VAR implementation and soccer team performance: a comparison between the 2014 and 2018 World Cups

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Abstract:

Introduction: In soccer, referees and assistants must make fast and accurate judgments based on the game rules. As an attempt to minimize refereeing errors and reduce their impact on match outcomes, the video assistant referee (VAR) was introduced on the game. The VAR is a technological apparatus that enables referees to review their decisions on video. The interruptions for VAR checking have an indefinite duration and occur randomly during the match. Therefore, disciplinary aspects and technical and physical performances of the teams are potentially susceptible to changes. **Objective:** The purpose of the present study was to verify whether the implementation of the VAR influenced disciplinary sanctions as well as the physical and technical performance of the teams participating in the 2018 FIFA World Cup, when compared to the previous edition (2014), in which the VAR was not used. **Methods:** The sample was comprised of matches played in the 2014 (n = 57) and 2018 (n = 59) editions of the FIFA World Cup. Teams' technical and physical performances and match data were compared between both tournaments. **Results:** Findings indicated that technical performance was influenced by the implementation of the VAR, as teams displayed reduced number of passes and increased percentage of accurate passes. Also, results showed an increase in average total distance covered and a decrease in the number of individual and total sprints per team, in the tournament in which the VAR was employed. Analysis of match data indicated a reduction in the number of offsides, fouls and red cards, more penalties and yellow cards, as well as more additional time in both halves and in the whole match. **Conclusions:** The implementation of the VAR prompted changes in the disciplinary aspects of matches and influenced the number of high-speed actions and technical actions performed by the teams, despite the increased accuracy in the execution of technical actions.

Key Words: Performance; referee; decision-making; technical skills; game

Introduction

Over the years, researchers have sought to identify the training and development strategies that contribute to successful performance by soccer teams (Andrade et al., 2021; Pietro & Mazzeo, 2019). As the game evolved, the role of referees has also recently received more attention, fundamentally with the purpose of ensuring increasingly fair contests (Mascarenhas et al., 2005). Referees and assistants must make fast and accurate judgments based on the rules of soccer, and constrained by several sources of information and great complexity inherent to the game (Helsen et al., 2006; Kolbinger & Lames, 2017). As a result, referees often make wrong decisions, which can directly influence the final score (Mallo et al., 2012; Unkelbach & Memmert, 2010).

Accordingly, in recent years, several technological resources have been gradually introduced to the game, in an attempt to minimize refereeing errors and reduce their impact on match outcomes (Spitz et al., 2020; Tamir & Bar-eli, 2021). For instance, in the 2018 World Cup in Russia, FIFA (Fédération Internationale de Football Association) introduced the video assistant referee (VAR). The VAR is a technological apparatus that enables referees to review their decisions on video, and its utilization is only allowed in situations involving goals, penalties, red card incidents and administrative affairs (FIFA, 2019). Fundamentally, the VAR operates as follows: (1) either the referee informs the VAR, or the VAR suggests that a certain event/decision be reviewed by the referee; (2) the video is analyzed by the VAR, who describes the event under analysis to the referee (using a headset); and (3) the referee reviews the video recording of the event in the sidelines, before taking the appropriate actions (FIFA, 2019).

Following the implementation of the VAR in official tournaments, researchers have started investigating its potential effects on match development (Han et al., 2020; Lago-Peñas et al., 2019). With respect

to the disciplinary aspects of matches, studies observed a reduction in the number of refereeing errors in awarding penalties and offsides (Spitz et al., 2020; Tamir & Bar-eli, 2021). However, the main criticism related to the VAR is due to the frequency matches are interrupted so that events can be reviewed and its potential effects on playing dynamics (Dyer, 2015; Svantesson, 2014). For instance, the study by Han and colleagues (2020) showed that, after the implementation of the VAR, referees added more extra time to the matches. Likewise, Lago-Peñas et al. (2019) observed a significant reduction in the number of offsides, fouls and yellow cards awarded by the referees, as well as increased additional time conceded at the end of both halves, following the implementation of the VAR.

Therefore, taking into account that interruptions for VAR checking have indefinite duration and occur in a random fashion during the match, disciplinary aspects and technical and physical performances of the team are potentially susceptible to changes. However, the study by Errekagorri and colleagues (2020) showed that in La Liga (the Spanish league), teams' technical and tactical collective performances were not significantly changed after the implementation of the VAR. This was one of the first studies investigating the influence of the VAR on teams' collective performance. Hence, further research addressing different competitions, as well as the exploration of other performance variables, are necessary steps towards a better understanding the degree of influence of the implementation of VAR on match facts and teams' performances.

