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# The effects of the Video Assistant Referee system (VAR) on the playing time, technical-tactical and physical performance in elite soccer

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## ABSTRACT

The main purpose of the present study was to assess if the intervention of the Video Assistant Referee (VAR) had effects in the playing time and in the technical-tactical and physical performances of the teams in the Spanish LaLiga during 2018-19 season. A total of 375 matches were grouped according the number of VAR interventions: none (VAR0), one (VAR1) and two or three (VAR2). The variables recorded were: total (TPT) and effective (EPT) playing time, passes, dribbles, crosses, shots, goals, corners, fouls, width, length, height, distance from the goalkeeper to their defence, and total (TD) and above 21 km/h distance covered. The results were: I) there was a slight increase in the TPT in VAR2 compared to VAR1 and VAR0 (99.1 vs. 96.0 vs. 95.1, respectively); II) there was a decrease in the EPT between VAR0 and VAR1 (52.5 vs. 51.5); III) there was an increase in the number of goals (1.2 vs. 1.5 vs. 1.7, in VAR0, VAR1 and VAR2); and, IV) there was a slight decrease in the TD (108,916 vs. 107,916 vs. 106,977, in VAR0, VAR1 and VAR2). In conclusion, the findings of the study suggest that the VAR hardly changes the game in elite soccer.

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Team sport; match analysis; notational analysis; time-motion analysis; video-replay technology

## 1. Introduction

Football referees have the arduous task of making judgements in game situations many times involving rapid movement, a number of players and many other factors which they have to deal with although often restricted by limited visibility (Lex et al., 2015). This has given rise to a deepening interest in examining the factors that condition the referee's job during matches. Some of the constraints studied include: the *flash-lag effect* (the difficulty of perceiving the position of an object when something else is happening at the same time) in the case of mistakes made in offside decisions (Helsen et al., 2006), *supporter noise* relating to favourable decisions for local teams (Nevill et al., 2002) or *player comments* on judgements about the seriousness of a foul (Lex et al., 2015). Other studies

suggest that referees add more extra time in close games when the home teams are behind and less time when they are ahead (Garicano et al., 2005; Lago-Peñas & Gómez-López, 2016).

With the aim of making the referee team's job easier and reducing the probability of error during matches, the Video Assistant Referee (VAR) was introduced into the Laws of the Game in 2018 (Fédération Internationale de Football Association, 2019) to help assess decisions taken by the main referee via video images in three situations: (I) goals, (II) penalties, and (III) red card incidents in which there is confusion identifying the player to be booked. Once the VAR has checked the video recording, the main referee is informed via earphones and he is the one who takes the final decision.

A previous study suggests that the implementation of the VAR has reduced the number of goals, fouls and yellow cards in Italy's *Serie A* (Lago-Peñas et al., 2019). This study also found that the use of the VAR in Germany's *Bundesliga* resulted in a fall in the number of off-sides and yellow cards, whilst provoking a rise in extra time added in the first half and to the match as a whole. To be exact, football matches which had more extra time added at the end appear to provoke a higher conditioning load and limit technical performance in the following matches (Rampinini et al., 2009; Winder et al., 2018). The decrease in footballers' physical performance during matches is substantially enhanced by the presence of extra time, in cases of a draw at the end of the regulatory 90 min in knock out competitions (Lago-Peñas et al., 2015), and by an increase in the length of the match due to a rise in the number of play interruptions throughout the game (Linke et al., 2018). In this sense, the number and duration of stoppages produced in a match due to time wasting, attention to injured players (in some cases due to fatigue) or substitutions, affects both playing time and total time. Therefore, according to the rules, the time spent on player substitution or the number of times players are treated on the pitch carry a stipulated prolongation of match length (e.g., 30 s for each substitution). Therefore, actual playing time is an aspect to take into account, given that it provides more precise information about the interpretation of the physical demands (Castellano et al., 2011) and of the strategic behaviour of the players (Harper et al., 2014). Only taking into account the total duration of the match when quantifying match demands could underestimate the physical performance of the players (Castellano et al., 2011; Wass et al., 2020).

