2023, Retos, 50, 1163-1171

Video Assistant Referee in soccer: A Scoping Review
Árbitro asistente de vídeo en el fútbol: una revisión del alcance

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Abstract. The Video Assistant Referee (VAR) is a technology that is changing the behavior of referees, players, managers, and fans in soccer. This scoping review mapped the studies on the use of VAR in soccer. An electronic database searching was performed in November 2020 using Medline/PubMed, Scopus, and Web of Science. Studies that analyzed field referees or video assistants and addressed professional field soccer were eligible. Studies' characteristics were extracted and summarized. An initial search found 346 potentially relevant titles; six of them followed all eligibility criteria, providing information on VAR in high-performance men's soccer competitions held in 18 countries. There was a multiplicity of variables analyzed in the primary studies, mainly quantitative approaches of the VAR effects on game parameters, as follows: Decision-making process (n=4), game time (n=3); goals (n=5); offside (n=4); yellow and red card application (n=3); fouls (n=2); penalties (n=3); and VAR incidents (n=2). In general, primary studies have indicated that VAR can significantly enhance the accuracy of referees' decision-making, as well as having had a positive influence on the game's outcome. However, some negative aspects have been observed, such as a reduction in effective playing time and limited training for referees. Studies on VAR in soccer are still in their initial stages, and research priorities were highlighted to help future research and practice on VAR in soccer.
Keywords: Sport, Soccer, Football, Decision Making, "Video-Assisted Techniques and Procedures"

Resumen. El Vídeo Asistente de Árbitro (VAR) es una tecnología que está cambiando el comportamiento de árbitros, jugadores, directivos y aficionados en el fútbol. Esta revisión de alcance mapeó los estudios sobre el uso del VAR en el fútbol. En noviembre de 2020 se realizó una búsqueda en bases de datos electrónicas utilizando Medline/PubMed, Scopus y Web of Science. Fueron elegibles los estudios que analizaron árbitros de campo o asistentes de video y abordaron el fútbol de campo profesional. Se extrajeron y resumieron las características de los estudios. Una búsqueda inicial encontró 346 títulos potencialmente relevantes; seis de ellos siguieron todos los criterios de elegibilidad y proporcionaron información sobre el VAR en competiciones de fútbol masculino de alto rendimiento celebradas en 18 países. Hubo una multiplicidad de variables analizadas en los estudios primarios, principalmente enfoques cuantitativos de los efectos del VAR en los parámetros del juego, como sigue: proceso de toma de decisiones (n=4), tiempo de juego (n=3); metas (n=5); fuera de juego (n=4); solicitud de tarjeta amarilla y roja (n=3); faltas (n=2); sanciones (n=3); e incidencias del VAR (n=2). En general, los estudios primarios han indicado que el VAR puede mejorar significativamente la precisión en la toma de decisiones de los árbitros, además de haber tenido una influencia positiva en el resultado del juego. Sin embargo, se han observado algunos aspectos negativos, como una reducción del tiempo efectivo de juego y una formación limitada de los árbitros. Los estudios sobre el VAR en el fútbol aún se encuentran en sus primeras etapas y se destacaron las prioridades de investigación para ayudar a futuras investigaciones y prácticas sobre el VAR en el fútbol.
Palabras clave: Deporte, Fútbol, Fútbol, Toma de Decisiones, "Técnicas y Procedimientos Video-Asistidos"

Fecha recepción: 05-07-22. Fecha de aceptación: 21-08-23
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Introduction

Modern Football has been practiced with more dynamic processes when everyone in the game should know how to be fast at the right time and in the correct spaces (i.e., speed with intentional process). This challenges everyone who are involved in the game, including the referees (Russell et al., 2020), who require superior training to excellent physical shape (Helsen & Bultynck, 2004), knowledge and proficiency in the rules of the game, and emotional control over the contexts that a match present. Accordingly, sport professionals need to develop competencies through high-level trainings and competitions, and with the use of complementary areas of intervention, e.g. injury prevention, psychological support or group communication (Huenullán et al., 2023). Therefore, the referee is expected to be fully prepared in terms of physical, technical, social and mental aspects and aware of his role in the sport (Sousa, 2016).