Correspondingly, the FIFA World Cup, an international tournament played by many of the best world players and national teams, has been considered a fruitful competition from which information of the highest level of soccer can be obtained (Aquino et al., 2019; Holienka et al., 2020). Recent research with teams participating in the FIFA World Cup indicated that external and contextual factors (e.g., ambient temperature, match status, level of opponents) are likely to influence teams' physical, technical and tactical performances (Dambroz et al., 2021; Kubayi & Toriola, 2019; Nassis et al., 2015). Nevertheless, despite the prominence of this tournament and the fact that it was the first official competition in which the video assistant referee was employed in all matches, the influence of VAR on the physical and technical performances of the teams participating in the 2018 edition of the tournament is yet to be investigated.

Thus, the purpose of this paper is to verify whether the implementation of the VAR influenced disciplinary sanctions as well as the physical and technical performance of the teams participating in the 2018 FIFA World Cup, when compared to the previous edition (2014), in which the VAR was not used. We hypothesized that the implementation of the VAR would result in significant changes in disciplinary sanctions and that it would be detrimental to teams' physical and technical performances.

Material and methods

Sample

The sample was comprised of 116 soccer matches (57 matches from the 2014 and 59 matches from the 2018 FIFA World Cups). Matches decided either in overtime or penalty shootouts were excluded from the sample (7 matches from the 2014 and 5 matches from the 2018 FIFA World Cups). In both tournament editions matches were played either at 1:30 PM, 4:00 PM or 8:30 PM.

Data collection

Performance data were obtained using the Castrol Performance Index, through match reports provided by FIFA at their official website (<http://www.fifa.com>). The Castrol Performance Index is calculated using real-time kinematic data, obtained through semiautomatic video cameras at a 25 Hz sampling rate. Data were then registered in spreadsheets of the Microsoft Excel 2016 for subsequent analysis.

Variables

Technical performance

Technical performance was analyzed according to the following variables: number of passes (au), number of accurate passes (au) and % of accurate passes.

Physical performance

Physical performance was analyzed according to the following variables: average distance covered by the teams (m), number of individual sprints (au) and total sprints per team (au).

Match data

After each match, data from the following variables were collected: number of goals (au), offsides (au), yellow cards (au), red cards (au), fouls (au), penalties (au), playing time in the first half (min), playing time in the second half (min) and total match time (min).

Statistical Analysis

Descriptive analysis (means and standard deviation) was performed. The normality of data distribution was tested using the Kolmogorov-Smirnov test. Independent t-tests and Mann-Whitney tests were performed for comparing variables' values between the 2014 and 2018 FIFA World Cup.

Effect sizes were calculated using Cohen's *d*, and classified as follows: negligible (< 0.20), small (0.21 to 0.60), medium (0.61 to 1.20) and large (> 1.20) (Cohen, 1992). Significance level was set at $p < 0.05$. All statistical procedures were performed using IBM SPSS for Windows, version 24.0.

Results

Means and standard deviation regarding teams' technical and physical performances in the 2014 and 2018 FIFA World Cups are displayed in the Table 1 below.

Table I. Means and standard deviation of teams' technical and physical performances in the 2014 and 2018 FIFA World Cups.

	<u>2014 World Cup</u>		<u>2018 World Cup</u>		<i>p</i>	<i>d</i>
	(No VAR)		(With VAR)			
	<i>M</i>	<i>DP</i>	<i>M</i>	<i>DP</i>		
<u>Technical Performance</u>						
Passes (au)	502.77	± 110.11	450.02	± 139.25	0.002*	0.42
Accurate passes (au)	383.05	± 110.35	379.64	± 136.56	0.853	-
Accurate passes (%)	75.17	± 6.25	82.58	± 6.04	< 0.001*	1.21
<u>Physical Performance</u>						
Average distance (m)	9240.19	± 745.29	10032.18	± 466.14	< 0.001*	1.27
Individual sprints (au)	35.91	± 5.51	32.70	± 4.24	< 0.001*	0.65
Total sprints (au)	361.39	± 55.35	327.87	± 42.53	< 0.001*	0.68

*Significant difference ($p < 0.05$); au – arbitrary unit; m – meters.