Consequently, it would be interesting to know whether the implementation of the VAR influences game dynamics of teams in the Spanish *LaLiga*. Therefore, the aim of this study was to assess whether the VAR's intervention affects playing time and team performance, both technical-tactical and physical, during the match. The working hypothesis was that playing time and both performances would be affected in matches in which the VAR intervened.

## 2. Methods

### 2.1. Participants

For the elaboration of this study, out of a possible 380 matches played in the Spanish *LaLiga* during 2018–19 season, there were a total of 375 matches analysed. Five matches were excluded due to technical issues. The Video Assistant Referee (VAR) intervened 121

times (once in 86 matches, twice in 13 matches and three times in 3 matches) in 102 matches (27% of the matches played). All the matches were divided into three groups according to the number of VAR interventions: none (VAR0,  $n = 273$ ), one (VAR1,  $n = 86$ ) and two or three (VAR2,  $n = 16$ ).

## 2.2. Variables

Taking into account previous studies (Castellano et al., 2011; Castellano & Casamichana, 2015; Castellano & Echeazarra, 2019; Harper et al., 2014; Lago-Peñas et al., 2019; Rampinini et al., 2009), the following variables were recorded for each match: 1) playing time variables [total playing time (TPT) and effective playing time (EPT)]; 2) technical-tactical performance variables [passes (PASS), dribbles (DRIBBLE), crosses (CROSS), shots (SHOT), goals (GOAL), corners (CORNER), fouls (FOUL), width (WIDTH), length (LENGTH), defence depth (HEIGHT) and distance from the goalkeeper to their defence (GKDEF)]; and, 3) physical performance variables [total distance covered (TD) and total distance covered above 21 km/h (TD21)]. The technical-tactical performance variables were grouped into three dimensions: individual performance, set piece and collective performance. Table 1 shows the dimensions, codes and definitions of these variables. Regarding the physical performance variables, they were evaluated based on the total distance covered by all the players in the team that participated in the match. Goalkeeper activity was also included.

## 2.3. Procedure

Location and motion data were obtained by the computerised multi-camera tracking system TRACAB® (ChyronHego, New York, USA) and events were obtained by OPTA® Sportsdata company (Opta Sports, London, UK), both using Mediacoach® software (Mediapro®, Barcelona, Spain). The reports were generated using Mediacoach®, for the predefined performance indicators. To ensure the reliability of the data collecting

**Table 1.** Codes and definitions of the technical-tactical performance variables for each dimension.

Dimensions	Codes	Definitions
Individual performance	PASS	Total number of passes completed by the team per match.
	DRIBBLE	Total number of attempts to beat an opponent by the team per match.
	CROSS	Total number of crosses made into the penalty box by the team per match.
	SHOT	Total number of shots made by the team per match.
Set piece	GOAL	Total number of goals scored by the team per match.
	CORNER	Total number of corners taken by the team per match.
	FOUL	Total number of fouls received by the team per match.
Collective performance	WIDTH	Mean team width per match, understood as the distance between the two furthest-apart players across the width of the pitch. To calculate this variable, the time in which the ball is out of play is excluded.
	LENGTH	Mean team length per match, understood as the distance between the two furthest-apart players along the length of the pitch. To calculate this variable, the time in which the ball is out of play is excluded.
	HEIGHT	Mean team defence depth per match, understood as the distance between the furthest back defender and the goal he is defending. To calculate this variable, the time in which the ball is out of play is excluded.
	GKDEF	Mean distance from the goalkeeper to their defence per match. To calculate this variable, the time in which the ball is out of play is excluded.

and codification processes of the *OPTA*® Sportsdata company a reliability test was conducted by two experienced analysts, using the Cohen's Kappa test. First, to assess the inter-observer reliability they carried out the codification of a randomly selected match of Spanish *LaLiga* showing a very good data quality ( $k = 0.89$ ), and then four matches were randomly selected, observed and compared with the *OPTA*® reports showing a good data quality ( $k = 0.80$ ) (Altman, 1991). The reliability of the *TRACAB*® video-tracking system has also been recently tested for positioning of the players (Linke et al., 2020) and physical performance (Pons et al., 2019), showing in both dimensions a good quality of the data. The generated reports were exported into *Microsoft Office Excel* (*Microsoft Corporation*, Washington, USA), a matrix was made and later analysed.