A referee named Collina, one of the best in history, said in 2006: "Many games of the century, supposedly taking place in the sixties and seventies, and sometimes you see resumes on television, notice how slowly they used to play. Look at all the space the forwards had! Football has not just gotten faster, it is much more athletic today, too. A player has to be able to do much more than in the past to be considered ideal" (Collina, 2006).

As the dynamics of the game evolve with players from different teams introducing innovative strategies (Barreira et al., 2014a), referees are faced with the challenge of making swift decisions. This is especially true given the intense pressure at the center of play (Barreira et al., 2014b; Barreira et al., 2014c) and the added hemodynamic stress (Lima e Silva et al., 2020). Such factors can influence decision-making processes (Philippe et al., 2009; Taylor et al., 2014).

To decrease refereeing errors, technologies have been introduced in sports to assist referees in their decisions (Kolbinger & Lames, 2017), as even the most experienced referees are subject to errors (Silva et al., 2018). The use of the Video Assistant Referee (VAR) has been a strategy used in different sports (Kittel et al., 2019). VAR was officially implemented in soccer in 2018 (Lago-Peñas et al., 2019), to improve the accuracy of refereeing and avoid clear errors in decisions, but only in situations of penalty, goal, red card, and this is especially true given the intense identification error, using image observation resources with different angles and speeds, requiring clear and objective communication between referees (IFAB, 2019).

The VAR intervenes whenever necessary. Its philosophy establishes minimal interference and maximal precision, which do not correspond to avoiding its use since interaction between the VAR and the central referee must occur as guided by the protocol (Bacigalupe, 2019).

Studies involving refereeing have evolved over the past 20 years (Pina et al., 2018). For example, a scoping review by Bloß et al. (2020) mapped the relationship between decision-making and physical load in referees and retrieved only four articles on soccer referees. A systematic review by Kittel et al. (2019) reported on decision-making using videos from different sports, mainly soccer (16 primary articles), suggesting studies that explore beyond the number of decisions.

However, none of the reviews included studies that focused on the VAR in soccer. Our search retrieved no VAR-specific scoping or systematic reviews. Therefore, the current study contributes to the initial mapping of VAR implementation in the scientific literature and will serve as a basis for future research. The mapping studies in the current VAR implementation and development scenario can help to increase our understanding and improve game performance, improve the overall sports experience. And quite possibly optimize the use of the VAR in other scenarios.

Objective

This review was intended to map empirical studies that present information on the implementation and use of the VAR in men's soccer, highlighting its main methodological characteristics (use and application, training, evaluations, and practices of use of the VAR) and its main intervening factors (training methods, use of technology) in a controlled or game environment.

Method

This study followed the methodological recommendations for the construction of a scoping review (Arksey & O'Malley, 2005), which deals with the following stages: 1) identifying the research question; 2) identifying relevant studies; 3) selecting the studies; 4) mapping the data; and 5) grouping, summarizing, and reporting the results (Levac el at., 2010). This scoping review was performed according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta Analyses) extension for Scoping Reviews checklist (Tricco et al., 2018). The protocol was not submitted to any study registration portals.

Identifying the research question

This review based on the following question: *what have studies shown about characteristics (use, training, evaluations, and practices of use of the VAR), intervening factors (training methods, use of technology), and the results on the use of the VAR in soccer?*

To optimize the mapping survey and to consider different research area elements, the criteria for this review were selected based on the population, concept, and context elements (Peters et al., 2020). Therefore, studies were considered eligible if they met the following criteria.

1) Sample: Only studies that analyzed referees or video assistant referees were included in the analysis.

2) Context: Only studies that addressed professional men's soccer at any level were selected.

3) Concept: Only studies that presented results (quantitative and/or qualitative) on the use of VAR whether in a training environment or during the game were selected, regardless of the methodological approach adopted. The study considered various investigative contexts and domains, whether they included field reviews or not, and whether they were analyzed through a subsequent post-event review or in real-time.

Studies in peer-reviewed article format, published in English, Spanish, or Portuguese, from 2000 to 2020. Although VAR was implemented in 2018, we considered the entire critical interval of higher research production in football refereeing (Bloß et al., 2020; Pina et al., 2018) in the expectation of reaching studies on the design or implementation of VAR.