Largely, teams' technical and physical performances differed statistically when comparing the 2014 and 2018 World Cups. As for the technical aspects, the 2018 World Cup displayed reduced number of passes ($t_{(113)} = 3.13$; $p = 0.002$; $d = 0.42$) and increased percentage of accurate passes ($z = -8.22$; $p < 0.001$; $d = 1.21$), compared to the 2014 edition. With respect to physical performance, increased average distance covered ($z = -9.69$; $p < 0.001$; $d = 1.27$), and reduced number of individual ($z = -4.31$; $p < 0.001$; $d = 0.65$) and total sprints ($z = -4.55$; $p < 0.001$; $d = 0.68$) were observed in the 2018 World Cup, compared to the 2014 tournament.

Means and standard deviation values of match variables in the 2014 and 2018 FIFA World Cups are displayed in the Table 2 below.

Table II. Means and standard deviation of match variables in the 2014 and 2018 FIFA World Cups.

Variables	<u>2014 World Cup</u> (No VAR)		<u>2018 World Cup</u> (With VAR)		<i>p</i>	<i>d</i>
	<i>M</i>	<i>DP</i>	<i>M</i>	<i>DP</i>		
Goals (au)	1.42	± 1.32	1.37	± 1.21	0.781	-
Offsides (au)	2.04	± 1.99	1.36	± 1.22	0.016*	0.41
Yellow cards (au)	1.33	± 0.90	1.70	± 1.24	0.031*	0.34
Red cards (au)	0.08	± 0.27	0.02	± 0.13	0.027*	0.28
Fouls (au)	14.58	± 4.76	13.41	± 4.32	0.038*	0.25
Penalties (au)	0.11	± 0.31	0.24	± 0.52	0.030*	0.30
Playing time – 1 st half (min)	46.56	± 0.55	47.05	± 1.05	0.014*	0.58
Playing time – 2 nd half (min)	48.55	± 1.02	49.59	± 1.22	< 0.001*	0.92
Total match time (min)	95.45	± 1.31	97.03	± 1.47	< 0.001*	1.13

*Significant difference ($p < 0.05$); au – arbitrary unit; min – minutes.

The comparison of match data between both tournaments showed significant differences in most of the variables analyzed. The 2018 edition of the FIFA World Cup displayed more offsides ($z = -2.41$; $p < 0.016$; $d = 0.41$), red cards ($z = -2.22$; $p < 0.027$; $d = 0.28$), increased playing time in the 1st ($t_{(63)} = -2.47$; $p = 0.014$; $d = 0.58$) and 2nd halves ($t_{(63)} = -7.07$; $p < 0.001$; $d = 0.92$), and total match time ($t_{(63)} = -6.31$; $p < 0.001$; $d = 1.13$), compared to the 2014 World Cup. On the other hand, the 2018 tournament had fewer fouls ($t_{(127)} = 2.09$; $p = 0.038$; $d = 0.25$), penalties ($z = -2.14$; $p < 0.032$; $d = 0.30$) and yellow cards ($z = -2.16$; $p < 0.031$; $d = 0.34$) awarded than the 2014 edition.

Discussion

The purpose of this study was to verify whether the implementation of the VAR influenced disciplinary sanctions as well as the physical and technical performance of the teams participating in the 2018 FIFA World Cup, when compared to the previous edition (2014), in which the VAR was not used. The main findings regarding the effects of the implementation of the VAR were the reduced number of individual and total sprints, and the increased average distance covered by the players. As for the technical performance, teams performed fewer passes and higher percentage of correct passes. Lastly, match data showed reduced number of offsides, fouls and red cards, yet more penalties, yellow cards, playing time in the first and second halves, as well as more

total match time, following the implementation of the VAR. These results support the initial hypothesis that the implementation of the VAR is associated with changes in disciplinary aspects and with the reduction of teams' technical and physical performances.

The implementation of the VAR coincided with teams performing fewer passes, yet increasing the percentage of accurate passes. The fact that the VAR enables referees to review plays and decisions may have prompted more careful defensive behaviors, which could have resulted in more space and time for players to carry the ball forward longer, before passing to a teammate (Lago-Peñas et al., 2019). In addition, the likely increase in space and time may have also facilitated the occurrence of accurate passes, as findings attested by our findings.