## 2.4. Statistical analysis

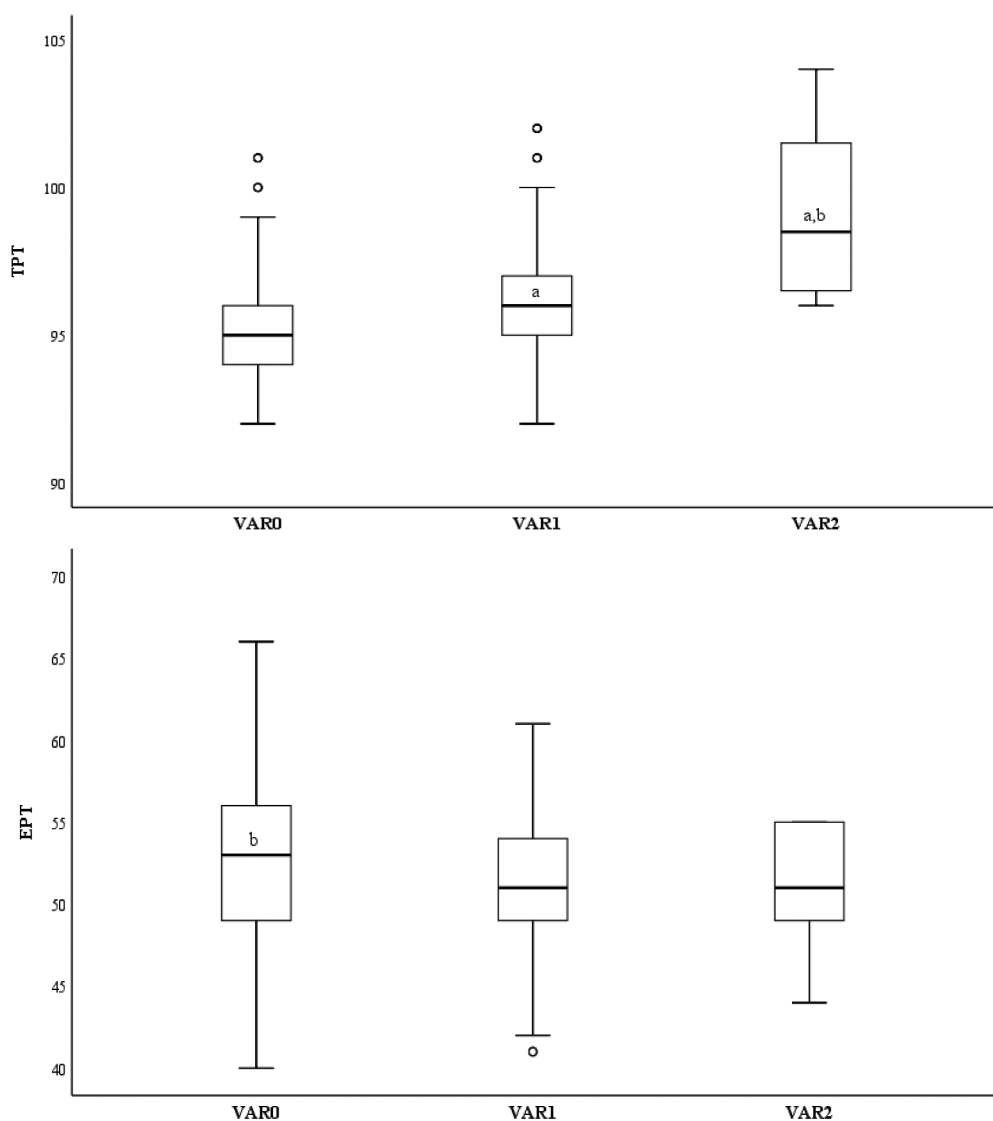
Descriptive statistics data from variables were presented using mean and standard deviation ( $\pm$ sd) with 95% confidence intervals (95% CI). The Levene test was used to assess equality of variances and the Kolmogorov Smirnov test to establish normality. One-way ANOVA analysis of variance for independent samples was used to test for differences in the variables between the three groups (VAR0, VAR1 and VAR2). Significant results were then analysed using post hoc Bonferroni's test, whereas Dunnett's T3 post hoc test was applied when the variances were not homogeneous. The level of significance was set at  $p < 0.05$ . Cohen's d effect size (ES) was also calculated (Cohen, 1988) to determine meaningful differences with magnitudes classified as (Batterham & Hopkins, 2006): trivial ( $<0.2$ ), small ( $>0.2-0.6$ ), moderate ( $>0.6-1.2$ ), large ( $>1.2-2.0$ ) and very large ( $>2.0-4.0$ ). The statistical analysis was conducted using *Microsoft Office Excel* (*Microsoft Corporation*, Washington, USA) and *IBM SPSS v25.0* (*SPSS Inc.*, Illinois, USA) for Windows.

