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How does Video Assistant Referee (VAR) modify the game in elite soccer?

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ABSTRACT

The aim of this study was to examine how the introduction of the VAR system influenced the play in elite soccer. The sample consists of 1024 matches played in the Italian Serie A and the German Bundesliga league during the seasons before and after the implementation of the VAR system. The following variables were recorded for each match: Fouls, Goals, Offsides, Penalties, Playing time in the first half, Playing time in the second half, Total Playing time, Red cards and Yellow cards. Match statistics were retrieved from the website of “Whoscored” (www.whoscored.com). A generalized linear model and a pairwise z-tests were used to compare seasons before and after the implementation of the VAR. There was a decrease in the number of offsides, fouls and yellow cards after the implementation of the VAR. Meanwhile, there was an increase in the number of minutes added to the playing time in the first half and the full game, but not in the second half. These findings may help coaches, players and managers to better understand the effects of the VAR system on professional soccer and to identify strategies to improve refereeing during matches.

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1. Introduction

Soccer referees’ decision-making process is a difficult task that implies to make correct judgements -according to the soccer rule book- on fast gameplay situations with several players and possibly limited visibility (Lex, Pizzera, Kurtes, & Schack, 2015).

To compensate the limits of referees’ perception, which may cause judgement errors and bias, different technological officiating aids have progressively been introduced in several sports (Kolbinger & Lames, 2017; Kolbinger & Link, 2016; Oudejans et al., 2002).

These devices can be broadly classified into 3 groups: those that support referees in decision making, devices that replace referees’ decisions, and devices that help referees to enforce the rules of a particular sport (Kolbinger & Lames, 2017). The Video Assistant Referee (VAR) can be classified into the first category.

VAR was introduced into the Laws of the Game (Fédération Internationale de Football Association, 2019) in 2018 to help referees in reviewing decisions made by the head referee by means of video footage only for three main situations (goals, penalty, red card incidents) and one administrative incident (mistaken identity). Once

the video footage is reviewed by the VAR, the head referee is advised via headset about what the video shows, and the appropriate decision or action is taken accordingly. Although VAR was tested for the first time during the 2012–13 season in the Eredivisie (Netherlands soccer first division), the system was fully adopted for top domestic European soccer leagues like Bundesliga (German first division) and the Serie A (Italian first division) until the beginning of the 2017–18 season.

Different video replay technology tools (Dyer, 2015) have been used previously with controversial results in several sports such as golf, rugby, American Football, or ice hockey. The main criticism of real-time video-replay devices like VAR is the possible disruption to the flow and pace of the game due to the stopping and starting, which might be especially disruptive in matches played in cool weather (Dyer, 2015; Svantesson, 2014).

Several studies have shown that referees' decisions can be influenced by several factors such as crowd noise, social pressure, match status or the strength of the teams (Boyko, Boyko, & Boyko, 2007; Dohmen, 2008; Garicano, Palacios-Huerta, & Prendergast, 2005; Riedl, Strauss, Heuer, & Rubner, 2015; Sutter & Kocher, 2004; Unkelbach & Memmert, 2010). For example, referees viewing videotaped potential fouls with crowd noise called significantly fewer fouls (15.5%) for the away team than those presented with only the video (Nevill, Balmer, & Williams, 2002). The so-called ± 1 bias, or extra time bias, of soccer referees has been extensively examined (Riedl et al., 2015). Garicano et al. (2005) showed that referees added significantly more extra time after the second half when the home team was behind by one goal than when it was ahead by one goal. Recently, it has been suggested that referees could be biased in favouring higher ranked teams in close games (Lago-Peñas & Gómez-López, 2016).

During international matches, referees need to take more than 130 observable decisions (Helsen, Gilis, & Weston, 2006). As a result, incorrect judgements made by the officials during matches are relatively frequent and can have a direct impact on the final result. Consequently, these judgements can have significant financial implications for clubs, managers, and players (Helsen et al., 2006; Kolbinger & Lames, 2017). Thus, technological officiating aids like VAR should play an important role in enhancing the quality of the refereeing.