Articles were excluded if they use simple measurement modes individually or collectively through a survey of frequencies of use; characterize incidents, impacts on the game, or field performance of the VAR; report on perceived performance and interaction, satisfaction with use, time spent on checks or revisions; compare seasons, competitions, or countries; and detail their training methods, pre-competition preparation, and field performance.

Identification of relevant studies

The literature search was conducted on 22 November 2020 using the following databases: Medline/PubMed, Scopus, and Web of Science.

Table 1.
Searching strategies

Targets	searching terms
Referee	(TITLE-ABS-KEY ("referee*" OR referee))
Soccer	(TITLE-ABS-KEY (football OR soccer))
Video	(TITLE-ABS-KEY ("video assistant referee" OR var OR "video*"))
Full searching formula	(TITLE-ABS-KEY ("referee*" OR referee)) AND (TITLE-ABS-KEY (football OR soccer)) AND (TITLE-ABS-KEY ("video assistant referee" OR var OR "video*")) AND (LIMIT-TO (DOCTYPE,"ar") OR LIMIT-TO (DOCTYPE,"re")) AND (LIMIT-TO (LANGUAGE,"English") OR LIMIT-TO (LANGUAGE,"Portuguese") OR LIMIT-TO (LANGUAGE,"Spanish"))

The search strategy was defined considering the different elements of the guiding question: referees, soccer, and video analysis. The search strategy included different

indexed terms and text words (Table 1), adapting to databases.

A complementary search was conducted by contacting the authors of relevant publications and manually reviewing the references of retrieved articles and reviews on the topic (Bloß et al., 2020; Kittel et al., 2019; Pina et al., 2018).

Study selection

For the selection of empirical articles, EndNote Web (https://web.endnote.com) was used and carried out by the main author (MLS); in case of doubt, a second reviewer (VCBF) would be consulted; in case of divergence, a third author (JMGC). The process started with the reading of the papers' titles and abstracts; once a potential study met the inclusion criteria or did not provide enough information regarding the eligibility criterion, it was subjected to full-text review. In the full-text review stage, studies that met all the selection criteria were included in the final review. The studies excluded during this process were duly justified and detailed for later presentation according to the PRISMA flowchart (Figure 1).

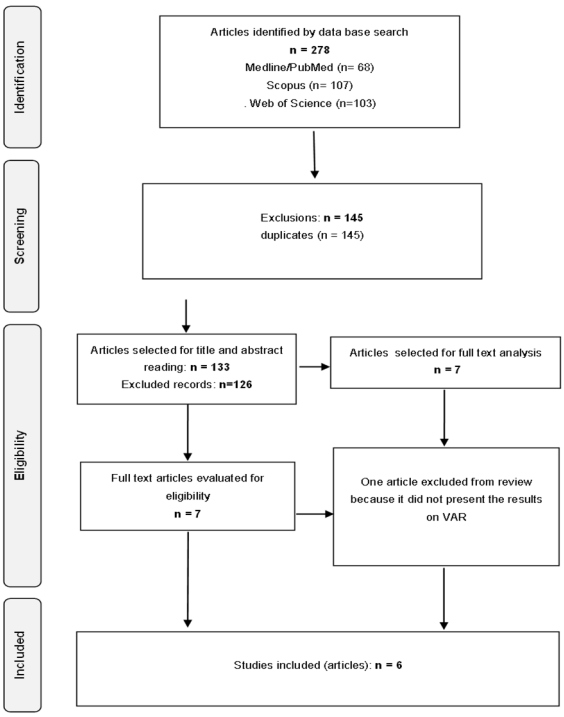

Figure 1. Primary Document Selection Process

Mapping and synthesizing the data

The data were extracted by two authors, where each one extracted data from part of the studies, then the other author performed a review of the collected information, using a worksheet designed exclusively to summarize the findings, which included the subjects divided by: a) characteristics; b) population of referees; c) study variables; and d) concepts addressed.

The data was synthesized considering the use of the VAR to allow the comparison of games and competitions. Thus, we characterize the studies by initially reporting the year of publication, title and journal, sample characteristics, place of competition, number of matches analyzed in the primary study, and profiles of the referees involved. Next, we present the variables investigated in the primary studies related to the implementation of the VAR, such as goals, impact on disciplinary decisions, technical decisions, time played, total playing time and actions of the VAR. Finally, we summarize the focus of the studies, the decisions and interventions made using the VAR and the results of the competition.