## 3. Results

Figure 1 shows the VAR's influence on playing time variables. As can be seen, there was a slight increase ( $p < 0.05$ ) in the TPT between VAR0 < VAR1 < VAR2 (95.1 vs. 96.0 vs. 99.1 min; ES = 0.5 for VAR0 < VAR1, ES = 1.8 for VAR0 < VAR2 and ES = 1.3 for VAR1 < VAR2) and a significant decrease ( $p < 0.05$ ) in the EPT between VAR0 > VAR1 (52.5 vs. 51.5 min; ES = 0.2 for VAR0 > VAR1).

Tables 2 and 3 show the VAR's influence on individual technical-tactical performance and set piece, and collective technical-tactical performance variables, respectively. As can be seen in Table 2, there was a significant ( $p < 0.05$ ) in the number of goals between the three situations (VAR0 < VAR1 = VAR2), however the differences' magnitude was small (ES = 0.2 for VAR0 < VAR1 and ES = 0.5 for VAR0 < VAR2). No differences were found for the other technical-tactical variables.

Figure 2 shows the VAR's influence on physical performance variables. As can be seen, there was a slight decrease ( $p < 0.05$ ) in the TD between VAR0 > VAR1 = VAR2 (108,916.2 vs. 107,916.2 vs. 106,977.0 m, respectively; ES = 0.2 for VAR0 > VAR1 and ES = 0.4 for VAR0 > VAR2). Nevertheless, no differences were found for TD21.



**Figure 1.** Means, standard deviations ( $\pm$ sd) and 95% confidence intervals (95% CI) of the TPT and EPT for each VAR group. Note: TPT is total playing time, EPT is effective playing time, VAR0 is matched without VAR intervention, VAR1 is matches with one VAR intervention, and VAR2 is matched with two or three VAR interventions. a> VAR0 and b> VAR1 for a significance level of  $p < 0.05$ .

#### 4. Discussion

The aim of this research was to assess whether the VAR's intervention affected playing time and both technical-tactical and physical performance of teams in the Spanish *LaLiga*. The main findings of the study are as follows: I) the VAR intervenes only a few times during a match, with a revision of game action being necessary in scarcely 27% of matches; II) implementation of the VAR has a slight influence on match length and on the technical-tactical and physical team performance.

**Table 2.** Means, standard deviations ( $\pm$ sd) and 95% confidence intervals (95% CI) for each individual technical-tactical performance and set-piece variables according to the VAR group.

Variables	VAR0		VAR1		VAR2	
	Mean ( $\pm$ sd)	95% CI	Mean ( $\pm$ sd)	95% CI	Mean ( $\pm$ sd)	95% CI
PASS	474.4 ( $\pm$ 126.2)	463.8–485.0	467.9 ( $\pm$ 113.2)	450.8–484.9	439.3 ( $\pm$ 112.8)	398.7–480.0
DRIBBLE	17.7 ( $\pm$ 6.4)	17.2–18.3	18.4 ( $\pm$ 6.2)	17.5–19.3	18.1 ( $\pm$ 7.2)	15.5–20.7
CROSS	18.2 ( $\pm$ 8.5)	17.5–19.0	18.8 ( $\pm$ 9.0)	17.5–20.2	18.4 ( $\pm$ 10.1)	14.7–22.0
SHOT	12.0 ( $\pm$ 4.7)	11.6–12.4	12.5 ( $\pm$ 4.9)	11.8–13.2	12.9 ( $\pm$ 6.5)	10.6–15.2
GOAL	1.2 ( $\pm$ 1.1)	1.1–1.3	1.5 ( $\pm$ 1.3) <sup>a</sup>	1.3–1.7	1.7 ( $\pm$ 1.1) <sup>a</sup>	1.3–2.1
CORNER	4.7 ( $\pm$ 2.6)	4.5–5.0	5.0 ( $\pm$ 2.9)	4.6–5.5	5.0 ( $\pm$ 3.7)	3.6–6.3
FOUL	13.5 ( $\pm$ 4.0)	13.2–13.9	13.7 ( $\pm$ 4.1)	13.0–14.3	13.3 ( $\pm$ 3.8)	11.9–14.6