To the best of our knowledge, no previous evaluation research was done for the use of VAR in soccer yet; thus the aim of this study was to examine how the introduction of the VAR system influenced the play in elite soccer. We hypothesized that (i) there is an increase in the number of minutes added to the playing time in the first and the second half and the number of red and yellow cards in matches with the VAR system; (ii) however, there are no differences in the number of Fouls, Goals, Offsides or Penalties.

2. Materials and methods

2.1. Participants

The sample consists of 1024 matches played in the Italian Serie A (544 matches, 272 without VAR and 272 with VAR) and the German Bundesliga league (480 matches, 240 with VAR and 240 without VAR) during the 2016/17 and 2017/18 seasons. The Video Assistant Referee (VAR) system was introduced in top European leagues by Bundesliga

and Serie A at the start of the 2017/18 season. Consequently, the seasons before and after the implementation of the VAR system were analyzed.

2.2. Procedures

The following variables were recorded for each match: Fouls, Goals, Offsides, Penalties, Playing time in the first half, Playing time in the second half, Total Playing time, Red cards and Yellow cards. Match statistics were retrieved from the website of “Whoscored” (www.whoscored.com). The inter-operator reliability of the company’s observational system (OPTA Client System) used to collect football match statistics was identified as reliable reaching an acceptable level of Kappa, ICC, r and SEM values (Liu, Hopkins, Gómez, & Sampedro, 2013). Ethics committee approval of the current study was gained from the local University.

2.3. Statistics

All statistical analyses were performed in R 3.5.2. Statistical significance was set at $p < 0.05$. Descriptive statistics for each variable in seasons without and with VAR are presented as mean and standard deviation, both in total and by league. As all outcome variables were count data, the variables were expected to follow either poisson or negative binomial distributions. A generalized linear model with a poisson distribution was initially fitted for each variable and tested for overdispersion (Cameron, & Trivedi, 1990). The test showed offsides, fouls and playing time in the first half to be overdispersed. They were therefore refitted using negative binomial distributions. A zero-inflated model was fitted to each variable using the corresponding distribution and compared to the original models using Akaike’s Information Criterion to test for zero inflation. Yellow cards, total playing time and playing time in the second half were better modeled using a poisson zero-inflated model. To test for differences between seasons before and after the implementation of the VAR, a generalized linear model was fitted for each outcome variable with the corresponding distribution. Pairwise z-tests were then used to compare seasons before and after the implementation of the VAR, both overall and separate for both leagues. Estimated marginal means before and after the implementation of VAR, together with 95% confidence intervals (CI) are presented graphically. Pairwise z-tests are presented together with the estimated change and 95% CI.

3. Results

Descriptive statistics of all variables in seasons without and with VAR are presented in Table 1, both in total and by league.

As can be seen in Table 2, there was a significant decrease in the number of offsides, fouls and yellow cards after the implementation of the VAR. Meanwhile, there was an increase in the number of minutes added to the playing time in the first half and the full game, but not in the second half.

Table 1. Descriptive statistics.