One of the main concerns regarding the implementation of the VAR is that the number of interruptions during a match, and the time referees take to make a decision, may possibly affect the dynamics of the game and players' physiological and psychological components (Dyer, 2015; Svantesson, 2014). Although players' physiological data were not controlled in the present study, findings indicated that teams experienced decreased physical performance. Overall, in the 2018 World Cup (with the VAR), players performed fewer sprints, and teams covered higher average distances. Considering that high-speed actions take place when the ball is being played (Castellano et al., 2011), and that after the implementation of the VAR more match interruptions were observed (Errekaogorri et al., 2020; Lago-Peñas et al., 2019), it is possible to suggest that the reduction in the number of high-speed actions may have been influenced by the presence of the VAR (Linke et al., 2018).

Regarding the increased average distance covered by teams in the 2018 World Cup (with the VAR), two aspects need to be emphasized for interpreting the results. The first refers to the climatic characteristics of the 2014 World Cup (without the VAR), held in Brazil. Matches were played in different regions, with great temperature range among them, which clearly affected teams' physical performances (Dambroz et al., 2021; Nassiss et al., 2015). In addition, recent studies observed a trend that indicates an increase in the total distance covered by the teams over the last few years, as a result of changes in the dynamics of the game regarding players' displacements (Bradley et al., 2015; García-Unanue et al., 2018). Hence, prudence is necessary when interpreting the average distance covered by the teams as a consequence of the implementation of the VAR, as this variable may possibly be related to other factors, such as climatic conditions, match status and quality of opposition (Goncalves et al., 2021; Ugalde-Ramirez, 2020).

Similarly, results showed increased duration of both match halves and, consequently, of the full match. Overall, such an increase results from the time added to compensate for the interruptions necessary for the VAR reviews. Therefore, the time during which the match is stopped, between the VAR review and the referee's decision (81.9 seconds on average) should be added at the end of the match, so that the effective playing time is not reduced. In the 2018 World Cup (with the VAR), the effective playing time was of 56 minutes and 14 seconds (FIFA, 2018). This time was slightly higher than the 55 minutes and 14 seconds of playing time in the 2014 World Cup (without the VAR) (FIFA, 2014). Hence, although the effective playing time was not assessed in the present study, it does not seem to be significantly harmed by the implementation of the VAR. Nevertheless, these outcomes did not corroborate with previous research, with respect to the increased total match time and the effective playing time (Errekaogorri et al., 2020; Lago-Peñas et al., 2019).

The reduced number of offsides following the implementation of the VAR may have occurred due to referees' decisions to allow the play to proceed, instead of awarding the offside, whenever they were not fully confident about the player's position, since, if a goal was scored, player's position would be reviewed by the VAR. On the other hand, despite the increased number of penalties awarded, this does not seem to have affected the number of goals scored, as these values were not significantly in the comparison between both tournaments. The fewer red cards awarded seems to be related to teams committing less aggressive fouls, and avoiding hostile complaints about the referee's decisions, since decisions could be reviewed and changed through the VAR in situations involving goals, penalties and red cards.

In the 2018 World Cup, there were more yellow cards awarded to each team, as well as fewer fouls. The reduced number of fouls is in accordance with a study conducted in the German and Italian leagues, after the implementation of the VAR, despite the fact that findings showed fewer yellow cards in these competitions (Lago-Peñas et al., 2019). Importantly, the accuracy rate of referees' decisions in the main national leagues in the world, for events entailing interpretation increased from 92.1% to 98.3% (Spitz et al., 2020). In a similar fashion, the FIFA Technical Report for the 2018 World Cup showed an increase from 95.60% to 99.35% in the referees' accuracy rate, when compared to the previous edition (FIFA, 2018). Hence, the number of yellow cards awarded seems to be more closely related to teams' behaviors in the different leagues, as well as to their playing styles and culture, than to the implementation of the VAR *per se*. As for the percentage of accurate decisions by the referees, they seem to have a positive relation with the implementation of the VAR. Consequently, the VAR has been considered an essential tool to help reducing decision mistakes by the referees.

In practice, the findings of the present study may help coaches, players and viewers understanding the influence of the VAR on game dynamics and teams' performances. Based on these results, coaching staffs may be able to identify specific behaviors of the teams during matches and employ training strategies aiming at improving performance, such as psychological guidance to help players maintaining their focus during interruptions, and training activities that encourage them to play more purposefully and to value ball possession.