We considered the main occurrences and impacts of the VAR use according to the game rules (IFAB, 2019) and the VAR protocol version 8 manual (IFAB, 2019). Thus, we sought to verify whether the studies provided information on variables that occurred in the game, imposed by the rules, which were observed and compared after using the VAR in games, such as goals, playing time, offside events, cards applied to fouls, or violent conduct. Thus, we sought only to identify the studies that verified the extent to which these variables occurred per game and/or competition.

Results

The application of the searching strategy in the databases retrieved 346 articles. After the application of the limits for document type, language, and publication year, there were 278 articles. Removal of duplicate articles resulted in 133 studies. Title and abstract review excluded 126 articles; thus, seven articles were subjected to full-text review. Of these, six were subjected to data extraction, while the other was excluded for not presenting the study results (Figure 1). The authors of the relevant publications were contacted, and the reference lists of the retrieved articles were manually reviewed (Bloß et al., 2020; Kittel et al., 2019; Pina et al., 2018), but no additional studies were identified.

The primary studies included were published between 2019 and 2020 in different scientific journals, most with high impact in the field of sport. The information collected on the use of VAR is from professional men's soccer competitions that took place in eighteen countries. As these are high performance competitions, we believe that it also involved elite refereeing, however, only one study characterized the referees and analyzed the accuracy of their decisions, using data provided by the competition promoter (Samuel et al., 2020). The initial mapping allowed identifying the authors, year of publication, country, sample, age of the referees, experience over time, journal title (Table 2).

Table 2.
Characterization of the included studies

Study	Author / year	Country	Sample	Age	Time experience	Title	Journal
A	(Lago-Peñas et al., 2019)	Italy Germany	1024 games	NR	NR	How does Video Assistant Referee (VAR) modify the game in elite soccer?	International Journal of Performance Analysis in Sport
B	(Errekagorri et al., 2020)	Spain	375 games	NR	NR	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
C	(Han et al., 2020)	China	960 games	NR	NR	The influence of the video assistant referee on the Chinese Super League	International Journal of Sports Science and Coaching
D	(Mather, 2020)	England	NR	NR	NR	A Step to VAR: The Vision Science of Offside Calls by Video Assistant Referees	Perception
E	(Samuel et al., 2020)	Israel	11 soccer referees	(Average age 34.54 ±6.23 years old)	Arbitration experience ranged from 10 to 25 years (average= 18.14± 5.41 years).	Implementation of the Video Assistant Referee (VAR) as a Career Change-Event: The Israeli Premier League Case Study	Frontiers in Psychology
F	(Spitz et al., 2020)	Australia, Belgium, China, Czech Republic, England, France, Germany, Italy, Netherlands, Poland, Portugal, South Korea, and USA	2195 games	NR	NR	Video assistant referees (VAR): The impact of technology on decision making in association football referees.	Journal of Sports Sciences

NR: not reported
N = 6 studies

Most of the studies addressed comparisons of elements that might have undergone changes after the implantation of technology in games. It was possible to check the countries, the number of matches, the number of reviews in different analyses (throughout the competition, between seasons of the same country, between competitions of different countries). The diversity of variables identified is mostly quantitative and addresses similar issues such as the effects of VAR on playing time and goal-related variables and player behaviour (Errekagorri et al., 2020; Han et al., 2020; Lago-Peñas et al., 2019), and the use of VAR (Samuel et al., 2020; Spitz et al., 2020) only one study reported on the perception of VAR implementation on Israeli referees' careers (Samuel et al., 2020).

Studies on VAR provided important information on elite competitions in the countries investigated. The data detailed the impact of its use on the number of offsides, fouls, the application of cards, the number of minutes of total playing time (Han et al., 2020; Lago-Peñas et al., 2019). In addition, they provided information on average review times and quantities of correct decisions (Samuel et al., 2020; Spitz et al., 2020).

