	0.010	381.61
Corner kicks	0.017	−0.006	0.040	0.140	386.08
Yellow cards	−0.056	−0.108	−0.003	0.038	383.97
Red cards	0.227	−0.041	0.495	0.097	385.51
Fouls	0.011	−0.002	0.023	0.094	383.97
Offsides	0.068	0.035	0.101	0.001	372.40
Playing time first half	−0.064	−0.095	−0.032	0.001	372.85
Playing time second half	−0.160	−0.193	−0.128	0.001	308.86
Total playing time	−0.083	−0.102	−0.063	0.001	326.52

BIC: Bayesian information criterion; CI: confidence interval.

model was fitted for each match performance variable and the goodness of fit was undertaken using the Bayesian information criterion (BIC), together with the 95% confidence interval (CI). A significance level was set at 0.05 or less. Effect sizes were categorised and interpreted as small ($d = 0.20$), medium ($d = 0.50$) and large ($d = 0.80$).[34] Statistical data were entered into a Microsoft Office Excel spreadsheet (Microsoft Corporation, Washington, USA) and analysed using the Statistical Package for the Social Sciences version 25.0 (SPSS Inc., Illinois, USA).

Results

Table 1 shows descriptive statistics of performance indicators at World Cup competitions with and without VAR. There were significant ($p < 0.05$) increases in the number of penalties ($M = 0.23$, SD = 0.46, $Z = -2.44$, $d = 0.33$, small effect), playing time during the first half ($M = 48.89$, SD = 2.12, $Z = -4.58$, $d = 0.50$, moderate effect), playing time during the second half ($M = 51.58$, SD = 1.57, $Z = -8.80$, $d = 1.20$, large effect) and total playing time ($M = 100.47$, SD = 2.83, $Z = -8.16$, $d = 1.04$, large effect) after the implementation of VAR. A significant decrease ($p < 0.05$) was observed in the number of offsides ($M = 1.31$, SD = 1.15, $Z = -3.31$, $d = 0.51$, moderate effect) after VAR was introduced. Furthermore, after the implementation of VAR, there was a decrease, although not significant, in the number of corner kicks, red cards and fouls.

Table 2 presents the findings of the generalised linear model for each match performance indicator. The results highlighted that the introduction of VAR had a significant impact on penalties ($p = 0.010$), yellow cards ($p = 0.038$) and offsides ($p = 0.001$), as well as increases in playing time during the first half ($p = 0.001$), second half ($p = 0.001$) and full game ($p = 0.001$).

Discussion

The aim of this study was to investigate how the implementation of the VAR system has changed the game in FIFA World Cup tournaments. The findings showed significant increases in penalties and playing time at the 2018 World Cup compared to the 2014 World Cup. There was also a significant decrease in the number of

offsides after VAR was introduced. The findings show that implementation of VAR positively influenced match performance indicators at the 2018 World Cup.

More penalties were awarded by referees at the 2018 FIFA World Cup ($n = 29$) as compared to the 2014 tournament ($n = 13$). This finding supports that of Han et al.,[29] which demonstrated that the number of penalties awarded by officials increased after the introduction of VAR. For example, at the 2018 FIFA World Cup, nine penalties which were not originally given during the game were awarded following a VAR review, and three penalties were rescinded.[30] The current observation demonstrates that the implementation of VAR contributed to referees giving more penalties, as it helped them to scrutinise fouls during video slow-motion playback that were missed due to the fast pace of the game.

Previous research has found that 26.1% of assistant referees' offside decisions were incorrect at the 2002 World Cup, and 10.0% were incorrect at the 2006 World Cup.[24] It has also been reported that the errors were likely the result of perceptual flash-lag effects, rather than optical effects resulting from incorrect positioning of assistant referees at the exact moment when a decision needed to be made.[35] Video-replay technology can be instrumental in correcting these limitations.[27] The present findings indicated a significant decrease, with moderate effect, in the number of offsides committed after the VAR system was introduced. A possible explanation for this finding could be that assistant referees were advised not to raise their flags for tight or uncertain offside decisions during the 2018 World Cup, as this would allow play to continue, and VAR could review the situation and overturn a goal if there was an offside leading up to it.

After VAR's implementation, there were significant increases in the playing time in both halves of the game, and thus for the entire game. There was a large effect size regarding results for the second half and total playing time, thereby demonstrating that the introduction of VAR had considerable impact on the duration of matches. The increase in playing time is mainly attributed to interruptions in matches caused by VAR checks, as referees are often required to watch video replays and communicate with the virtual assistant referee, thereby temporarily delaying the final decision.[29] Consequently, this process may disrupt the flow of the game, undermining players' momentum and zeal.[36,37]

A non-significant reduction in red cards and fouls was observed after VAR was introduced. This result corroborates that of Lago-Peñas et al.,[27] who reported that the introduction of VAR contributed to referees awarding fewer free kicks and showing fewer red cards in the Italian Serie A and German Bundesliga. This decrease may be attributed to the fact that in these competitions, the VAR system tracked the entire stadium with at least 12 cameras, so that each player's movements were closely monitored and could be clearly shown on the video monitor, thus deterring players from committing malicious fouls.[29,38] Therefore, players may have had to be more cautious with their aggressive behaviour related to tackles, fouls and unnecessary dissent against referees' decisions.[27]

Conclusion

This study explored the impact of the VAR system on match performance indicators at the FIFA World Cup. The findings highlighted significant increases in the number of penalties and for the playing time in the first half and second half, as well as the total playing time. Further, there was a significant reduction in the number of offsides after the implementation of the VAR system. Although VAR enhances referees' decision-making, the increase in playing time is of great concern, as it often disrupts the flow of the game and breaks players' momentum. Through improvement of the VAR rules, there is potential for the reviews to become quicker and more precise, which can help to maintain the flow of the game, while also ensuring correct and fair adjudication.

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