Note: PASS is total number of passes completed, DRIBBLE is total number of attempts to beat an opponent, CROSS is total number of crosses made into the penalty box, SHOT is total number of shots made, GOAL is total number of goals scored, CORNER is total number of corners taken, FOUL is total number of fouls received, VAR0 is matches without VAR intervention, VAR1 is matches with one VAR intervention, and VAR2 is matches with two or three VAR interventions.  
a> VAR0 for a significance level of  $p < 0.05$ .

One of the arguments against the use of the VAR is that the natural flow of a game may be negatively affected by video-technology (Ryall, 2012; Svantesson, 2014). Since a referee team makes approximately 200–250 foul/no foul decisions per game (Helsen & Bultynck, 2004), the VAR protocol is restricted to match-changing incidents. This study shows that the VAR intervened very few times during the championship, only mediating in 27% of matches. This implies, therefore, that in more than 70% of all matches, checks of match-changing incidents do not lead to a revision. Most VAR checks occur in the background, thus having a minimal impact on the course of the game.

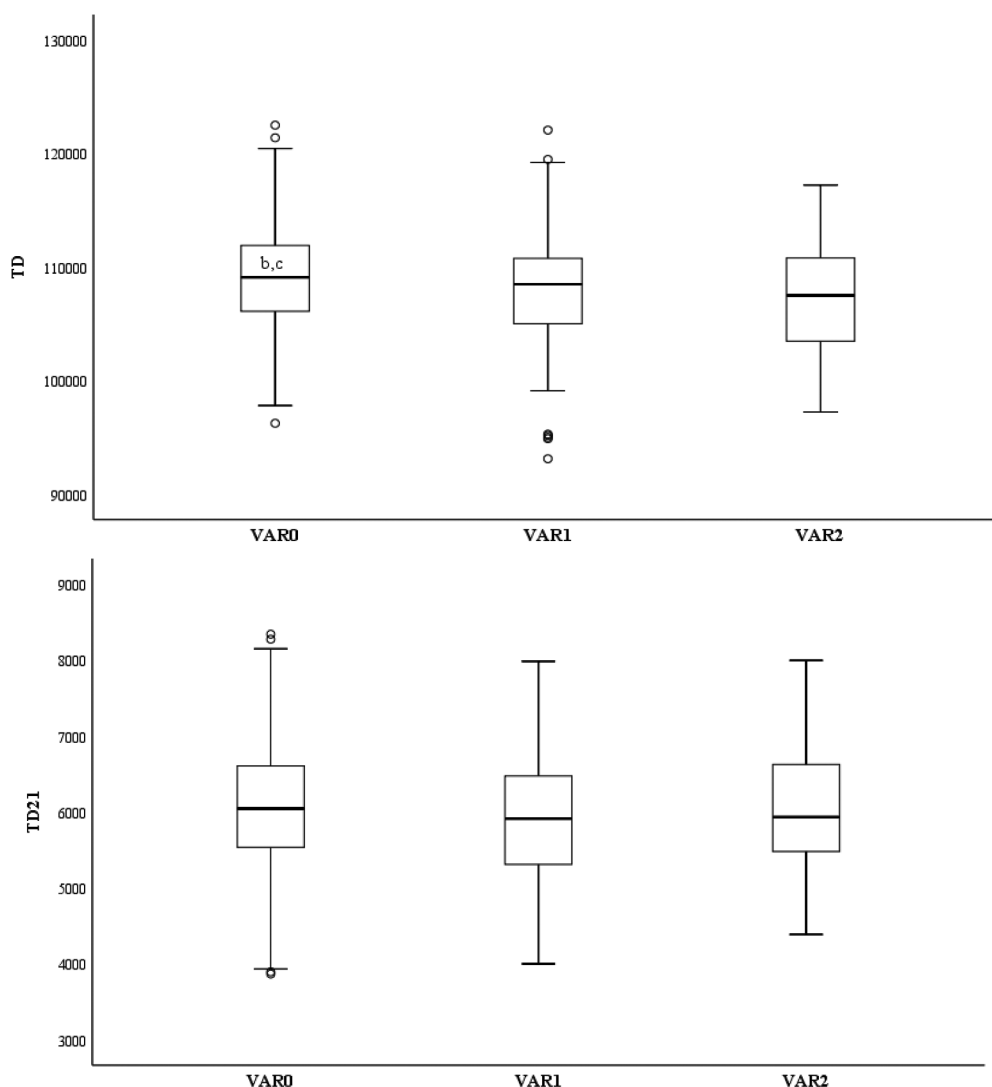
The current results showed that there is a significant increase in the TPT in the full game and a simultaneous decrease in the EPT. These findings are in line with those provided by Lago-Peñas et al. (2019). According to this study, the average duration of the second half and the full game in the Italian *Serie A* and the German *Bundesliga* was 15 and 20 s higher, respectively, after the implementation of the VAR. Consequently our findings suggest that the VAR system does not dramatically affect the duration of the match.