The main results of the studies included in this review can be organized according to the parameters related to decision-making using the VAR as follows (Table 3):

Table 3.
Characterization of the variables verified in the included studies

Referee-related variables	(Lago-Peñas et al., 2019)	(Errekagorri et al., 2020)	(Han et al., 2020)	(Mather, 2020)	(Samuel et al., 2020)	(Spitz et al., 2020)
Total time in the game	x	x	x			
Time in the first half	x		x			
Time in the second half	x		x			
Effective Playing Time		x				
VAR incidents					x	x
Checks					x	x
Reviews					x	x
Penalty	x		x			x
Invasion	x					
Goal	x	x	x	x		x
Off-side	x		x	x	x	
Red cards	x		x			x
Yellow cards	x		x			
Fouls	x		x			
Decision making			x	x	x	x

N = 11 variables: Total time in the game = 90 min including extra time, Time in the first half = referring to the use of the VAR in the first stage of the match, Time in the second half = referring to the use of the VAR in the second stage of the match, VAR incidents = focused on the analysis of the incidents that used the VAR, Verifications =using the VAR to verify moves, Evaluations =referring to the use of the VAR to evaluate game moves, Penalty = using the VAR in penalty decisions, Invasion =using the VAR in area invasion decisions during penalties, goal = using the VAR to analyze ball situations in or out of goal, off-side = using the VAR to analyze off-side situations, Outside the side =, Red cards = using the VAR to analyze situations expulsion of players, Yellow cards = using the VAR to analyze situations of fouls punishable by a yellow card, Foul = using the VAR to analyze committed fouls, Decision making = utilize the VAR for decision-making.

Goals

The VAR provided an increase in goals after the application of penalties in the Spanish league as the number of interventions per game increased (Errekagorri et al., 2020) and when considering the 13 national football associations (Australia, Belgium, China, Czech Republic, England, France, Germany, Italy, The Netherlands, Poland, Portugal, South Korea, USA) evaluated in a broader study (Spitz et al., 2020), but it decreased in the Italian Series A (Lago-Peñas et al., 2019).

Offside

Two studies compared the impacts of VAR use on offside, showing a reduction in the German Bundesliga (Lago-

Peñas et al., 2019) and the Chinese Super League (Han et al., 2020). And one highlighted interference of the technological resource in the analysis of the final decision in cases of impediments (Mather, 2020).

Yellow and red card application

The VAR decreased the number of yellow card applications (Lago-Peñas et al., 2019) and increased the number of red cards (Spitz et al., 2020).

Fouls

Only two studies addressed fouls during games with VAR use, reporting reductions in Italian Series A and German Bundesliga (Lago-Peñas et al., 2019) and the Chinese Super League (Han et al., 2020).

Penalties

There was an increase in the number of penalties in the 13 competitions analyzed by Spitz et al. (2020).

Game time

The total playing time increased in the German Bundesliga (Lago-Peñas et al., 2019), the Chinese Super League (Han et al., 2020), and the Spanish La Liga (Errekagorri et al., 2020) in games that featured VAR intervention. The VAR increased the first part in the Bundesliga and both parts in the Chinese Super League (Han et al., 2020; Lago-Peñas et al., 2019).

Decision-making

Four studies cited decision-making: only one reported improvement in the decision-making process throughout the competition (Samuel et al., 2020); one showed the improvement on decision-making between the first and second moments, that is, before and after VAR analysis (Spitz et al., 2020); one only presented descriptive data on VAR use (Han et al., 2020).

Table 4. presents a synthesis of the information of each related primary document, in which we can observe from the research methods, such as the variables that were analyzed after the implementation of the VAR, the objectives of the studies and the main results found.

Table 4.
Information in each primary document related to: Authors, Extraction methods Competitions, analyze Situations with VAR, Decision making / Interventions, Study objective, Main results.