| Variable | Total | | | | Bundesliga | | | | Serie A | | | |
|-----------------------|--------|------|-------|------|------------|------|-------|------|---------|------|-------|------|
| | No VAR | | VAR | | No VAR | | VAR | | No VAR | | VAR | |
| | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| Fouls | 27.5 | 6.18 | 26.3 | 6.65 | 27.9 | 5.96 | 27.6 | 6.60 | 27.2 | 6.36 | 25.1 | 6.48 |
| Goals | 2.96 | 1.80 | 2.74 | 1.66 | 2.91 | 1.81 | 2.88 | 1.68 | 3.00 | 1.79 | 2.62 | 1.64 |
| Offsides | 4.59 | 2.41 | 4.19 | 2.46 | 4.74 | 2.54 | 4.09 | 2.44 | 4.45 | 2.28 | 4.28 | 2.47 |
| Penalties | 0.34 | 0.57 | 0.31 | 0.55 | 0.30 | 0.52 | 0.33 | 0.58 | 0.38 | 0.61 | 0.29 | 0.53 |
| Playing Time 1st half | 45.99 | 1.04 | 46.17 | 1.32 | 45.77 | 0.91 | 46.04 | 1.30 | 46.19 | 1.11 | 46.29 | 1.33 |
| Playing Time 2nd half | 48.21 | 1.56 | 48.32 | 1.71 | 47.65 | 1.52 | 47.84 | 1.63 | 48.71 | 1.42 | 48.75 | 1.67 |
| Total Playing Time | 94.20 | 2.03 | 94.51 | 2.18 | 93.40 | 1.93 | 93.88 | 2.14 | 94.90 | 1.86 | 95.07 | 2.06 |
| Red Cards | 0.20 | 0.47 | 0.18 | 0.43 | 0.15 | 0.40 | 0.15 | 0.38 | 0.24 | 0.52 | 0.21 | 0.46 |
| Yellow Cards | 4.21 | 2.02 | 3.74 | 2.12 | 3.87 | 1.96 | 3.40 | 2.11 | 4.50 | 2.03 | 4.03 | 2.09 |

Table 2. Change between seasons without and with VAR.

| Variable | Estimate | 95% CI | | Z-ratio | P-value |
|-----------------------|----------|--------|-------|---------|---------|
| | | Lower | Upper | | |
| Fouls | -1.24 | -2.02 | -0.46 | -3.104 | 0.002 |
| Goals | -0.21 | -0.41 | 0.00 | -1.954 | 0.051 |
| Offsides | -0.41 | -0.71 | -0.11 | -2.711 | 0.007 |
| Penalties | -0.03 | -0.10 | 0.04 | -0.781 | 0.435 |
| Playing Time 1st half | 0.20 | 0.06 | 0.34 | 2.819 | 0.005 |
| Playing Time 2nd half | 0.12 | -0.12 | 0.36 | 0.985 | 0.325 |
| Red Cards | -0.02 | -0.07 | 0.04 | -0.634 | 0.526 |
| Total Playing Time | 0.32 | 0.06 | 0.59 | 2.365 | 0.018 |
| Yellow Cards | -0.47 | -0.72 | -0.22 | -3.644 | 0.000 |

CI = Confidence interval

Figure 1 shows the estimated marginal means (with 95% CI) of the seasons without and with VAR for each of the two leagues respectively. When comparing seasons without and with VAR in each of the league, the number of goals decreased in Serie A, offsides in Bundesliga, fouls in Serie A and yellow cards in both competitions (Table 3). The number of extra minutes added during the first half and for the full game increased in Bundesliga, but not in Serie A.

4. Discussion

Different technological officiating aids have been introduced progressively in soccer. The VAR system is one of them. It was fully adopted for top domestic European soccer leagues at the beginning of the 2017–18 season. However, to the best of our knowledge, no previous evaluation research was run for the use of this technology in soccer. This study provides new information about how the introduction of the VAR system influences the game in elite soccer. Overall, the VAR system does not modify the game in elite soccer. The main findings were that: (i) there was a significant decrease in the number of offsides, fouls and yellow cards after the implementation of the VAR; (ii) there was an increase in number of minutes added to the playing time in the first half and the full game, but not in the second half; (iii) individual differences were found when comparing seasons without and with VAR in the Italian Serie A and the German Bundesliga.