The VAR's intervention during a match had hardly any effect on team play both on a technical-tactical and physical level. TPT increased (VAR1 + 1% and VAR2 + 4%), while EPT decreased (VAR1 and VAR2 decreased by 1% with respect to VAR0) as did the TD (VAR0 > VAR1 = VAR2), and the number of goals increased in relation to VAR0.

**Table 3.** Means, standard deviations ( $\pm$ sd) and 95% confidence intervals (95% CI) for each collective technical-tactical performance variables according to the VAR group.

Variables	VAR0		VAR1		VAR2	
	Mean ( $\pm$ sd)	95% CI	Mean ( $\pm$ sd)	95% CI	Mean ( $\pm$ sd)	95% CI
WIDTH	43.4 ( $\pm$ 2.8)	43.1–43.6	43.4 ( $\pm$ 2.6)	43.0–43.7	44.1 ( $\pm$ 2.4)	43.2–44.9
LENGTH	35.9 ( $\pm$ 1.8)	35.8–36.1	35.9 ( $\pm$ 1.5)	35.7–36.2	36.3 ( $\pm$ 1.6)	35.7–36.8
HEIGHT	37.4 ( $\pm$ 3.2)	37.1–37.6	37.2 ( $\pm$ 3.2)	36.7–37.6	37.2 ( $\pm$ 3.7)	35.8–38.5
GKDEF	24.4 ( $\pm$ 1.9)	24.3–24.6	24.6 ( $\pm$ 2.0)	24.3–24.9	24.3 ( $\pm$ 2.0)	23.6–25.0

Note: WIDTH is mean team width, LENGTH is mean team length, HEIGHT is mean team defence depth, GKDEF is mean distance from the goalkeeper to their defence, VAR0 is matches without VAR intervention, VAR1 is matches with one VAR intervention, and VAR2 is matches with two or three VAR interventions.



**Figure 2.** Means, standard deviations ( $\pm$ sd) and 95% confidence intervals (95% CI) of the TD and TD21 for each VAR group. Note: TD is total distance covered by all the players in the team, TD21 is total distance covered above 21 km/h by all the players in the team, VAR0 is matched without VAR intervention, VAR1 is matched with one VAR intervention, and VAR2 is matched with two or three VAR interventions. b> VAR1 and c> VAR2 for a significance level of  $p < 0.05$ .

The VAR's intervention hardly altered the teams' technical-tactical performance. The only difference in this sense is that in matches with some kind of VAR intervention (VAR1 and VAR2) more goals were scored. This data is difficult to interpret, but it may be related to the situations in which the rules state that the VAR should intervene. These tend to take place usually near to the goal, arising from actions which could suggest a penalty or a goal scored from a dubious position. In this sense, it is interesting to note that goals scored from a penalty increased 2% (from 9% to 11%) in the 2017–2018 season



(before the introduction of the VAR) in relation to the 2018–2019 season of this study ([www.whoscored.com](http://www.whoscored.com)).