Authors	Extraction Methods	Analyzed Competitions	Situations with VAR	Decision- Making / Interventions	Study objective	Main Results
(Lago-Peñas et al., 2019)	Whoscored	Italian Serie A: 544 matches in 2016/17: 272 without VAR and in 2017/18: 272 with VAR German Bundesliga: 480 matches in 2016/17: 240 without VAR and in 2017/18: 240 with VAR	NR	NR	Comparison between seasons with and without the use of VAR	(i) there was a significant decrease in the number of offsides, fouls and yellow cards after VAR implementation; (ii) there was an increase in the number of minutes added to playing time in the first half and in the full game, but not in the second half.
(Errekagorri et al., 2020)	Reports were generated in Mediacoach® through the company OPTA® Sportsdata	La Liga Spanish League 2018-2019	121 times (once in 86 matches, twice in 13 matches and three times in 3 matches) in 102 matches (27% of matches played).	NR	Assess whether the VAR intervention affected the playing time and the technical-tactical and physical performance of the teams	i) there was a slight increase in the total playing time, and a decrease in the distance covered between the three situations; ii) significant decrease in effective playing time between VAR0 a VAR2
(Han et al., 2020)	Whoscored	Chinese Super League: 480 games (2017) without VAR and 480 games (2018) with VAR.	NR	NR	Comparison between seasons with and without the use of VAR	1) the offside and fouls in the Chinese Super league dropped significantly; 2) playing time in the first half, second half and total playing time increased significantly; 3) VAR technology inhibited the home teams' advantage
(Mather, 2020)	NR	Premier League: First phase	NR	34 goals canceled	Discussion about the 20ms intervals between the images analyzed in the offside	Suggestion of changing the offside rule in the VAR to recognize the problem, projecting an "uncertainty zone".
(Samuel et al., 2020)	Questionnaire using the change scheme for the practice of sport psychology (SCSPP) and interviews	Israeli Premier League September 2018 to March 2020	NR	Bigger mistakes and successes at the beginning of the competition than the pilot period with mistakes decreasing throughout the championship	Examine elite referees' perceptions and responses to the VAR, as well as their coping efforts (including conscious coping decisions) and support resources.	The referees varied in their perception of the result of the changing process, with three perceiving it positively, four neutrally and four negatively. Skills in using VAR and hits increased as the competition progressed.
(Spitz et al., 2020)	Data provided by VAR officers	Australia, Belgium, China, Czech Republic, England, France, Germany, Italy, Netherlands, Poland, Portugal, South Korea, and USA: with VAR in seasons 2016/2017 and / or 2017/2018.	795 reviews	164 penalties awarded; 88 penalties canceled, 132 red cards awarded; 6 red cards canceled, and 61 goals scored; 175 goals canceled	Predicting decisions after VAR intervention and examining the number and duration of interventions per match	There were 1544 matches without review (70.3% of all matches); 530 matches with only 1 rating (24.2% of all matches); 103 matches with 2 ratings (4.7% of all matches); 15 games with 3 ratings (0.7% of all games); 2 games with 4 reviews (0.1% of all games) and 1 game with 6 reviews (0.1% of all games). There were more penalties and red cards and fewer goals due to VAR interventions, and the predictive chances of making the right decision were significantly higher when a decision was made using VAR, compared to the initial decision made without VAR.

Discussion

This review was intended to map empirical studies presenting information on the implementation and use of VAR in field soccer. We summarized the studies presenting the characteristics, intervening factors, and the results of VAR use in soccer. We found that incipient scientific literature was written on the use of VAR and its potential contributions to soccer, with six studies addressing the use of VAR in 18 different soccer leagues. When analyzing the primary studies that investigated VAR, we expected these studies to focus on the action performed, i.e., the decision the referee makes. However, we found superficial studies with quantitative data on the analysis of referee decision making.

However, the studies analyzed the use of VAR in a descriptive way, more quantitatively and less qualitatively, and even technologically (Mather, 2020). The access to the analysis of professionals with experience in the entities that promote competitions, allowed the sharing of sensitive and important information to be disclosed, such as the precise analysis of a decision in the field (Spitz et al., 2020) or in the Video Operation Room - VOR (Samuel et al., 2020).

We realized the initial importance of identifying the profiles of the use of VAR reported in the scientific literature, as we believe that this will help to understand whether the critical errors of refereeing have changes (increased or decreased). All primary studies presented important information on the use of VAR in practice. We will now analyze the main conclusions found:

Analyses performed

The studies that have examined the use of VAR during competitions have focused on major national events and, consequently, on elite professional referees, but only one study by Samuel et al. (2020) provides a detailed characterization of the referees participating in the analyzed competition. The interest in evidencing direct data on the impact of VAR on the game was more frequent. We noticed a large gap of information on the profiles of the referees who participated in this initial process. However, this may also have been because some studies used secondary data from platforms.