In contrast, with respect to the referees, findings help reinforcing the idea the proper preparation of the entire referee team is essential to ensure the quality of the game, since the faster and more accurate the decisions and feedbacks, the lower the impact on teams' performances. The main limitations of the present study are the absence of contextual variables (e.g., match status, amount and duration of interruptions by the VAR, tournament stage, quality of opposition) in the analyses, as well as the fact that the significant differences found between both tournaments (i.e., 2014 and 2018 FIFA World Cups) cannot be exclusively or directly attributed to the implementation of the VAR, reasons for which any attempts to generalize findings or extrapolate inferences demands caution. Future studies may help addressing these issues, by controlling for these variables, in order to ensure higher methodological rigor regarding the influence of the VAR, as well as the magnitude of its impact on players and teams' performances.

Conclusions

Our findings indicated that the VAR implementation affected the teams' performance, as shown by the decrease in high-speed and technical actions. On the other hand, the accuracy of the technical actions was not impaired. Overall, after the VAR implementation, the teams reduced the number of passes and increased the percentage of accurate passes. Our results also showed that the average total distance covered by the players was higher, and the number of individual and total sprints per team was lower in a tournament employing the VAR. Lastly, the implementation of the VAR influenced match duration and the number of disciplinary measures taken during matches.

As for the practical implications, this study reinforces the idea that proper preparation of the entire referee team is essential to ensure the quality of the game since referees' decisions must be taken as fast and most accurately as possible. In this regard, the VAR can be considered an essential tool to help reduce the decision mistakes done by the referees. We also highlight that our study provided novelties to the field since we considered the teams' technical and physical performances after VAR implementation.

Conflicts of interest – The authors declare that there is no conflict of interest.

References

- Andrade, L., Machado, G., Gonçalves, E., & Teoldo, I. (2021). Decision making in soccer: Effect of positional role of u-13 soccer players. *Journal of Physical Education and Sport*, 21(3), 1413–1420. <https://doi.org/10.7752/jpes.2021.03180>
- Aquino, R., Machado, J. C., Clemente, F. M., Praça, G. M., Gonçalves, L. G. C., Melli-Neto, B., Ferrari, J. V. S., Vieira, L. H. P., Puggina, E. F., & Carling, C. (2019). Comparisons of ball possession, match running performance, player prominence and team network properties according to match outcome and playing formation during the 2018 FIFA World Cup. *International Journal of Performance Analysis in Sport*, 19(6), 1026–1037. <https://doi.org/10.1080/24748668.2019.1689753>
- Bradley, P. S., Archer, D. T., Hogg, B., Schuth, G., Bush, M., Carling, C., & Barnes, C. (2015). Tier-specific evolution of match performance characteristics in the English Premier League: it ' s getting tougher at the top. *Journal of Sports Sciences*, 1–8. <https://doi.org/10.1080/02640414.2015.1082614>
- Castellano, J., Blanco-Villaseñor, A., & Álvarez, 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>
- Cohen, J. (1992). A power primer. *Psychological Bulletin*, 112(1), 155–159. <https://doi.org/10.1037/0033-2909.112.1.155>
- Dambroz, F., Teoldo, I., & Primola-Gomes, T. N. (2021). Influence of the ambient temperature over the tactic, technical and physical performances of national teams. *Journal of Universal Movement and Performance*, 3, 39–45. <https://doi.org/10.17561/jump.n3.5>
- Dyer, B. (2015). The controversy of sports technology: a systematic review. *SpringerPlus*, 4(524), 1–12. <https://doi.org/10.1186/s40064-015-1331-x>
- Erreagorri, I., Castellano, J., Echeazarra, I., & Lago-Peñas, C. (2020). The effects of the Video Assistant Referee system (VAR) on the playing time, technical-tactical and physical performance in elite soccer. *International Journal of Performance Analysis in Sport*, 1–10. <https://doi.org/10.1080/24748668.2020.1788350>
- FIFA. (2014). *2014 FIFA World Cup Brazil™ Technical Report and Statistics*.
- FIFA. (2018). *The FIFA World Cup™ in Numbers*.
- FIFA. (2019). Laws of the Game: Video Assistant Referee (VAR) protocol. In *The International Football Association Board*. FIFA.
- García-Unanue, J., Pérez-Gómez, J., Giménez, J. V., Felipe, J. L., Gómez-Pomares, S., Gallardo, L., & Sánchez-Sánchez, J. (2018). Influence of contextual variables and the pressure to keep category on physical match performance in soccer players. *PLoS ONE*, 13(9), 1–10. <https://doi.org/10.1371/journal.pone.0204256>
- Goncalves, L. G. C., Clemente, F. M., Vieira, L. H. P., Bedo, B., Puggina, E. F., Moura, F., Mesquita, F., Santiago, P. R. P., Almeida, R., & Aquino, R. (2021). Effects of match location, quality of opposition, match outcome, and playing position on load parameters and players' prominence during official matches in professional soccer players. *Human Movement*, 22(3), 35–44. <https://doi.org/10.5114/hm.2021.100322>