In terms of conditional variables, in matches with VAR intervention (VAR1 and VAR2), the TD dropped significantly albeit with a small magnitude. The results of this research coincide with those of a previous study (Lago-Peñas et al., 2015), in which a drop in TD was observed in matches with a higher TPT. On the other hand, the VAR did not appear to affect the TD21 variable, as the teams accumulated the same quantity of distance covered at that speed. However, if we consider that the greatest part of accumulated distance in speed ranges takes place when the ball is in play (Castellano et al., 2011) and the EPT was lower in matches where the VAR intervened, it could be concluded that the intensity and rhythm of play were somewhat higher in matches where the VAR intervened.

In terms of limitations, it would have been interesting to have considered contextual variables (Castellano et al., 2011), such as season phase (beginning, middle or end), the place where the match takes place (home or away), the momentary result or the quality of the opponent, to know whether VAR intervention affects teams' game dynamics in terms of these variables. Another limitation of this research was to not differentiate between the different types of VAR intervention in relation to the kind of action requiring it, something which could allow an assessment of the particular influence of each type on game development.

Overall, the findings of the present study showed that when the VAR system intervened: I) there was a slight increase in the TPT between the three situations (95.1 vs. 96.0 vs. 99.1 min, in VAR0, VAR1 and VAR2, respectively); II) there was a significant decrease in the EPT between VAR0 and VAR1 (52.5 vs. 51.5 min); III) there was an increase in the number of goals scored in the matches (1.2 vs. 1.5 vs. 1.7, in VAR0, VAR1 and VAR2, respectively); and IV) there was a slight decrease in the TD between the three situations (108,916.2 vs. 107,916.2 vs. 106,977.0 m, in VAR0, VAR1 and VAR2, respectively). These findings suggest that the VAR system hardly affects the game in elite football. However, it would appear necessary to continue studying the effects on the game in other variables, with the implementation of innovations for aiding conventional refereeing, in order to know with greater exactitude the type and degree of repercussion and assess its applicability.

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## Disclosure statement

No potential conflict of interest was reported by the authors.

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## Ethical approval

The data have been treated in accordance with the Declaration of Helsinki, being granted the clubs' consent to access the data and having received permission from the Ethics Committee on Humans (CEISH) of the University of the Basque Country (UPV/EHU).

## References

- Altman, D. G. (1991). *Practical Statistics for Medical Research*. Chapman & Hall.
- Batterham, A. M., & Hopkins, W. G. (2006). Making meaningful inferences about magnitudes. *International Journal of Sports Physiology and Performance*, 1(1), 50–57. <https://doi.org/10.1123/ijsp.1.1.50>
- Castellano, J., Blanco-Villaseñor, A., & Álvarez-Pastor, D. (2011). Contextual variables and time-motion analysis in soccer. *International Journal of Sports Medicine*, 32(6), 415–421. <https://doi.org/10.1055/s-0031-1271771>
- Castellano, J., & Casamichana, D. (2015). What are the differences between first and second divisions of Spanish football teams? *International Journal of Performance Analysis in Sport*, 15(1), 135–146. <https://doi.org/10.1080/24748668.2015.11868782>
- Castellano, J., & Echeazarra, I. (2019). Network-based centrality measures and physical demands in football regarding player position: Is there a connection? A preliminary study. *Journal of Sports Sciences*, 37(23), 2631–2638. <https://doi.org/10.1080/02640414.2019.1589919>
- Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Lawrence Erlbaum.
- Fédération Internationale de Football Association. (2019). *Laws of the game: Video Assistant Referee (VAR) protocol* FIFA.
- Garicano, L., Palacios-Huerta, I., & Prendergast, C. (2005). Favoritism under social pressure. *The Review of Economics and Statistics*, 87(2), 208–216. <https://doi.org/10.1162/0034653053970267>
- Harper, L. D., West, D. J., Stevenson, E., Russell, M., & Sandbakk, O. (2014). Technical performance reduces during the extra-time period of professional soccer match-play. *PloS One*, 9(10), e110995. <https://doi.org/10.1371/journal.pone.0110995>
- Helsen, W., & Bultynck, J. B. (2004). Physical and perceptual-cognitive demands of top-class refereeing in association football. *Journal of Sports Sciences*, 22(2), 179–189. <https://doi.org/10.1080/02640410310001641502>
- Helsen, W., Gilis, B., & Weston, M. (2006). Errors in judging “offside” in association football: test of the optical error versus the perceptual flash-lag hypothesis. *Journal of Sports Sciences*, 24(5), 521–528. <https://doi.org/10.1080/02640410500298065>
- Lago-Peñas, C., Dellal, A., Owen, A. L., & Gómez-Ruano, M. A. (2015). The influence of the extra-time period on physical performance in elite soccer. *International Journal of Performance Analysis in Sport*, 15(3), 830–839. <https://doi.org/10.1080/24748668.2015.11868834>
- Lago-Peñas, C., & Gómez-López, M. (2016). The influence of referee bias on extra time in elite soccer matches. *Perceptual and Motor Skills*, 122(2), 666–677. <https://doi.org/10.1177/0031512516633342>