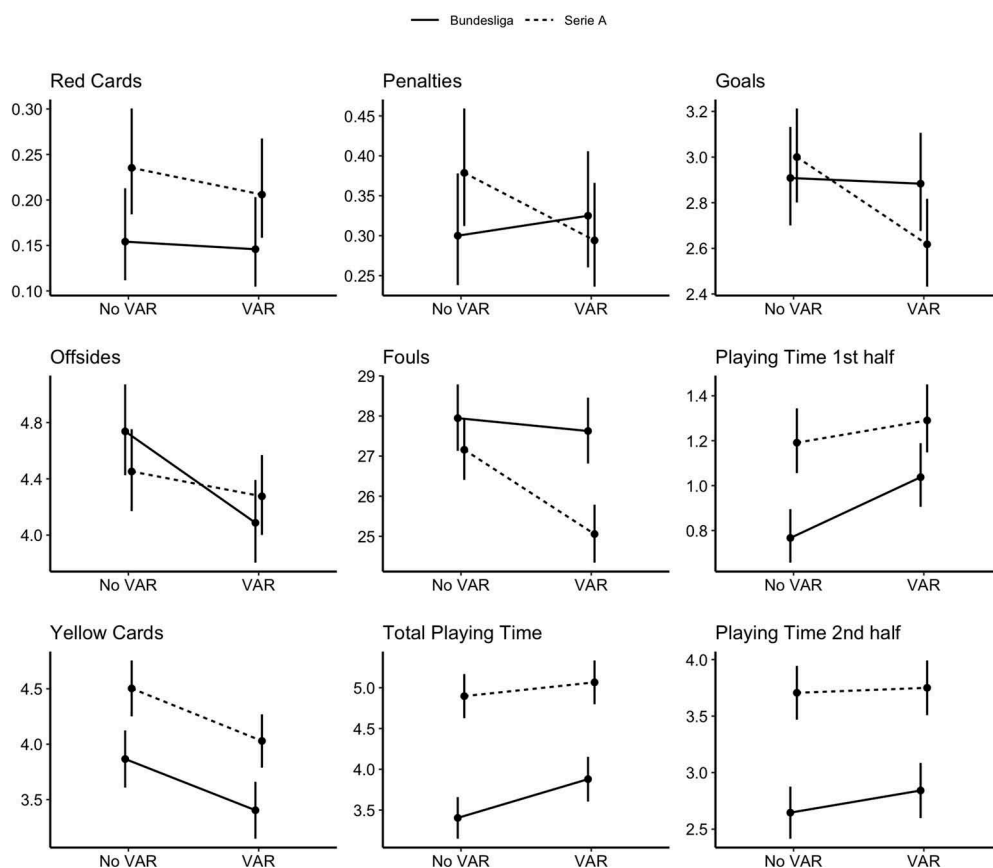


Figure 1. Change between seasons without and with VAR in Bundesliga and Serie A.

Table 3. Change between seasons without and with VAR in Bundesliga and Serie A.

| Variable | Bundesliga | | | | | | Serie A | | | | |
|-----------------------|------------|--------|-------|---------|---------|----------|---------|-------|---------|---------|--|
| | Estimate | 95% CI | | z-ratio | p-value | Estimate | 95% CI | | z-ratio | p-value | |
| | | Lower | Upper | | | | Lower | Upper | | | |
| Fouls | -0.32 | -1.49 | 0.85 | -0.539 | 0.590 | -2.10 | -3.15 | -1.05 | -3.921 | 0.000 | |
| Goals | -0.03 | -0.33 | 0.28 | -0.161 | 0.872 | -0.38 | -0.66 | -0.10 | -2.661 | 0.008 | |
| Offsides | -0.65 | -1.09 | -0.21 | -2.921 | 0.003 | -0.18 | -0.58 | 0.23 | -0.851 | 0.395 | |
| Penalties | 0.02 | -0.08 | 0.13 | 0.490 | 0.624 | -0.08 | -0.18 | 0.01 | -1.700 | 0.089 | |
| Playing Time 1st half | 0.27 | 0.09 | 0.46 | 2.875 | 0.004 | 0.10 | -0.11 | 0.31 | 0.932 | 0.351 | |
| Playing Time 2nd half | 0.20 | -0.14 | 0.53 | 1.143 | 0.253 | 0.04 | -0.30 | 0.38 | 0.255 | 0.799 | |
| Red Cards | -0.01 | -0.08 | 0.06 | -0.236 | 0.814 | -0.03 | -0.11 | 0.05 | -0.730 | 0.465 | |
| Total Playing Time | 0.47 | 0.10 | 0.85 | 2.489 | 0.013 | 0.17 | -0.21 | 0.55 | 0.870 | 0.384 | |
| Yellow Cards | -0.46 | -0.83 | -0.10 | -2.492 | 0.013 | -0.47 | -0.82 | -0.13 | -2.666 | 0.008 | |