- Han, B., Chen, Q., Lago-Peñas, C., Wang, C., & Liu, T. (2020). The influence of the video assistant referee on the Chinese Super League. *International Journal of Sports Science and Coaching*, 15(5–6), 662–668. <https://doi.org/10.1177/1747954120938984>
- 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>
- Holienka, M., Nagy, N., Baša, R., & Babic, M. (2020). Relationship between the shooting success rate and match result in soccer at the FIFA world cup 2018. *Journal of Physical Education and Sport*, 20(3), 1513–1521. <https://doi.org/10.7752/jpes.2020.03208>
- Kolbinger, O., & Lames, M. (2017). Scientific approaches to technological officiating aids in game sports. *Current Issues in Sport Science*, 2(001), 1–10. https://doi.org/10.15203/ciss_2017.001
- Kubayi, A., & Toriola, A. (2019). Trends of goal scoring patterns in soccer: A retrospective analysis of five successive FIFA World Cup Tournaments. *Journal of Human Kinetics*, 69, 231–238. <https://doi.org/10.2478/hukin>
- 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>
- 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 and Medicine*, 17(4), 662–667.
- Mallo, J., Frutos, P. G., Juárez, D., & Navarro, E. (2012). Effect of positioning on the accuracy of decision making of association football top-class referees and assistant referees during competitive matches. *Journal of Sports Sciences*, 30(13), 1437–1445. <https://doi.org/10.1080/02640414.2012.711485>
- Mascarenhas, D. R. D., Collins, D., & Mortimer, P. (2005). Elite refereeing performance: Developing a model for sport science support. *The Sport Psychologist*, 19(4), 364–379. <https://doi.org/10.1123/tsp.19.4.364>
- Nassis, G. P., Brito, J., Dvorak, J., Chalabi, H., & Racinais, S. (2015). The association of environmental heat stress with performance: Analysis of the 2014 FIFA World Cup Brazil. *British Journal of Sports Medicine*, 49(9), 609–613. <https://doi.org/10.1136/bjsports-2014-094449>
- Pietro, M., & Mazzeo, F. (2019). Improvement in soccer learning and methodology for young athletes. *Journal of Physical Education and Sport*, 19(3), 795–801. <https://doi.org/10.7752/jpes.2019.s3113>
- Spitz, J., Wagemans, J., Memmert, D., Williams, A. M., & Helsen, W. F. (2020). Video assistant referees (VAR): The impact of technology on decision making in association football referees. *Journal of Sports Sciences*, 39(2), 147–153. <https://doi.org/10.1080/02640414.2020.1809163>
- Svantesson, D. J. B. (2014). Could technology resurrect the dignity of the FIFA World Cup refereeing? *Computer Law and Security Review*, 30(5), 569–573. <https://doi.org/10.1016/j.clsr.2014.07.004>
- Tamir, I., & Bar-eli, M. (2021). The moral gatekeeper: Soccer and technology, the case of Video Assistant Referee (VAR). *Frontiers in Psychology*, 11(613469), 1–7. <https://doi.org/10.3389/fpsyg.2020.613469>
- Ugalde-Ramírez, A. (2020). Physical activities according to playing positions, match outcome, and halves during the 2018 Soccer World Cup. *Journal of Physical Education and Sport*, 20(6), 3635–3641. <https://doi.org/10.7752/jpes.2020.06490>
- Unkelbach, C., & Memmert, D. (2010). Crowd noise as a cue in referee decisions contributes to the home advantage. *Journal of Sport and Exercise Psychology*, 32(4), 483–498. <https://doi.org/10.1123/jsep.32.4.483>