Comparative analyses of the variables investigated were conducted throughout a competition considering matches with and without VAR (Errekagorri et al., 2020); at different times of the same competition (Han et al., 2020; Lago-Peñas et al., 2019), and between competitions in different countries (Spitz et al., 2020). However, when comparing several competitions, we should consider the cultural variations of the game, the game models, and the specificities in the refereeing experiences during training with VAR.

Most studies used descriptive and comparative analyses of quantitative data. Only one study used a more qualitative approach with a questionnaire and longitudinal interventions. We noticed gaps regarding the use of more robust analyses focused on referee decisions. As for the contexts of play involved in field assignment, only one study analyzed the venue of the game in the comparative analyses. Other contexts of the game and their effects on the need for technological intervention were not considered.

Goals and Offside

The reduction of offside events was cited by Lago-Peñas et al. (Lago-Peñas et al., 2019), who investigated the German Bundesliga, and was corroborated by Han et al. (2020) in the Chinese Super League. This may have been impacted by the direct intervention of the procedures that the protocol recommends correcting factual errors in the field.

The possibility of correcting early decisions converted the number of offside events to from goals (Errekagorri et al., 2020). These may have been motivated by the safety of ensuring the completion of attacking actions, as the VAR protocol procedures allowed, and which would otherwise be interrupted by the assistant referee's misjudgment. However, it does not corroborate the findings of Lago-Peñas et al. (Lago-Peñas et al., 2019), who found a decrease in goals in Italian Serie A. However, it is important to remember that the context of the game can influence the number of goals in a match (González-Ródenas et al., 2020), as well as situational, offensive, and defensive variables (Aguado-Méndez et al., 2020).

In other words, VAR corrected serious, factual errors that would have a direct impact on the match final score. However, some analysis involving the thorough use of the frame in VAR are still controversial. Its use must be accurate and correct to facilitate the decision setting. Mather (2020) suggested a gray area for offside analysis, since some game situations may suffer interference from the equipment used and the speed of the players on the field.

Yellow and red card application

According to Lago-Peñas et al. (Lago-Peñas et al., 2019) the presence of the VAR decreased the number of yellow card judgments. On the other hand, it probably increased the number of red card judgments, as verified by Spitz et al. (2020). This can be justified by the ability of the VAR to review details not otherwise noticed during play allowing greater rigor in the judgment of the referees on the field, thus increasing the number of red cards.

When it comes to disciplinary behavior, it seems that VAR has brought a greater sense of fairness to the field, by rigorously punishing the use of excessive force and inappropriate behavior, which was previously unnoticed by the referee. Therefore, the different angles in the analysis of the point of contact are important and protect the physical integrity of the players.

Fouls and Penalties

Decisions involving penalties are often influenced by the speed of the game (Lex et al., 2015). Errekagorri et al. (2020) reported an increase in the amount of penalties in one competition during the season that used VAR. This study corroborates the analysis of 13 competitions reported by Spitz et al. (2020) in which penalties were the review

incidents with the highest frequencies (43.5%), with decision changes. An essential element analyzed by Samuel et al. (2020) was the impact on the referee's career when scoring a penalty or not, where the referees analyzed their decisions and the role of the VOR referees in their final decision making. Penalties increased by aiding resources in the penalty area where many quick situations occur that are not always visible to the referees which enabled the identification and punishment of these irregular events, which in turn have high potential for conversion to a goal.

Game time

Concerning the analysis of data referring to playing time, both studies converged in the increase of total playing time. There was an increase in playing time in the Spanish league (Errekagorri et al., 2020) and in the German Bundesliga (Lago-Peñas et al., 2019), due to an increase in the number of interventions per game. However, this review identified only one study analyzing the times of checks, field reviews and VOR, data provided by the entities promoting the competitions. In turn Spitz et al. (2020) presented important data on check and review times, where field reviews averaged 62.0 seconds. Access to information on the use of VAR is still limited, so competition data could be made widely available, possibly allowing further scientific analysis.

We caution that taking the total review time and dividing it by all the matches in a competition, including matches that did not have on-field or VAR reviews, gives a misleading average usage time picture. Particularly when the interventions in a competition are timely, but too time-consuming. Therefore, it would be interesting to know with more transparency the percentage of games that used the resource, as well as the average time of use of VAR by review amounts. This would allow identifying how much a competition needs VAR, and how referees conduct this process per incident and per game.