CI = Confidence interval

Criticisms of video-replay technology, when used in soccer, is that the stopping and starting of the game to check the video of a contentious moment will disrupt the flow and pace of the game (Nlandu, 2012; Svantesson, 2014). The current results showed that: (i) there is a significant increase in the number of minutes added to the playing

time in the first half and the full game, but (ii) this extra time is very reduced: only 15 seconds in the first half and 20 in the full game. Consequently, it seems that the VAR system does not increase substantially the extra time added by the referees.

After the implementation of the VAR, there was a decrease in the number of fouls and yellow cards. This decrease may be because players are probably less aggressive as a consequence of the technological officiating aids. Given that the VAR system can help referees in reviewing decisions made by the head referee through video footage, players have to be more careful with their behaviors in the game related to fouls, tackles and protests. For example, it has been demonstrated that the use of vanishing spray, that helps referees to enforce the rules of the game, reduces the extent of rule violations (Kolbinger & Link, 2016). However, this decrease is minimal. Future studies should address this association.

According to Kolbinger and Lames (2017) errors in offsides calls may be explained by perceptual limitations. Oudejans et al. (2002) identified that assistant referees are positioned off the offside line for 86.5 % of the detected offside decisions. Therefore, they concluded that the majority of erroneous offside calls are affected by poor positioning. However, Helsen et al. (2006) suggest that the phenomenon that contributes most to those calls is the flash-lag effect, the tendency of the human eye to perceive a moving object ahead of its actual position. Video-Replay technology can be instrumental to correct these limitations. The current results suggest that there is a significant decline in the number of offsides after the implementation of the VAR system. However, additional studies should be done analyzing if the offside calls are right or wrong.

Individual differences were found in the Italian Serie A and the German Bundesliga. For example, the number of extra minutes added during the first half and for the full game increased in Bundesliga, but not in Serie A. The number of goals, fouls A and yellow cards decreased in Serie A while and the number of offsides, yellow cards and the extra time added during the first half and for the full game were influenced by the VAR in Bundesliga. These results may reflect that the culture of the game is diverse, with varying degrees of overlap and distinctiveness. Future studies are needed in order to verify if the effects of the VAR system are generalizable or depend on each country.

Concerning the limitations of the current study, some aspects should be highlighted. Boyko et al. (2007) suggest that different referees provide significantly different levels of home advantage and show that variations in the home bias of subjective officiating are likely responsible. Future studies should include this variable in their explanatory models. Lago-Peñas and Gómez-López (2016) found that referees favor big teams by shortening close games where the big team is ahead and lengthening close games where the big team is behind. Consequently, the strength of the teams should be considered in future studies. Games at the end of the season are generally considered more important than those at the beginning of the year. Garicano et al. (2005) demonstrate that from the beginning to the end of the season, the added time bias increased by almost 40 seconds in -1 relative to $+1$ matches. As a consequence, this variable should be included in future studies. Other leagues' data should be assessed to verify the robustness of these results.

With relation to the practical applications, the findings of the present study highlight the relevance of analysing novel technological officiating aids in soccer. Present findings

may help coaches, players and managers to better understand the effects of the VAR system on professional soccer and to identify strategies to improve refereeing during matches. Overall, the VAR system does not substantially modify the game in elite soccer. The Video Assistant Referee protocol could be revised in order to avoid the possible disruption to the flow and pace of the game due to the stopping and starting and to provide clear information to players, coaches and supporters.

In conclusion, the current study showed that the VAR system does not modify the game in elite soccer. The main findings were that: (i) there was a significant decrease in the number of offsides, fouls and yellow cards after the implementation of the VAR; (ii) there was an increase in number of minutes added to the playing time in the first half and the full game, but not in the second half;

Disclosure statement

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