- Lago-Peñas, C., Rey, E., & Kalén, A. (2019). How does Video Assistant Referee (VAR) modify the game in elite soccer? *International Journal of Performance Analysis in Sport*, 19(4), 646–653. <https://doi.org/10.1080/24748668.2019.1646521>
- Lex, H., Pizzera, A., Kurtes, M., & Schack, T. (2015). Influence of players' vocalisations on soccer referees' decisions. *European Journal of Sport Science*, 15(5), 424–428. <https://doi.org/10.1080/17461391.2014.962620>
- Linke, D., Link, D., Lames, M., & Kerhervé, H. A. (2020). Football-specific validity of TRACAB's optical video tracking systems. *PloS One*, 15(3), e0230179. <https://doi.org/10.1371/journal.pone.0230179>
- Linke, D., Link, D., Weber, H., & Lames, M. (2018). Decline in match running performance in football is affected by an increase in game interruptions. *Journal of Sports Science & Medicine*, 17(4), 662–667.
- Nevill, A. M., Balmer, N. J., & Williams, A. M. (2002). The influence of crowd noise and experience upon refereeing decisions in football. *Psychology of Sport and Exercise*, 3(4), 261–272. [https://doi.org/10.1016/S1469-0292\(01\)00033-4](https://doi.org/10.1016/S1469-0292(01)00033-4)
- Pons, E., García-Calvo, T., Resta, R., Blanco-Pita, H., López-Del Campo, R., Díaz-García, J., Pulido, J. J., & Sunderland, C. (2019). A comparison of a GPS device and a multi-camera video technology during official soccer matches: agreement between systems. *PloS One*, 14(8), e0220729. <https://doi.org/10.1371/journal.pone.0220729>
- Rampinini, E., Impellizzeri, F. M., Castagna, C., Coutts, A. J., & Wisløff, U. (2009). Technical performance during soccer matches of the Italian Serie A league: effect of fatigue and competitive level. *Journal of Science and Medicine in Sport*, 12(1), 227–233. <https://doi.org/10.1016/j.jsams.2007.10.002>
- Ryall, E. (2012). Are there any good arguments against goal-line technology? *Sport, Ethics and Philosophy*, 6(4), 439–450. <https://doi.org/10.1080/17511321.2012.737010>
- Svantesson, D. J. B. (2014). Could technology resurrect the dignity of the FIFA World Cup refereeing? *Computer Law & Security Review*, 30(5), 569–573. <https://doi.org/10.1016/j.clsr.2014.07.004>
- Wass, J., Mernagh, D., Pollard, B., Stewart, P., Fox, W., Parmar, N., Jones, B., Kilduff, L., & Turner, A. N. (2020). A comparison of match demands using ball-in-play vs. whole match data in elite male youth soccer players. *Science and Medicine in Football*, 4(2), 1–6. <https://doi.org/10.1080/24733938.2019.1682183>
- Winder, N., Russell, M., Naughton, R. J., & Harper, L. D. (2018). The impact of 120 minutes of match-play on recovery and subsequent match performance: a case report in professional Soccer players. *Sports*, 6(1), 22. <https://doi.org/10.3390/sports6010022>