Decision making

No included studies primarily focused on arbitration decisions. However, Samuel et al. (2020) detailed the difficulties faced by referees both on and off the field during and post-decision making. These challenges, along with an observed lack of experience and adequate training in VAR, may have contributed to the perception that the use of VAR has adversely affected referees' careers (Samuel et al., 2020). Nonetheless, the disclosure of both successes and mistakes should be promoted in all competitions for the sake of transparency and improved decision quality.

Most studies corroborate that the use of VAR favored decision making both between seasons (Han et al., 2020; Lago-Peñas et al., 2019) and throughout the competition (Errekagorri et al., 2020; Samuel et al., 2020), and especially immediately after the identification of a serious error committed on the field (Spitz et al., 2020). Spitz et al. (2020) presented quantitative data on VAR checks, reviews, and types of VAR incidents from 2195 matches. Another crucial point to be considered, cited by Mather (2020), stems from the technological limitations that can make arbitration decisions difficult.

No form of training with intervention was identified in the studies. Samuel et al. (2020) reported improvements between offline VAR training and game practice as competitions progressed. This strengthens the need for intensification from familiarization with the use of technology to actual training. Considering that in soccer, training is most effective when it simulates the conditions of an actual game (Borges et al., 2022) . Only one study addressed communication between field referees and VOR (Samuel et al., 2020). As the rules of soccer continue to evolve, especially with the introduction of VAR, the importance of decision-making training becomes even more pronounced (Spitz et al., 2020). Referees are required to swiftly assimilate new information perceived during the match, integrate it with prior knowledge, and adhere to VAR protocol procedures to ensure high-quality decisions. The dynamic nature of the game, combined with the technological nuances introduced by VAR, underscores the need for continuous training and adaptation.

Limitations and future suggestions

As a limitation of this work, it should be noted that the number of primary documents was less than what had been desirable. The publication of studies framed in the mixed methods in the field of sports sciences is imperative (Preciado et al., 2021). The figure is lower if we focus on observational studies (Anguera et al., 2014) and the studies that, in addition to the above, are from focus on VAR are still further reduced. We reported on a study that employed a mixed-methods approach, incorporating Social Network Analysis (SNA) to analyze interactions between players during the 2018 World Cup. Although the tournament was in the initial stages of implementing the VAR system, the study did not focus on VAR-related aspects (Clemente et al., 2019).

Future studies could identify which behaviors stimulate incidents involving the VAR, the locations in the field in which incidents occurred most often. That is, they will be able to go beyond the comparative analysis of VAR use as reference variables in terms of the number of goals, number of cards presented, time spent on review, and number of impediments, also factoring in the game contexts and data regarding VAR training.

This makes it necessary to use more robust research methodologies to observe and analyze review events, such as systematic observations that help to better understand the processes and procedures adopted during the game and their immediate effects on the decisions of field or VOR referees.

Another possibility would be to delve deeper into how VAR is implemented and adapted in different countries, considering technological specificities and their application.

Conclusions

This review presented the mapping of studies on the use of VAR between 2000 and 2020. It is already possible to verify early research on its use, which has evolved quickly according to data from relevant competitions in 18 countries. However, considering the search range applied, the studies did not reach all continents.

Most of studies included in this review reported that VAR interfered positively with the game by improving the number of correct decisions made by referees. Specifically, after the first decision made, involving clear errors of goal and penalty incidents that were not detected on the field. Even though there is an increase in total playing time and a reduction in effective playing time, VAR presents itself as a crucial resource for maintaining security and justice by correcting refereeing errors in soccer games.

Regarding the training and evaluations of referees in the use of VAR, it's essential to note the varying methodologies adopted across different leagues and countries. While the primary studies provided insights into the application and impact of VAR, there's a noticeable gap in the literature concerning the specific training protocols, evaluation metrics, and standardized practices associated with VAR usage. Future research might delve deeper into these areas to offer a comprehensive understanding of VAR's integration into the sport.

Acknowledgments

Individual grants from the Conselho Nacional de Desenvolvimento Científico e Tecnológico for VCBF ("CNPq Productivity Grant" process number: 312091/2021-4). The views of the funding agency had no influence on the content or conduct of the review.

Disclosure of interest

No potential conflict of interest was reported by the authors.

Funding

We report that there is no funding associated with the work presented in this article.

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